Land Matters

Agrofuels, Unequal Exchange, and Appropriation of Ecological Space

Hermele, Kenneth

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To the memory of my parents

Perla Hermele, Königsberg 1923 – Netanya 2002
Arthur Hermele, Berlin 1922 – Stockholm 1996

& to Ingrid, my love

Table of Contents

Tables

Figures

The Argument: The Return of Malthus

This study deals with land-based resources and the role they play in today's and tomorrow's global socio-ecological metabolic regime.[1] I set out recognizing that Thomas Robert Malthus was wrong when he posited a contradiction between population increase and agricultural growth, and I conclude that he may well be proven right in the future.

It is a commonplace to say that Malthus was wrong, but too often his thoughts are dismissed out of hand without pondering why he erred. Thinking about the "why" helps us understand that he was not so much wrong as too late *and* too early in his prediction.

He was too late, because he did not see that the global socio-ecological metabolism was about to shift from land-based resources to fossil fuels, which did away with the limit to agricultural growth, at least temporarily; and he was too early to witness that fossil fuels would come up against their own limits in terms of supply as well as in terms of global warming.

The last two hundred years, say from 1798 when Malthus anonymously published his *Essay on the Principle of Population*, until 1992 when the

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[1] A society's metabolic flows are variously labelled "socio-economic" and "socio-ecological" in the literature. Since I consider the economy a social entity, I feel that the concept "socio-economic" is redundant; "socio-ecological", on the other hand, underlines that a society's metabolism is best understood by studying the social (including the economy) as well as the ecological spheres. Hence, from now on, socio-ecological metabolic flows.

The term "regime" also needs specifying. I use "regime" loosely throughout this study, as do many of the sources I rely on, giving it a fluid meaning. The Merriam-Webster online dictionary defines regime as "a mode of rule or governance", and I use it as synonymous with "system", "profile" or "complex", other equally imprecise but useful concepts. Thus, I use "regime" in relation to climate politics (climate regime), to describe the gradual shifts over time in the use of land (agro-regimes), as well as in order to capture the dominating energy and resource flows of a society (socio-ecological metabolic regime).

United Nations Framework Convention on Climate Change, UNFCCC, was launched, constitute an exception to the predominance of land-based resources, a respite created by reliance on fossil fuels. This way out of the Malthusian trap was complemented by the appropriation of space – land areas – overseas reached via trade and colonial occupation.

This exceptional period *could* be prolonged if we replace oil by coal or other fossil fuels, but I will rule out this option for climate reasons. Likewise, I will disregard the appropriation of new forested land areas anywhere on the globe on the same ground: deforestation is one of the main drivers of climate change. As a consequence, we as a global society are limited to the land areas which already have been cleared for human use.

With these self-imposed limitations, peak oil coexists with peak soil: today's five billion hectares of crop lands and pastures have to suffice for the global socio-ecological metabolic needs of renewable resources for the production of food, feed, fibres, and fuels.

However, to make do with this land area – five billion hectares – will not be easy as a number of drivers are increasing the quest for these very same land areas: economic, demographic, dietary, and environmental needs all operate in the same direction, and they all require more land areas to be met. Against this background, one does not have to be Malthus to predict a conflict between the socio-ecological metabolic needs of a larger, wealthier and more meat-consuming global population, and the available land areas to produce the goods to satisfy these needs.

The global conflict over land and land-based resources is already playing itself out as witnessed by the land areas which are being "grabbed" in Africa, Asia and Latin America as well as in Eastern Europe by a variety of resource-hungry actors, from sovereign wealth funds (Norway, Saudi Arabia) and agro-businesses (Monsanto) to states (Arab Emirates, China) and financial institutions (World Bank).

Land grabbing is frequently a violent and conflictual process of "resolving" competing claims for land and land-based resources, violating the rights of the present land holders and users. This may be one explanation why land grabbing, as a particular clear case of appropriation of ecological space, has received a fair amount of attention. But two other forms of appropriation of ecological space have not, ecologically unequal exchange and environmental load displacement, including trade in waste. To my argument, however, all these movements are essential vehicles for accessing

land-based resources: importing ecological resources – either directly or embodied in the traded goods[2] – and disposing of waste are both land-based movements which underline the centrality of land areas to the global socio-ecological metabolic regime.

Agrofuels are illustrative of the conflicts concerning land areas and land-based resources which lie ahead of us. Agrofuels are promoted as energy-efficient, ecologically sound, economically viable, geopolitically cautious, and they are held to be non-competitive with present land uses. But the opposite is true on every count: they are energetically doubtful, ecologically destructive, unviable without subsidies, geopolitically risky, and may lead to dramatic land use changes locally, regionally, nationally and globally, causing further global warming.

Of course, my argument is based on my two limiting assumptions: no fossil fuels, no deforestation. But even if we as a global system use coal or other energy sources to replace oil, the appropriation of ecological space will continue – although at a slower pace – and cause further deforestation, the various drivers looking for land areas are strong enough to keep up the pressure on the earth's surfaces even without factoring in a substitution of agrofuels for fossil fuels. Just consider that as you have been reading this argument, 247 forested hectares have been cleared somewhere around the globe.[3]

***

In what follows, I will investigate the importance of land areas and land-based resources in three related aspects. Part I looks into the use of land in the global socio-ecological metabolic regime prior to the advent of fossil fuels, during the dominating reign of fossil fuels, and into a hypothetical future of a re-emerging land-based socio-ecological metabolism. The focus is upon agrofuels, with a case study of Brazilian sugarcane ethanol.

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[2] "Embodied land" refers to the land used to bring forth a product, not its actual content. In the jargon of the environmental movement, such "embodiment" is often called a product's "rucksack".

[3] Global annual deforestation rate is approximately 13 million hectares; see http://www.fao.org/newsroom/en/news/2005/1000127/index.html. I assume that by now ten minutes have passed.

Part II then turns to discussing how to measure ecologically unequal exchange of land areas and land-based resources through the use of various non-monetary metrics. If land has re-emerged as a strategic resource, as I argue, then gauging ecologically unequal exchange is one way to understand how power translates into appropriation of strategic resources.

In Part III, finally, I discuss the implications of such appropriation of ecological space and suggest the emergence of a new agro-regime, where the fungibility of land and land-based resources – their substitutability, their multiple uses – explains their central role in the strive to provide ever more of food, feed, fibres, and fuels.

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Before I start, a few basic data concerning global land use are given below for easy reference. See Table 1.1.

Table 1.1. Global land use 2009-2010, million hectares

Global land area	13,003
Crop lands	1,534
Pastures	3,355
Forests	5,257

Source: FAO 2012, Tables 3 and 48.

In the following, I will use rounded figures – 1,500 hectares for crop lands, 3,500 hectare for pastures, and 5,000 hectares for forests – in order to stress that my argument is based on simplifications regarding the trajectory – past, present, and future – of the global socio-ecological metabolic regime.

PART I

LAND USE AND AGROFUELS

Many demands are directed towards the limited land areas of the globe, and the possibility of meeting them all has been hotly debated. Do we, as a global society, live in a win-win world, or are we restrained by having to make stark choices, a situation best characterized by trade-offs? To be somewhat more specific: can the global desire for land to provide food, feed, fibres, and fuels be met simultaneously; or will one kind of land use by necessity clash with, and rule out, other equally pressing needs?

No single land-use is more representative of the conflicting stands concerning win-win vs. trade-off, than the growing of feedstocks for agrofuels. This has nothing to do with the importance of agrofuels today, but rather with their potential for replacing the dependence on fossil fuels, allegedly without contributing to climate change.

To see the immensity of the task which we as a global society are confronting, let us start by returning to the metabolic shift which took place in the late 1700s and early 1800s from land-based energy sources to coal, and from that vantage point look at today's most advanced producer of agrofuels, Brazil. We will then see that agrofuels are being promoted by a coalition of energy and climate scientists, environmental NGOs, global corporations, international financial institutions, and states in search of a win-win energy future.

This may sound as too formidable opponents for even thinking about alternative future pathways for the socio-ecological metabolism, but I will show that accepting my two limiting assumptions does not preclude the possibility of imaging a future with many people living decent lives – if only we accept changing some of the basic assumptions of what such life styles entail.

1. The Importance of Land

For over two centuries, economics has been known as "the dismal science"[4] and no-one did more to earn this label than Thomas Malthus, classical economist and priest, who in 1798 predicted a clash between population growth and agricultural production, as a result of "fixed laws of our nature". Though he later elaborated his argument further, it is the first simple formulation which has remained in focus. Malthus wrote:

> I think I may fairly make two postulata.
>
> First, That food is necessary to the existence of man.
>
> Secondly, That the passion between the sexes is necessary, and will remain nearly in its present state.
>
> These two laws, ever since we have had any knowledge of mankind, appear to have been fixed laws of our nature; and, as we have not hitherto seen any alteration in them, we have no right to conclude that they will ever cease to be what they now are. […]
>
> Assuming, then, my postulata as granted, I say, that the power of population is indefinitely greater than the power in the earth to produce subsistence for man.

[4] The phrase goes back to 19th century British historian Thomas Carlyle who first used it about Malthus; the characterization caught on when Carlyle attracted a wider audience in 1849 by defending slavery in his *Occasional Discourse on the Negro Question*. See David Levy and Sandra Peart: *The Secret History of the Dismal Science*, http://www.econlib.org/library/Columns/LevyPeartdismal.html.

> Population, when unchecked, increases in a geometrical ratio. Subsistence increases only in an arithmetical ratio. A slight acquaintance with numbers will show the immensity of the first power in comparison of the second.[5]

Why this disparity should exist between a geometric growth rate for population – 1, 2, 4, 8, 16, 32, 64 – and an arithmetic for agriculture – 1, 2, 3, 4, 5, 6, 7 – leading to population having grown nine times faster than agriculture after only six periods, Malthus never bothered to explain or substantiate. In a later edition of his work, he simply stated that his assertions were self-evident:

> The first of these propositions [population's geometrical growth] I considered as proved the moment the American [population] increase was related, and the second proposition [agriculture's arithmetical growth] as soon as it was enunciated.[6]

This was not a wise defence, not even then: instead of using the knowledge which existed regarding the factors conditioning population and agricultural growth rates, Malthus opted for pure conjecture. Based only on the example of the American rate of population increase – which he obtained from Benjamin Franklin – he devised a law of population growth which he then applied to England, a very different context; he further postulated that it would be valid forever, making the human propensity to procreate, in the colourful words of the environmental historian Donald Worster, equal to "a breeding machine" which goes on producing at the same steady rate, just as "the new power loom".[7]

Malthus's failure to rely on concrete data was used by his detractors who appeared as soon as his essay was published. But I believe the story of Malthus is more interesting than simply concluding that he was wrong: he was in fact right at the moment of writing, the end of the 18th century, only to subsequently be proven wrong for two hundred years as agriculture (as well as population growth) took turns which he had not foreseen. Today, however, the Malthusian perspective is anew a useful point of departure for discussing present and future conflicts over land.

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[5] Malthus 2004/1798:12-13.

[6] Malthus 1801, quoted in Foster 2000:96.

[7] Worster 1994:152.

Two counter-arguments to Malthus

After publishing his essay, Malthus immediately reaped criticism for lacking an understanding of agriculture. In a surprisingly early rendition of the metabolic rift the Scottish economist James Anderson argued that the reason why agriculture did not improve its productivity was because it was deprived of what it needed in terms of manure and human waste. "Every person who has but heard of agriculture" he wrote in 1801, three years after Malthus,

> knows that animal manure, when applied to the soil, tends to add to its fertility; of course he must be sensible that every circumstance that tends to deprive the soil of that manure ought to be accounted an uneconomical waste highly deserving of blame.[8]

Thus, the limits to agriculture were not caused by the limits of available land areas, as Malthus thought, but resided in the failure to secure the re-application to agriculture of the resources which it had been bereaved of but which were essential in order to uphold its productivity. This is an argument which 66 years later was essential to Karl Marx's critique of agriculture during industrialization and early urbanization, the break in the circular flow of resources from countryside to town and back, which blocked the development of agriculture. As Marx wrote in the first part of Capital, "all progress in capitalist agriculture is a progress in the art, not only of robbing the worker, but of robbing the soil":

> Capitalist production […] disturbs the metabolic interaction between man and the earth, i.e. it prevents the return to the soil of its constituent elements consumed by man in the form of food and clothing; hence it hinders the operation for the lasting fertility of the soil.[9]

This, then, was one line of argument against the formula that Malthus had embraced: there was a man-made circumstance behind the slow productivity growth of agriculture, which, logically, could be removed if only man re-established the metabolic circular flow. To Marx, the need to import guano from Peru as fertilizer, bridging the rift, indicated that this metabolic break

[8] Quoted in Foster 2000:145.

[9] Marx 1990/1867:637.

had stopped agriculture from being self-sustained.[10] The dependence on guano also heralds a way of resolving the impasse of agriculture which since then has become the rule: instead of re-establishing a circular and renewable flow of resources, land areas and land-based resources were sourced overseas and imported into the Centre of the global system.

One result of this transfer of land-based resources from the Periphery was clear already after a couple of decades: the exploitation of guano, which had accumulated over thousands of years, was carried out at such a rapid pace that the resource base was destroyed. An island off the coast of Africa, previously covered with guano was soon "reduced to nothing but a plateau of bare rock", and even the guano islands outside Peru were transformed, in the words of a contemporary observer, into "vast sarcophagi" reminiscent of "death and the grave."[11] Today, similar ruthless practices to access primary commodities continue with the practice known as "Mountain top removal". See Figure 1.1.

There was also another line of argument opposing Malthus's formula, the fact that he had neglected the contribution that scientific advancement would bring. Commenting on Malthus, Friedrich Engels wrote in 1844, twenty-three years before the first volume of Capital was published:

> Where has it been proved that the productivity of the land increases in an arithmetical progression? […] science increases at least as much as population. The latter increases in proportion to the size of the previous generation, science advances in proportion to the knowledge bequeathed to it by the previous generation, and thus under the most ordinary conditions also in a geometrical progression. And what is impossible to science?[12]

Malthus's argument counter-posing arithmetic and geometric growth rates was so alluring that Engels applied the same imagery even as he criticized Malthus: according to Engels not only population but also agriculture would increase geometrically.

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[10] Foster 2000:156.

[11] Quoted in Clark & Foster 2012:76-77. The origin of the word guano is the Quechua word for bird dung.

[12] Engels 1844:19.

Figure 1.1. Mountain top removal. Coal mine in West Virginia, USA
Source: http://ilovemountains.org/resources#whatismtr.

Boserup: No laws of agriculture

121 years later, in the mid-1960s, economist Ester Boserup argued that agricultural development was a much more dynamic story than the straitjacket Malthus had assumed, and that population pressure could be a driver for higher agricultural productivity, thus removing the conflict that he had stipulated.

Boserup's standpoint had more to do with a belief in the capacity of peasants to gradually adapt to changing circumstances than with Engels's trust in the advance of science. She thought that the impact of population growth often was a positive one, and that:

> the population within a given land area can double several times without having to face either starvation or lack of employment opportunities in agriculture.[13]

Boserup's reasoning is frequently reduced to a one-dimensional counter-argument to Malthus's equally simplified thesis, as the above quotation may lead you to conclude: against his strict contradiction population/agriculture, she is held to believe that a growing population is the Mother of invention. But in fact Boserup argued that population growth *may* result in an intensification of the use of land, not that it always would. Increasing population pressure on limited land areas, Boserup thought, might drive peasants to develop area-intensive methods in order to maximize the crop yield per hectare.

Thus, to Boserup, contrary to Malthus, there were no laws at play but only contingent relationships, where the outcome could be either positive or negative. Boserup sums up on one of the first pages of her study:

> It is not to be denied that the food potential of the world has been narrowed down by populations, who did not know how to match their growing numbers by more intensive land use without spoiling the land for a time or forever. But nevertheless, the neo-Malthusian theories […] are misleading, because they tend to neglect the evidence we have of growing populations which managed to change their methods of production in such a way as to preserve and improve the fertility of their land. […] Growing populations may in the past have destroyed more land than they improved, but it makes little sense to project past trends into the future, since we know more and more about methods of land preservation and are able, by means of modern methods, to reclaim much land, which our ancestors have made sterile.[14]

This is a surprisingly open declaration at the outset of Boserup's study, and one which she is not remembered for having made. Here, Boserup actually goes along with Malthus's tenet of a contradiction population-agriculture by conceding that a growing population may destroy the land upon which it lives, only to conclude that "we" in the future need not repeat such mistakes.

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[13] Boserup 1965:117.

[14] Boserup 1965:22.

Malthus: No limits to growth

Malthus and Boserup have remained the opposing poles in the population-agriculture discourse, and anyone entering the debate customarily refers to both of them, usually decrying Malthus and celebrating Boserup. But although Malthus, as we have seen, was severely criticized and even ridiculed for his opinion as soon as his essay was published, nothing seems to have stopped the advance of the Malthusian formula in the public consciousness if we are to believe Worster who claims that Malthus's "ironclad ratios and his warnings of impending national apocalypse" have become "part of the folklore of capitalism".[15] It may well be, as the economic historian Eric Roll assumes, the fact that Malthus expressed his argument in such a simple formula which explains why his theory was seen as "spectacular", leading to both "support and criticism in abundance".[16]

Malthus has been identified with one of the crucial issues of economic and social development, the question of limits to growth, and Worster claims that Malthus "introduced a new ecological dimension to Adam Smith's study of human economics".[17] But Malthus himself felt the need to attenuate his original unwavering position, and in a later editions of his essay he softened some of his positions in a final chapter called Of our rational expections respecting the future improvement of Society:

> On the whole […] though our future prospects respecting the mitigation of the evils arising from the principle of population may not be so bright as we could wish, yet they are far from being entirely disheartening, and by no means preclude […] gradual and progressive improvement in human society.[18]

[15] Worster 1994:152-153.

[16] Roll 1961:196.

[17] Worster 1994:150.

[18] Quoted after the 1809 American edition, Vol II, chapter XII:499.

And he further underlined (already in the first edition of his Essay):

> No limits whatever are placed to the productions of the earth; they may increase for ever and be greater than any assignable quantity.[19]

Nevertheless, and although his lack of ecological insights has been noticed,[20] Malthus has come to be seen as the symbol of a whole dismal tradition which forecasts the end of growth. Also today, should one venture to question that economic growth can go on, and resource use expand forever, one should expect to be branded a "neo-Malthusian".

However, recognizing that Malthus had an important point in turning our attention to the possibility of a conflict between a society's metabolic needs and available land areas to meet those needs, should not refrain us from criticizing the mistake he committed when he presented his theory, in the words of economic historian Richard Wilkinson, "as a law valid for all time".[21] He did not realize that he was standing exactly at the turning point when Britain was about to initiate a transition from one metabolic regime to another, from solar and land based energy to fossil fuels, thus temporarily doing away with, in the words of historian Rolf Peter Sieferle, "the first and the most important characteristic of the agrarian solar energy system", its "dependency upon territory".[22]

Therefore, instead of giving a credible forecast for the future development path of societies, Malthus summed up what had been the limiting conditions until the moment he wrote, but which would not constitute a restraint on economic growth thenceforth, at least not before today's double peak of oil and soil. Economist Paul Krugman correctly observes:

> was right about roughly 58 out of 60 centuries of civilization […] We only think Malthus got it wrong because the two centuries he was wrong about were the two centuries that followed the publication of his work.[23]

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[19] Malthus 2004/1798:18.

[20] See Foster 2000:92-93, and Martínez-Alier 1990:100.

[21] Wilkinson 1973:22-23.

[22] Sieferle 2001:25.

[23] Krugman 2009.

Ecological windfalls from fossil fuels and colonial occupation

At the time of Malthus's writing, the basic limiting production factor in Britain was not capital nor labour but rather land, and what ushered Britain into an industrial mode of production and a new socio-ecological metabolic regime was that it managed to break the constraints imposed on growth and development by its scarce resource. Britain's land limits were shifted in time and space, from agricultural lands to coal, and from Britain to its colonies. In this way, Britain obtained access to land areas below its own ground and above ground across the sea. As summarized by historian Kenneth Pomeranz:

> the significance of the Atlantic trade [to Europe's development resides] not in terms of financial profits and capital accumulation, nor in terms of demand for manufactures – which Europe could have probably generated enough of at home – but in terms of how much they relieved the strain on Europe's supply of what was truly scarce: land and energy.[24]

It was not only the growth of agriculture which was blocked, all activities dependent on land ran up against their limits before the advent of fossil fuels and the appropriation of land areas overseas, most importantly forestry. This constraint was reflected in the change in relative prices of fire wood: while the price of firewood followed the general price movements in the early 1500s, it had already by the end of that century become significantly more expensive, until it by the mid-1600s had outgrown the general price index by a factor of almost three.[25]

Taken together with the use of its own coal, the cross-Atlantic trade gave Britain a windfall gain which led it "*out* of a world of Malthusian constraints",[26] or as we might re-phrase it, out of the dismal world forecasted by Malthus, thus liberating capital accumulation in Britain from the limits imposed by land.

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[24] Pomeranz 2000:23.

[25] Wilkinson 1973:114. Price index for firewood stood at 1208 in 1633-1642, while the general price index only had risen to 451 (index 1451-1500 = 100).

[26] Pomeranz 2000:23.

In Britain's exchange with the United States of America, its former colony, we find a case of unequal exchange: the US was sending more and receiving less in terms of embodied labour and land, and Britain, was receiving more and sending less. Comparing the flows around 1850 of embodied labour hours and land areas in one thousand pounds of US cotton cloth and one thousand pounds of British textiles, the raw cotton imported by Britain embodied eight times as many labour hours, and 60 times as much land as British textiles sold for the same amount.[27] In the terminology which I use here, Britain appropriated ecological space from the US via trade.

The shift to a mineral regime

Demographer EA Wrigley has observed that Britain in the 18th century was being transformed from an organic to a mineral economy, and he notes that in an organic economy, most resource use is tied to "the fixed supply of land and […] its organic products",[28] before he goes on to list the essential land-based products central to the old regime: food, feed, fibres, leather, textiles, and construction materials. In other words, an organic economy is almost totally dependent on, and restricted by, land areas.

In a mineral economy, on the other hand, the land area limitation is suspended, temporarily, as the principal economic activities increasingly come to use energy in the form of mineral resources to replace draught animals and human power:

> Always previously a productive agriculture had been the base of the whole span of economic activity because all industrial processes depended principally or exclusively on organic raw materials. The new [mineral] age was built upon different foundations. The fruits of the earth were increasingly used as food alone. It was not from the soil but from beneath the soil that the raw materials of a new economic age were drawn.[29]

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[27] See Hornborg 2007: 267-268.

[28] Wrigley 1988:5.

[29] Wrigley 1988:73.

Wrigley recounts a telling example where France in 1840 by its use of steam power benefited from the equivalent of one million workers (in horsepower). The steam engines can thus be said to be, to use the image applied by contemporary economist and statistician Pierre Émile Levasseur, "true slaves, the most sober, docile and tireless that could be imagined". By 1887, the steam power capacity of France equalled 98 million people, "deux esclaves et demi par habitant de la France".[30] Wrigley points out that "Englishmen, of course, were slave owners on a much larger scale" as the British steam engine capacity was more than twice the French.

The need to be area-efficient – the concern of Boserup – in order to avoid competition between energy and food was an argument mobilized to support large-scale investments in transport infrastructure debated in Britain at this time. Since each horse needed 4-8 acres of hay annually, canals and railroads would free up large tracts of land for the production of food for human consumption by replacing horses with barges and trains. As an engineer reflecting upon a proposed canal about 1800 concluded:

> How desirable any improvement that will lessen the keep of horses.[31]

In 1833, a report to the House of Commons on "steam carriages" presented quite a straightforward argument:

> It has been said that in Great Britain there are above a million of horses engaged in various ways in the transport of passengers and goods, and that to support each horse requires as much land as would upon an average support eight men. If this quantity of animal power were displaced by steam-engines, and the means of transport drawn from the bowels of the earth, instead of being raised upon its surface, then, supposing the above calculation correct, as much land would become available for the support of human beings as would suffice for an additional population of eight millions.[32]

The surface of the earth was obviously the scarce resource to protect here, and "the bowels" – coal – provided the solution to competing land uses.

The limits of the land-based metabolic regime can also be illustrated by posing a counter-factual question: could the transformation from agriculture

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[30] Two and a half slaves for every inhabitant in France. Quoted in Wrigley 1988:76.

[31] Quoted in Wilkinson 1973:123-124.

[32] Quoted in Wilkinson 1973:124-125.

to industry which occurred in Britain have happened without the transition to land area saving fossil energies? Well, hardly, as four "Britains" would have been needed by World War I only to produce the required volumes of charcoal in the absence of coal for the iron ore smelters.[33] And had Britain not had coal available, it would have needed to use five times its entire merchant fleet all year round to transport the forest produce needed in place of the actual coal consumption that took place in 1790.[34] Likewise, a hypothetical exercise shows that Britain needed its whole land area by 1850, and five times that by 1900, just to be able to substitute its use of fossil fuels by hypothetical forest biomass.[35]

And similarly for agricultural products which were imported from the colonies to Britain. Just to replace the cotton which was brought to Britain in 1815 by wool would have required grazing sheep on lands larger than the combined crop and pasture lands of Britain.[36]

Britain's coal deposits also helped fuel other countries, such as Denmark which made use of British coal to replace the energy obtained from its disappearing forests. In the 1760s, almost every ship which called on Copenhagen from Britain carried coal.[37] Thinking counter-factually about what would have happened had this ecological relief not come about, historian Thorkild Kjærgaard paints a gloomy picture indeed, for Denmark as well as for Europe as a whole: "an entropic nightmare" where people

> might have wandered about, shivering with cold and searching for dried cowpats to provide a little heat and with which to cook, and there might not have been enough wood to make as much as a handle. Ecological chaos would have reigned, marked by hitherto unknown degrees of sand drift [common in Denmark at the time], increasingly violent hydrological disturbances, and unmercifully decreasing agricultural production.[38]

The limits that a solar, land-based regime set for development and growth were thus replaced by a fossil-fuelled growth path which for two centuries,

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[33] Sieferle 2001:122.

[34] Sieferle 2001:107-108.

[35] Schandl & Krausmann 2007:120-121

[36] Pomeranz 2000:276.

[37] Kjærgaard 1994:120.

[38] Kjærgaard 1994:125.

combined with scientific advancement of the kind envisioned by Engels, and by the ecological relief that imports of land-based resources from the empires achieved, invalidated Malthus's forecast. However, the limits were only displaced in time and space, not dissolved; in due time they would re-appear. But in the meantime, the metabolic needs of Europe were shifted not only elsewhere, to colonial lands, but also "elsewhen", to use sociologist William Catton's innovative word, to fossil fuels.[39]

Two hundred years ago the transport capacity was far from sufficient for the enormous volumes of traded goods that the metabolic shift required, but soon new vessels, new ports, and new routes jointly enabled the import of ever-increasing volumes. This is the real significance of the construction of the Suez and Panama canals, ready for use in 1869 and 1914, respectively: they were made necessary by the speedy transition to a new metabolic regime. At the same time, in a recursive process, they facilitated and helped speed up the arrival of this new regime.

The benefits of this revolution in transport and energy in terms of greater access to crucial resources were immediate for the colonial power: India's exports to Britain of grain increased threefold 1875-1900 (from 3 to 10 million tons), and amounted by the end of the 19th century to approximately one fifth of Britain's wheat consumption.[40]

Just as the transitions in Britain from land surfaces to minerals, and from local to overseas resources, were accompanied and facilitated by a greatly increased transport capacity, the exploitation of hinterlands by cities was speeded up when railways replaced horses to become the main transporter of raw materials to the factories of the cities, and then again for distributing the produce back out of the cities.

Historian William Cronon shows this relationship for Chicago, a city which drew its life blood from a vast hinterland, criss-crossed by railways, roads, and waterways to secure its needs of raw materials, timber and cattle from the countryside. As a resident of Chicago concluded in 1893:

> Without farmers there could be no cities.[41]

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[39] Catton 1980:41.

[40] Davis 2002:299.

[41] Quoted in Cronon 1991: 97.

The logic can also be turned around: without cities, the country-side would look very different. Perhaps not a sensational insight, but nevertheless something which is frequently overlooked as witnessed by the urban historian Jane Jacobs who seems oblivious of the essential function played by a hinterland for urban growth and wealth. In her account of "the wealth of nations" – the title of her book – "import replacing" cities and city regions are essential:

> Obviously, cities good at working up export activities or drawing visitors or serving as cultural, political or religious capitals do not necessarily generate city regions. Something more than exporting or administration is required. That something more is the capacity of the city to replace wide ranges of its imports exuberantly and repeatedly.[42]

Although Jacobs correctly describes "supply regions" as akin to "colonial economies", she nevertheless believes that large countries with many cities are the key to development:

> the larger a nation and the more cities it contains, the greater the opportunities for unhindered city trade.[43]

Her ideal is cities which trade with each other, and hence big nations with many cities are better set to develop than "little city-states like Hong Kong or Singapore and small nations like Taiwan, which are inherently so vulnerable to trade barriers raised against them by other nations".[44] The "hard, plain truth", says Jacobs on the last page of her book, is that:

> Societies and civilisations in which the cities stagnate don't develop and flourish further. They deteriorate.[45]

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[42] Jacobs 1985:47.

[43] Jacobs 1985:209.

[44] Jacobs 1985:209. Jacobs here expresses doubt regarding the future of three of the most successful economic performers after World War II period, the so called Asian Tigers; the fourth "tiger", South Korea, escapes her dire prognosis, presumably because it is quite populous, with 48 million inhabitants 2010.

[45] Jacobs 1985:232.

But they do not need a hinterland: cities grow by replacing the goods they previously imported from other cities with their own produce.

In summarizing the relationship between Chicago and its supply areas, Cronon, on the other hand, stresses that disregarding the relationship with the hinterland obscures the real implication of the exchange which takes place: the urban landscape with its streets, stores and people is premised on a gigantic but "absent" – that is, invisible – country-side. What looks like urban "temples of commerce" are in fact dependent on "mausoleums of landscapes vanishing from the city's hinterland", as Cronon graphically states.[46]

A famous advertisement from the early 1900s shows this clearly, and somewhat ironically. The leading Chicago department store Montgomery Ward, the tallest building in Chicago at the time, markets itself as a "busy bee-hive", alluding to nature and industrious insects which bring goods to the city's population. But the only production premises shown in the advertisement are factories without relationship to agriculture or to any hinterland. The Montgomery Ward "beehive" is self-sustained, or so it would seem.

This is only one side of the coin, however. Montgomery Ward was not just a huge department store, it also sold its goods via mail order catalogues throughout the country, thus reaching out to the hinterland that its advertisements neglected. Cronon visualizes "millions of families around the country with dog-eared [Montgomery] Ward and [the competing] Sears catalogues sitting at their kitchen tables [holding] innumerable dinner table conversations about possible purchases" and concludes that we stand in front of "a landscape of obscured connections":

> The ecological place of production grew ever more remote from the economic point of consumption, making it harder and harder to keep track of the true costs and consequences of any particular product.[47]

But it was not only the origin of the inputs which was hidden, also the disposal of waste remained obscured, and the full extent of the flows which

[46] Cronon 1991:263.

[47] Cronon 1991:340.

pre-condition the existence of cities are hidden from view. The nature of the situation is well captured by the case of Hong Kong.[48]

A small land area with high population density and an impressive industrial capacity, Hong Kong, even before becoming part of China, draws on land areas and water-based resources of the Chinese mainland and the ocean waters surrounding it, sourcing its needs and depositing its waste outside of its borders, including in the global commons (the sea and the atmosphere). In this way, Hong Kong "occupies" 220 times its own surface in order to secure the renewable resources it consumes in one year; if we add the hypothetical land area needed to absorb the carbon dioxide emissions of Hong Kong, then its total "ecological footprint" is more than 300 times larger than its land area.[49]

Concluding remarks

The perspective of the metabolism of cities, such as Hong Kong, and of individual companies, such as Montgomery Ward, can also be applied to countries, and looking at societies as socio-metabolic regimes has, at least since the days of Karl Marx, been a fruitful way to understand the relationship economy-nature: agrarian and industrial economies show systematic differences between what may be termed land-based agrarian and fossil-based industrial regimes. The differences are consequential, as can be seen from Table 1.2.

[48] See Newcombe et al. 1978, Boyden et al. 1981, Warren-Rhodes & Koenig 2001. Prior to this, engineer Abel Wolman, renowned for having initiated the chlorination of drinking water in Baltimore and a number of American cities, argued in the mid-1960s that cities must become aware of their metabolism in order to control and diminish the pollution they cause their hinterland. Wolman described a typical US city of one million inhabitants as point of exchange with its hinterland, both as a source of its needs of water, food, and fuels, and as a sink for its sewage, emissions, and waste. See Wolman 1965.

[49] Boyden et al. 1981:115-119, Warren-Rhodes & Koenig 2001:349.

Table 1.2. Socio-ecological metabolic regimes compared

	Agrarian	Industrial	Difference Industrial/Agrarian
Population density, cap/km^2	<40	100-300	2.5-8
Material use/t/cap/yr	2-5	15-25	3-12
Energy use/GJ/ha/yr	20-30	200-600	7-30
Biomass energy share, %	95-100	10-30	0.1-0.3
Fossil fuel energy share, %	0-5	60-80	12-80
Material use t/ha/yr	1-2	20-50	10-50

Sources: Fischer-Kowalski et al. 2007, Table 8.1, and Krausmann et al. 2008, Table 1.

While the industrial metabolic regime uses 3-12 times as much material per capita as the agricultural regime, and 7-30 times as much energy per hectare, and while its fossil energy share is 12-80 times as large, its dependency on biomass energy is 3-10 times *less* than in the average agricultural regime.

The explanation for these differences, as I have argued, is that fossil fuels were substituted for land-based resources, thus avoiding that land restricted further capital accumulation and economic growth. This new industrial regime has by now spread also to regions of the global system which until recently were dominated by the agricultural mode. The impact in terms of global flows is staggering, see Figure 1.2.

All in all, the global material flows – construction minerals, ores, fossil fuels and biomass – have multiplied by a factor of six, from less than 10 billion tons in 1900 to 60 billion tons by the early 2000s. In absolute terms, also biomass use multiplied, although it has lost the dominant position it occupied in 1900. Furthermore, the rate of growth is impressive: in 1990 the total material flow was 42 billion tons, and it grew by as much as 40 per cent to reach 60 billion tons in only fifteen years.[50]

[50] UNEP 2011:10-11.

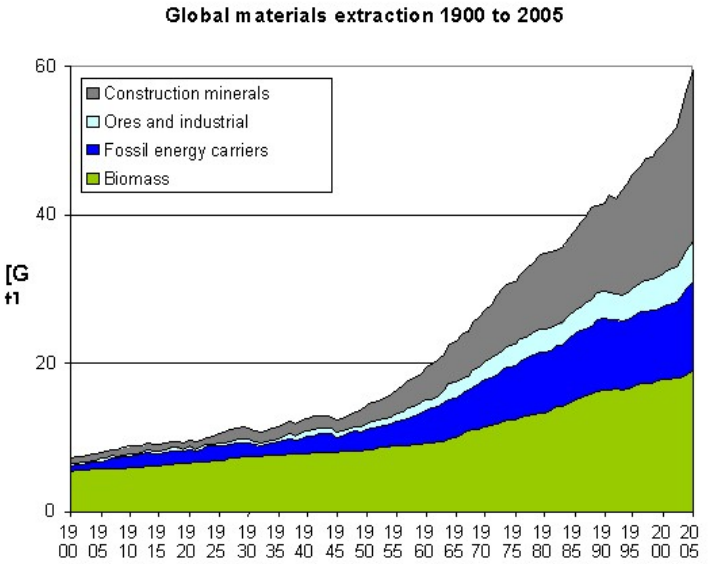

Figure 1.2. Global materials extraction 1900-2005, billion tons
Source: http://www.uni-klu.ac.at/socec/bilder/global_materials_extraction_gross.jpg

My assumption regarding the twin peaks of oil and soil implies that land areas and land-based resources are re-emerging as essential strategic resources, thus becoming of concern to the wielders of political, economic and military power, be they countries, national and international institutions, or corporations.

This means that we are entering a new phase where the absent aspect (to use Cronon's term) of the metabolism of economies is giving way to a situation where ever more open attention will be dedicated to land areas, land-based resources and raw materials in general. As Alexander Haig testified already in 1980 to the US Congress, "the era of 'resource wars' has arrived".[51] In this perspective, growing conflicts over land areas and land-based resources are to be expected.

[51] Quoted in Klare 2002:236. At this time, Haig had left his position as chief commander of the NATO forces but had not yet been appointed Secretary of State by Ronald Reagan.

To military analyst Michael Klare, Haig's welcoming of the opportunity to go to war is reminiscent of previous US imperial strategies. The difference, says Klare, is that the resources which are considered strategic today include water and timber, in addition to oil.[52] With the increasing likelihood that we have reached peak oil, and taking climate change seriously, I would add agricultural lands in general to the list of strategic resources, the land areas needed to produce food, feed, fibres, and fuels. After all, even soldiers are dependent on land areas for their metabolic needs.

There exists a terrifying historic parallel here: the dependency upon land areas and land-based resources opens the door to some of the most dreadful experiences of hunger and starvation in the history of mankind. In the late 19th century, large-scale famine was caused by the subordination of local needs to the metabolic requirements of the imperial power, Great Britain. The outcome was a death toll estimated at 30-60 million people in famines in India, China and Brazil in 1876-1879 and 1896-1900.[53]

At the same time, however, exports of grain continued to Britain, as we have seen; however, had the grain exports from India to Britain in the midst of frightful mass starvation not taken place, 25 million people could have been saved.[54]

Today's race for land areas and land-based resources portrays a situation which is not all that dissimilar: a growing appropriation of land by a complex made up by international financial institutions, states and transnational corporations, at the same time as many countries of the South have been robbed of state capacity and have no reserves to protect their own populations, had they been so inclined. They are harvesting a couple of decades of neo-liberal policies after the debt crisis of the 1980s with privatization and commoditization of land areas and land-based resources.

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[52] Klare 2002:7.

[53] Davis 2002:7. The earth's population in 1900 was 1.7 billion people; today, with a global population of seven billion, the equivalent number of victims would amount to as many as 126-241 million people.

[54] Davis 2002:310.

2. Land Use Scenarios for Agrofuels and Nine Billion People

Forecasting a growing importance of land-based resources has become more common today, as we have witnessed a new pattern of price movements for raw materials in general and food in particular during the last decade. It started four years into the 21st century when food and primary commodity prices began to rise almost vertically, and it appeared at first to culminate in 2008, when they reached their highest level since the oil price hikes of the mid-1970s.[55] See Figure 2.1.

Both curves, in nominal terms (orange) and deflated by industrial prices (yellow), portray the same trajectory. Following the financial crisis of 2008, food prices plummeted as expected, but already a year later, they began climbing again, reaching, and then surpassing the 2008 pre-crisis record level as early as 2011.

This was surprising: for almost 50 years, food prices had been low and stable, with the 1970s a brief exception to the general downwards-sloping trend. As of now, however, a reversed tendency appears to be establishing itself.

These are short-term price movements, of course, and not essential to my argument which is long-term and structural, but I do believe they herald a new phase of dependency on land areas and land-based resources.

[55] See UNCTAD 2011.The raw materials price index reached approximately 225 in 2008, but although it had more than doubled in just a few years this was still not enough to match the level of the mid-1970s when it hit approximately 340. Index 2000 = 100.

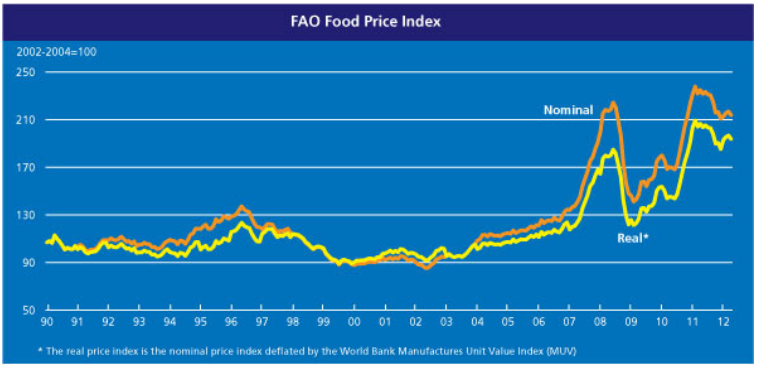

Figure 2.1. Food price index 1990- 2012
Source: http://www.fao.org/worldfoodsituation/wfs-home/foodpricesindex/en/. Index 2002-2004 = 100. The graphs end by April 2012.

Drivers behind the new price trend

The causes behind the price movements of the early 21st century are contentious and no consensus as to the respective importance of the various drivers has been reached. One contentious issue has been what importance to attribute to the growth of land areas dedicated to agrofuels in Brazil (sugarcane ethanol), USA (maize ethanol), and the EU (rapeseed biodiesel), just to mention the largest producers. These agrofuel areas compete with land for food for humans, directly (grains) or indirectly (soy and corn for animal feed). In the US, the share of the maize harvest used for ethanol was 30 per cent, while the part of rapeseed going to biodiesel in the EU was as high as 60 per cent.[56] Important land areas, certainly, but *how* important is not easy to say as many equally influential factors were at play.

In addition to the increased use of land for agrofuel production, droughts were recorded in major producing countries like Australia; simultaneously, oil prices rose vertically, reaching 140 USD a barrel in 2008, all of which prompted a growing number of speculative contracts for food and feedstocks which pushed prices ever higher. Add to this the

[56] v Braun 2008.

increasing demand for food and meat from a wealthier and more numerous world population, and anything but steep price rises would have been surprising.

Perhaps the combination of low stocks and speculation in food and other land-based resources was particularly problematic. The global stocks of the main cereals – rice, wheat, and maize – had been going down: in 2001/02 they stood at close to 600 million tons; by 2003/04, they had fallen to a little over 400 million tons, and this dangerously low level was repeated in 2006/07 and 2007/08.[57]

Add to this a speculation surge in agricultural and other primary commodities, which can be traced back to the early 1990s when Goldman Sachs as the first of the major global bankers started selling a new "product", the Goldman Sachs Commodity Index Fund. As other banks and finance institutions followed suit, the "business segment" exploded from 13 billion USD 2003 to 317 billion USD 2008, a 24-fold increase in just five years. Then the crash hit, and the forecasted growth of this "instrument" into the trillion dollar bracket had to be postponed.[58]

Given this complexity, allocating shares to the respective factors is better left undone, but the literature is nevertheless awash with statements targeting one or the other of the various drivers, with a special penchant for the role of agrofuels, the newest addition to the demand-pushers. At one extreme, agrofuel production is seen as the main culprit behind the price increase, much more important than any of the other drivers. While the impact of higher energy prices (on fertilizer prices and transport costs) is held responsible for only 25-30 per cent of the total food price increase by an influential World Bank report, "most of the remaining 70-75 per cent increase in food commodities prices was due to agrofuels".[59] Other factors, for instance the export bans which were imposed by some exporting countries in order to prevent food riots and improve the local availability of food, were seen as secondary consequences caused by the growth of agrofuels.

At the opposite end of the spectrum, the agrofuel lobby plays down the role of fuels by calling it "only one among a myriad of factors that drove up

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[57] See FAO Cereal production, utilization and stocks, http://www.fao.org/worldfoodsituation/wfs-home/csdb/en/.

[58] Kaufman 2010:27, 32.

[59] Mitchell 2008:17.

commodity prices".[60] Although this perspective just as the previous one takes note of the plethora of contributing factors, their relative weights are inverted: agrofuels are now seen to be insignificant. In a similar vein of argument, Monsanto, a major food and agrofuel corporatoin, maintained that "grain shifting to the production of biofuels represents only a small part of increased food prices", while the major responsibility rests with the rising cost of oil. In a web-comment, Monsanto concluded:

> there is virtually no connection to biofuels and these unfortunate shortages around the globe.[61]

The International Food Policy Research Institute opted for adducing a responsibility of 30 per cent of the food price rise to agrofuels, mostly on account of the toll that ethanol took on the supply of maize in the USA.[62] This relative weight for agrofuels has become standard by now. For instance, the FAO, after reviewing the literature, concludes that there is no consensus about the impact of agrofuels but nevertheless maintains that they have contributed 30-40 per cent to the upswing for internationally traded maize, and "somewhat less" for other basic commodities.[63]

There are in fact so many factors involved here, that attributing the relative share to the various drivers for the rise in food prices is not possible with a reasonable degree of certainty. Several studies testify to this and simply conclude that the picture is complex, that many factors are at play simultaneously, and that it is best not to be too sure about the impact. In other words, no-one really knows. Still a recent analysis of the price hike concludes, as confidently as all the others, that speculation "played a key role" while it found "no evidence" for a link with stronger demand from China and India, and only "some role" for agrofuels.[64]

China's role for the price trend has been misconstrued, however. Although it is true that China was not overly dependent on the imports of

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[60] Garten Rothkopf 2009:498.

[61] See "Monsanto´s Biofuel Story. Food and Fuel: It's not an 'either/or' equation", www.monsanto.com/monsanto_today/for_the_record/biofuels.asp. Accessed 2009-12-24, later deleted from Monsanto's website.

[62] v Braun 2008:5.

[63] FAO 2009:5.

[64] See Baffes & Haniotis 2010:18.

cereals prior to the 2008 price rises – in fact China, and India, were net exporters of cereals during the three years leading up to the price spike, 2005/06-2007/08[65] – it nevertheless had become one of the major importers of agricultural products (not just food) by the end of the decade. At the same time, the US surpluses sold on the global market decreased significantly. Thus, although China and India probably did not create the price rise of 2004-2008, China may be responsible for keeping prices up.[66] I believe that these two trends taken together – the increase in demand from China and the diminution in the supply from the US – will be the main drivers for the future.[67]

My central concern, however, is not to allocate exact percentages to the various factors pushing prices upwards, but to consider the inter-connectedness of markets and of land uses. The reason is that there exists a large degree of substitutability among feedstocks for similar or competing purposed, maize and soybean are used for human consumption, as animal feed and as feedstocks for fuels (ethanol and biodiesel, respectively); sugarcane is used as sweetener as well as for ethanol; rape seed and palm oil are used for biodiesel and as inputs to the food industry. This reinforces the point I made at the outset about the fungibility of land: not only is land fungible but agricultural feedstocks have substitutable uses, further strengthening the fungibility of land.[68]

Therefore, a change in one feedstock has a tendency to impact land areas dedicated to other crops, and such spill-overs affect production and cultivation also in neighbouring countries and overseas. What we are witnessing, then, is not only increases in the price of food and other land-based resources, but, more importantly, the integration of a number of interdependent markets.

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[65] FAO 2009a:18-19.

[66] See WTO International Trade Statistics 2009, 2011, Table II:15.

[67] This is also the opinion that the FAO belatedly has come around to: while it in 2009 held that China (and India) had nothing to do with the price rises of food and agricultural products of the preceding year, it later concluded that two developments jointly share the responsibility: the increase in imports to Asia, and the levelling off of exports from North America as of 2007. See FAO 2009a:19 and FAO 2011:75, respectively.

[68] While money is perfectly fungible, land is less so: depending on quality and climate, a certain land area is more or less easy to substitute for any other area. But the fact that land is not perfectly fungible should not lead us into disregarding its relative fungibility.

Consider the impact of using US maize to produce ethanol for the US market: as maize is diverted from animal feed to produce ethanol, American hogs must be fed by other products, for instance by importing maize from Argentina, the second largest exporter after the US; and when soybean production in Argentina is turned over to produce biodiesel, the global food industry may be stimulated to look for substitutes from palm oil plantations in Indonesia and Malaysia – and vice versa if biodiesel plants use Asian palm oil as feedstock; or when Brazil enlarges the land areas planted with sugarcane and soybean, Brazilian cattle ranchers may be pushed onto new lands, inside and outside of Brazil. Put another way, what may appear to be independent land use changes are in fact a series of linked events, one alteration of land use leading to the next.

Allocating responsibility for price movements to individual drivers in this situation risks missing the inter-dependencies: a movement in one market may cause significant knock-on effects in various other markets. Focusing on deciding which of the many factors at play here is the most important force in pushing up the prices of food and primary commodities may hide the real issue: the centrality of land-based resources to the global socio-ecological metabolism today, and still more in the future.

Agrofuels and land use scenarios: How much is possible?

The focus on agrofuel as driver of food price movements should be seen against the background of the recent surge of studies set out to assess the potential of agrofuels to replace fossil fuels. The point of departure for such studies is not that biomass and agrofuels today play an important role in the global fuel system, they do not. Biomass as a whole accounts for 10 per cent of global energy use, and out of this only 2 per cent is used as liquid fuel for transport. See Figures 2.2 and 2.3. Why spend so much attention on something which is two per cent of ten per cent, i.e. two pro mille, of global energy use?

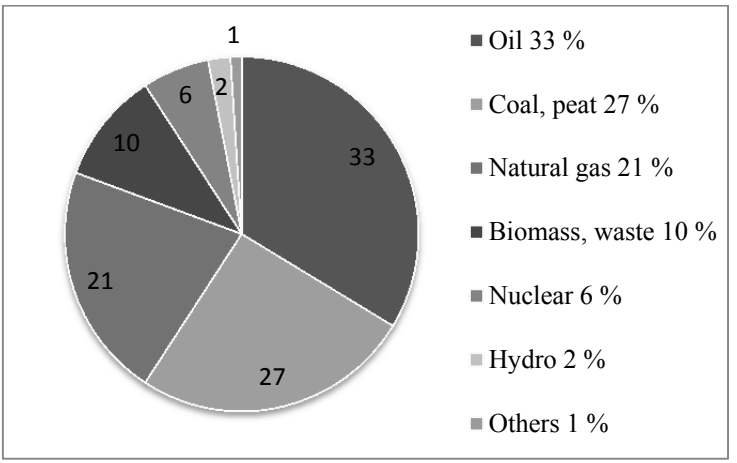

Figure 2.2 World Energy Supply 2009, %
Based on IEA 2011a:6.

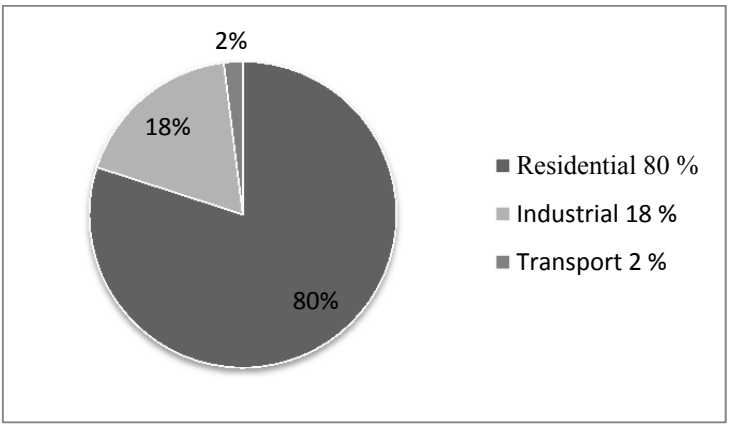

Figure 2.3. Global use of biomass for energy c 2000, %
Based on FAO 2008:11.

The interest in agrofuels has not been driven by climate or ecological concerns primarily, but by geopolitical considerations. The present phase of agrofuel expansion began in Brazil in the mid-1970s as the military government initiated the Pro-Álcool – pro-alcohol – programme in order to increase its energy independence and reduce import costs in the aftermath of the oil price increases 1973-1974. Similarly, the US Congress mandated in

2005 in the Energy Independence and Security Act that 137 billion litres of agrofuels be sold on the US market by 2022 – twice the global production of ethanol today. Hence, geopolitics is at the core of today's craving for agrofuels, a situation which the arrival of peak oil cannot help but reinforce.

In addition, the ongoing negotiations on a new (or prolonged) agreement to curb climate change have contributed to propelling agrofuels into the foreground of the environmental debate as the climate negotiations increasingly are focusing emissions from agriculture and forestry, which together accounted for 26 per cent of global GHG emissions in 2005, almost as much as transportation and industry combined.[69]

Put differently, the environmental acceptability of expanding land use is as limited as of using fossil fuels; to repeat, peak oil is now concomitant with peak soil. But if agrofuels can be portrayed as climate neutral, this land-based resource becomes of key interest to a transition to a post-fossil energy system, and the only remaining issue is how much of the stuff can be produced.

Against this background, the many studies to gauge the global agrofuel potential which have appeared recently make sense. But these assessments, based as they are on wildly different assumptions, arrive at wildly diverging outcomes. For instance, which feedstocks should be the mainstay of agrofuel production in the scenario? The choice will decide the result in terms of reduced dependency on fossil fuels, GHG balance, production volumes, geographical location of agricultural lands as well as possible conflicts with other land uses, deforestation, etc.

Enter the Review article, where a number of individual studies are summed up, more often than not leading to the conclusion that the "truth" is somewhere in the middle range of the reviewed studies.[70] The average values thus have a tendency to be classified as reasonable, while in fact many of the studies are unrealistic and not to be taken seriously, other than as an indication of how eager the pro-agrofuel interests are to inflate the potential of the respective promoted feedstocks.

The analytical merry-go-round does not stop here. When political decisions are imminent, there is the need to once and for all decide what "science" tells us about the potential of agrofuels. Since social and natural

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[69] See World Resources Institute, http://www.wri.org/image/view/11147/_original.

[70] See for instance Berndes et al. 2003, who cover 17 studies of the potential contribution of biomass to global energy supply, and Haberl et al. 2010, summarizing 10 studies.

scientists have presented different guestimates, and since they then have summarized their own or their colleagues' studies in terms of wide spans of probabilities, the final word to guide decision-makers goes to "independent" consultants who do not have any axes to grind (or so it is assumed).[71] Just as in so many review articles, the consultants do not attempt to distinguish good from bad estimates, and the wide spans are replicated.

As time presses on, finally, international organisations such as the FAO, UNEP, the World Bank and the IPCC feel the need to rule on which feedstocks are the best, how GHG emissions are to be computed, which direct or indirect land use changes should be included. This is intended to lay the ground for global politics, and also to open up for agreeing on norms for certification.

At the same time, and feeding this flood of studies, reviews, assessments and summaries, natural scientists are eagerly devising new, better, more efficient feedstocks and processes. From first generation ethanol, based on sugarcane and maize, there is increasing talk of second generation (based on cellulose, opening up the prospect of using fast growing species, grasses and residues from forestry), and even third generation agrofuels (based on algae), all of which, of course, will lead to further studies.

Three approaches to the study of future land use

At the end of the 1990s, a number of worrying studies were presented which echoed the re-emergence of the Malthusian perspective on the significance of limited land-based resources. The reports highlighted the difficulty to produce enough food for a growing world population which also was becoming wealthier, leading to a diet of more animal products and more calories.[72]

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[71] An example here is the influential Gallagher Review of the Indirect Effects of Biofuels Production 2008, commissioned by the British government from the Renewable Fuels Agency, which in turn commissioned a number of sub-studies from consultancy firms.

[72] See Dyson 1999, Pinstrup-Andersen et al. 1999, Daily et al. 1998, and Brown & Kane 1995.

What is striking when you read these accounts today is that they totally missed to foresee the role that agrofuels would play in the scenario-constructions which have appeared since, the first ones just a few years later.

While these late 20th century forecasts do account for food supply bottlenecks related to decreasing agricultural yields, and while they do factor in growing populations and new consumption and dietary patterns following upon economic growth, they do not even mention the prospect that new demands on agricultural lands may be forthcoming to produce liquid fuels.

Still more alarming is that the FAO today continues to focus on the use of land for food production, neglecting other competing uses, leading to a serious under-assessment of the needed land areas. In one of its most influential studies during the last decade, the FAO estimated the demand for food and meat production to increase (in volume) by 50 and 85 per cent, respectively, by 2050 (compared to 2005/07).[73] Add to this the equally growing demand for fibres and fuels and the seriousness of land constraints should be clear.

To deal with all of these conflicting demands on the same land areas, producers of agrofuel scenarios have used three different approaches to frame the discussion about the global potential: forecasting, backcasting, and fantasies.

Forecasting: How much agrofuels can be produced?

One frequently asked question is: how much agrofuels can be produced globally? When reviewing the discussion around this issue, the United Nations Environment Programme (UNEP) gives a surprisingly large span, 40 – 1100 EJ (or 28 times), and then arbitrarily settles for somewhere below the middle of the range, 200-400 EJ (see Table 2.1). The reason for such a wide span is the varying assumptions and estimates that the underlying studies build on, and the scaling-up effect when such differences are extrapolated to the whole globe, and projected into the future.

[73] Bruinsma 2009:5. The frequently quoted FAO figure which states that food production needs to increase by 70 per cent by 2050 is expressed in value terms, not in volumes; it is the latter which is most relevant to my concern, the global competition for limited land areas.

Table 2.1. Global potential of biomass for energy 2050, EJ/year

Biomass source	Potential span	"Realistic" span
Energy farming on current agricultural land	0-700	100-300
Biomass production on marginal land	60-110	
Residues from agriculture	15-70	
Forest residues	30-150	
Dung	5-55	
Organic wastes	5-50	
Total	**40-1,100**	**200-400**

Source: UNEP 2009:40. EJ = exajoule = quintillion joule (18 zeros) = billion billion joule. Note that the figures are for all energy uses of biomass, not only agrofuels.

The actual global supply of energy (from all sources) is approximately 500-600 EJ. The upper bound for biomass by 2050 in Table 2.1 – 1,100 EJ – is thus immensely optimistic, implying that twice the total available energy today could be coming from biomass alone, requiring a twenty-three fold increase of biomass energy (which was 48 EJ in 2005). UNEP's more modest assessment of the potential, 200-400 EJ, is still impressive, implying an increase by 4-10 times of today's global production of agroenergy by 2050.[74]

Estimating the biomass *potential* is only the first step when elaborating a scenario for the *actual* production of agrofuel. Against the background of the optimism informing the estimates of Table 2.1, agrofuel production scenarios could have been expected to yield equally exuberant pictures but although there are such examples, mostly from the agrofuel industry and its consultants, more sombre scenarios dominate. Typical here is the FAO which foresees fast growth of agrofuels but still of a more reasonable kind: agrofuel volumes will double by 2015, and then double again by 2030, going from 2 to 3 per cent of total liquid fuels.[75]

Summing up: impressive growth rates for agrofuels but still not enough to make a major impact on the dependency on fossil fuels. What we find, then, is a paradox: on the one hand, agrofuels are simply too small to play a major part in the postulated metabolic regime shift from fossil to renewable

[74] Also this range may be overoptimistic, at least according to a more recent study which set the global agrofuel potential to "only" 210 EJ (with a span of 160-270 EJ), a comparatively modest assessment but still four times today's figures. See Haberl et al. 2010:399.

[75] This is based on the assumption that total transport fuels also will grow, albeit at a slower rate. See FAO 2008:44.

energies; on the other hand, the expansion of agrofuel feedstocks will have important consequences by competing for land which today has other uses. The substitutability of land used for food, feed, fibres, and fuels means that increasing agrofuel production will immediately impact other uses, leading to direct and indirect land use change all along the supply chains.

Backcasting: How much agrofuel is needed to meet blending requirements?

The second approach is in one sense more realistic, as it takes its point of departure from the mandatory blending requirements already decided. All over the world, in the South no less than in the North, such blending requirements are already in place. See Table 2.2.

The trend is global with India mandating 20 per cent ethanol and biodiesel by 2017, and China 10 per cent (in nine provinces), but the most important mandates are the requirements of the US to sell 137 billion litres of agrofuels by 2022, and the EU target of 10 per cent renewables by 2020.[76] Backcasting from such mandates we arrive at the volumes that need to be produced somewhere on the globe. See Table 2.3.

The assumption underlying Table 2.3 – not very convincing – is that the total need will be supplied by one feedstock alone. But the results are nevertheless worth pondering: even modest blending requirement of 10 per cent would entail a very strong demand for agricultural land areas.

Are the land areas of Table 2.3 large or small? The answer depends on what you compare them to: compared to the crops in question they are very large, but compared to the global cropland area – 1.5 billion hectares – even meeting a ten per cent blending requirement from one feedstock alone does not seem an impossible proposition. Consider for instance using sugarcane to meet the total need: its land area has to increase by 350 per cent, not an impossible proposition given the rather small land area globally planted with sugarcane, 20 million hectares.

[76] REN 2011, Table R12, and IEA 2011:Table 1.

Table 2.2. Current and future blending targets and mandates

Country/Region	Current mandate/target	Future mandate/target
Argentina	E5, B7	
Australia	New South Wales E6, B5	
Bolivia	E10, B2.5	B20 2015
Brazil	E20-25, B5	
Canada	E5, B2	
Chile	E5, B5	
China	E10 9 provinces	
Colombia	E10, B20	
Costa Rica	E7, B20	
Dominican Republic		E5, B2 2015
European Union	5.75 % biofuels	10 % renewable energy in transport 2020
India	E5	E20, B 20 2017
Indonesia	E3, B2.5	E5, B5 2015; E15, B20 2025
Japan	500 Ml/year	800 Ml/year
Kenya	E10 Kisumu	
Korea	B3	
Malaysia	B5	
Mexico	E2 Guadalajara, Monterrey, Mexico City	
Mozambique		E10, B15 2015
Norway	3.5 % biofuels	
Nigeria	E10	
Paraguay	E24, B1	
Peru	E7.8, B5	
Philippines	E10, B5	
South Africa		2 % 2013
Taiwan	E3, B2	
Thailand	B5, 3 Ml/day ethanol	9 Ml/day ethanol 2017
Uruguay	B5	E5 2015
USA	48 Gl ethanol	137 Gl ethanol 2022
Venezuela	E10	
Vietnam		50Ml biodiesel, 500 Ml ethanol 2020
Zambia	E5, B10	

Source: IEA 2011, Table 1. E2 = 2 % ethanol blend; B2 = 2 % biodiesel blend. Ml = million litres, Gl = billion litres

Table 2.3. Land area required to meet 10 % blending requirement by 2030 in million hectares and %

	Palm Oil	Soybean	Maize	Sugarcane	Sorghum
Land area needed, Mha	48	361	147	70	116
Global crop area, Mha	41	91	145	20	45
Share of crop area required for agrofuels, %	117	396	101	350	258

Sources: Ravindranath et al. 2009:121, USDA 2009, and FAO 2008. Mha = million hectares.

Fantasies. What if we move people and agriculture around as we please?

Thinking about the future in this way may be too cautious; in the light of the task that is set before us by "peak oil", we should ask the really dramatic question: "How much land do we need to do away with the global use of petrol?"

This is a tall order – remember that agrofuels today only account for two per cent of liquid fuel use – so we had better contemplate using all available feedstocks, irrespective of their yields, thus also including feedstocks that today normally are left out of the discussion because of their alternative use (such as wheat and rice). How much of today's petrol could then possibly be replaced by ethanol? See Table 2.4.

Table 2.4. Ethanol potential and share of today's global petrol use

Feedstock	Global land area today, Million hectares	Potential ethanol production, billion litres	Share of global petrol use, %
Wheat	215	205	12
Rice	150	271	16
Maize	145	284	17
Sorghum	45	22	1
Sugarcane	20	91	6
Cassava	19	39	2
Sugar beet	5	27	2
Total	**599**	**939**	**57**

Source: FAO 2008, Table 3. Total crop land is 1 500 Mha.

By using as much as 599 million hectares – 40 per cent of the global crop land – we would still only replace 57 per cent of today's petrol use. But then *all* of the land areas dedicated to the world's major food crops – wheat, rice and maize – would be occupied by feedstocks for agrofuels, and the world's food needs would have to be grown somewhere else, a clear conflict fuel – food.

Although these scenarios may look like far-fetched games, the truth is that such fantasies are presented as serious, science-based inputs to the discussion of the future energy system of the planet. Here, the so called scientific community is playing a shady role, legitimating abstract thinking and encouraging disregarding potential large-scale transfers of land. Take the idea that food production ought to be carried out where the preconditions are the best globally. The reason for this mind game is that the actual food production pattern today is less than "ideal", and researchers and think tanks suggest in earnest a transfer of agricultural production from today's "suboptimal" land areas to land where yields are higher. This means basically concentrating food production to high-productive regions which are "under-used" today (especially "under-used" are Russia and Eastern Europe in this view), while liberating low productive land from the need to produce food; here, Africa is explicitly targeted as a future provider of agrofuel feedstocks.

After such a transfer of agriculture from low to high productive regions, the food production system will attain a greatly increased area-efficiency and needed crop lands will be considerably reduced. But I am understating the dramatic conclusion; listen to the result of one such elaboration suggesting to "optimize" agriculture globally:

> Results indicated that the application of very efficient agricultural systems combined with the geographic optimization of land use patterns could reduce the area of land needed to cover the global food demand in 2050 by as much as 72 per cent of the present area.[77]

The choice of words is not innocent. A total remake of the global agricultural land use – suggesting land use change on 72 per cent of the areas used today, presumably doing away with the food sovereignty of more than a billion people – is called "geographic optimization". And the land areas thus

[77] Smeets et al. 2007:56.

cleansed (my use of a loaded word) become in the next step following this logic ”surplus agricultural land”, a notion that holds out the promise that nobody will be hurt if over two thirds of present agricultural lands are freed in order to be turned over to the production of agrofuel feedstocks.

In a similar study we are encouraged to do away with the “constraints on localizing agricultural production” that we have inherited from the past, to “think outside the box” and shift agricultural production to the land areas where productivity is highest; the approach taken is called "globalized production". The conclusion, just as in the previous study, is that the land areas needed to feed the planet could be substantially reduced. In this scenario, the land saving potential is even higher – 85 per cent – as “globalized production” is calculated to only need 15 per cent of today’s crop land to produce food for the whole planet; the remainder is thus freed and could be made available for agrofuels, a truly stunning result.[78]

Of course, people still have to eat, but this may be arranged by transporting food from the high-producing surplus land areas to the deficit land areas. That we are dealing with fantasies here is evident from the fact that the “globalized” land use pattern is based on assuming “an unrestricted global market (no trade barriers, no transportation costs, no subsidies)”;[79] but such unreal assumptions are needed if you are to construct a scenario where everybody’s food as well as energy security is based on, and presupposes the possibility of, exchanges over large distances and across national borders.

Behind the term “globalized production” we find a redistribution of land use for the production of food, feed, fibres, and fuels for a global market. Food will be produced in North America, Europe, and the former Soviet Union, while Africa and Latin America will concentrate on producing feedstocks for meat and agrofuels.

Although this scenario is called “global” it advocates monopolization of food production in the North, thus offering a powerful resource weapon which, among other objectives, could be used to secure a continuous flow of agrofuels from the South. In case of non-compliance by feedstock producers such as Argentina (soybean), Brazil (sugarcane, soybean), Mozambique (sugarcane), and Indonesia (palm oil), the food arm – the withholding of food exports to deficit countries – could be used to bring recalcitrant feedstock suppliers in line. In this way, these scenarios unexpectedly,

[78] Müller et al. 2006:1 and Table 5.

[79] Müller et al. 2006:5.

considering their unreal assumptions, do show geopolitical realism by justifying displacing food production, and the power that go with it, from the South to the North.

Global scenarios of this kind assume the existence of docile suppliers of feedstocks in exchange for food imports which they need to provide for their own populations. To repeat, such exercises are not innocent, they play an important role in legitimizing thinking (first) and acting (later) to secure the land areas and the land-based resources that powerful interests need in order to secure their own socio-ecological metabolism. Thus, to me, scenario fantasies such as these are indications that the strategic interest in land areas is shifting.

The "scientific community" is obfuscating the geopolitical aspects arising from, and the power struggles surrounding such grand transformations of land use. Instead, arguments and scenarios are frequently discussed as if there were no conflicts or contradictions in overcoming the global resource constraints of limited land areas and land-based resources. A case in point is the argument that was presented in the guise of a state-of-the art report to the UNFCCC climate conference in Copenhagen 2009, COP 15.[80] There are no conflicts regarding climate change and climate policies which cannot be overcome if only politicians would listen more to scientists, the International Alliance of Research Universities claimed:

> Science needs to demonstrate (i) what an 'optimal' land-use pattern might look like; (ii) that this pattern would warrant the generation of sufficient quantities of the desired functions and resources; and (iii) which socio-political strategies can realise the envisioned transformation in good time.[81]

[80] Richardson et al. 2009. The cover of this "synthesis report" lists the following members of the International Alliance of Research Universities: Australian National University, ETH Zürich, National University of Singapore, Peking University, University of California-Berkeley, University of Cambridge, University of Copenhagen, University of Oxford, University of Tokyo, and Yale University.

[81] This quote is from a contribution to the synthesis report by Hans Joachim Schellnhuber and Veronika Huber of the Potsdam Institute for Climate Impact Research. See Richardson et al. 2009:35.

The "scientific community" labelled this approach "visionary" and expressed its wish to

> consider a novel global division of land-use activities that would significantly improve the geographical pattern of food and fibre production, biodiversity protection, infrastructure and energy generation.[82]

Again, note the choice of words: science, optimal, functions, visionary, novel, improve. In fact, the "scientific community" had based its visionary ideas on the fantasies of researchers who dream of a world without history, without conflicts and contradictions over land, and without power struggles.

Fantasy check: How many vegans can the Earth stomach?

Although scenarios of future agrofuel production, as we have seen, customarily are based on extremely unrealistic assumptions, most of them nevertheless fear to enter the topic of dietary change: reducing meat consumption is an option which is left out of many of the scenarios considered.

Even when the importance of life style changes is recognized in principle, such aspects are nevertheless not included in the "realistic" scenarios. Thus, in a state-of-the-art review of agrofuels and land availability, commissioned by the influential Gallagher commission, the consultant simply skips the whole issue:

> As we do not consider the vegetarian and affluent diets to be very realistic for 2020, we simply discarded these results in the analysis here.[83]

The international NGO Oxfam recently launched a campaign to cut hunger in the world without considering the varying demands on agricultural lands of different diets: no conflicts pitting meat consumption for the global middle class and agrofuels for their cars against the basic food rights of poor

[82] Richardson et al. 2009:34.

[83] CE Delft 2008:11-12.

people were recognized in spite of the fact that a reduction of meat or agrofuels could free large land areas for the production of food for millions of people. Oxfam does recognize that meat consumption appropriates much more water and space per kilo or calorie than grains, but nevertheless avoids the obvious conclusion from such well-known facts, preferring to stick to a traditional distributional perspective: if food was distributed equally, no-one would go hungry.[84] Perhaps Oxfam simply was afraid to play "the meat card" and take on powerful opponents of the global north, the global upper and middle classes, who can be assumed to cherish their right to eat meat and drive cars.

But more daring scenarios may be devised when life-style changes are factored in: assuming more sustainable dietary patterns has dramatic consequences for land use, and hence for the availability of land, which in turn spills over to the question of potential conflicts over land.[85] Meat is here the crucial issue. It has been estimated that 350 million hectares of today's croplands are used to produce feed for animals, approximately one fourth of the total cropped area.[86]

I will present an attempt to measure the potential for agrofuels in a context of life style changes. I take as my point of departure the forecasts for population growth and calorie development published by the relevant UN agencies, and then I see what happens with the required land areas if we simultaneously change our food and feed production to the maximum area-efficient agriculture I have found in the North, that is a high-tech, mechanized, high-input system.[87] Since I am elaborating my scenarios in the context of the double peak for oil and soil, I only use the 5 billion hectares which already today are being cropped and grazed. After providing for food for the global human population in such an area-efficient production system, I then ask what land areas will be available for producing agrofuels.

From this it should be clear that I proceed in the opposite order from the one we came across in the previous scenarios: instead of focusing on the potential for producing agrofuel feedstocks, I will calculate the land areas of today's crop and pasture lands which could be made available for such

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[84] See Oxfam 2011:66 and Figure 3.

[85] Scenarios which include diet change have been elaborated by Wirsenius 2003, Hoogwijk et al. 2003, Müller et al. 2006, Erb et al. 2009, Wirsenius et al. 2010, and Foley et al. 2011.

[86] Foley et al. 2011:338.

[87] See Appendix to this chapter for details.

feedstocks *after* discounting the land areas required to meet global food needs. The results are presented in Table 2.5. The first two scenarios deal with the situation in 2010, that is, today; the three following scenarios are elaborated on the assumed global population, calorie regimes and diets for 2050.

Scenarios 1 and 2: Year 2010

Now, we may pose a couple of What if?-questions (based on Table 2.4). Would it mean a lot if we increased the land area efficiency? Yes, Scenario 1 shows that even with a wealthy diet – 35 per cent animal calories – there would still be 26 per cent of the agricultural land available for agrofuel production – 1.3 billion hectares – since the area needed would be greatly reduced with area-efficient agriculture.

If we leave the wealthy scenario and assume less animal consumption, still larger land areas would be freed up, 2.4 billion hectares and 3.9 billion hectares for sufficiency and vegan diets, respectively. These are *very large* land areas made available for other uses than producing food and feed for meat.

Even assuming that everybody on earth had a heavy life-style in calories – scenario 2 – would not alter the conclusion substantially: the available land areas would shrink, of course, but even a wealthy life-style would leave as much as 10 per cent of total crop and pasture lands – 500 million hectares – for agrofuels if only it is area-efficiently cultivated.

Scenarios 3, 4, and 5: Year 2050

The remaining scenarios of Table 2.5 deal with the future: what happens by 2050 when the world population will be 9.1 billion people, with heavier diets on average.

- Can a heavy (≥ 3,130 kcal) and wealthy (35 per cent meat) diet be sustained on the available land areas by 2050? Scenario 3 and 4 indicate No.
- But what if we reduce our diets to sufficiency levels (i.e. only 20 per cent animal-based food)? Yes, then even a global population of 9.1 billion people fit, leaving substantial lands – 1.2 or 0.7 billion hectares depending on the calorie intake – for agrofuels.

- With vegan diets, the land areas available would be much greater still, naturally: 3.4 or 3.2 billion hectares respectively.

In other words, to change to a less meaty diet is the easiest way to reconcile the conflicting demands on limited land resources arising from population increase and economic growth.[88] Also changing to a less heavy diet in terms of calories would liberate important land areas.

Table 2.5. What if? Share of global crop and pasture land areas to satisfy human diets 2010-2050, % and billion hectares

Scenario	Life style calories	Global population (millions)	Vegan diet	Sufficiency diet: 20 % animal	Wealthy diet: 35 % animal
1. 2010	with 2001 average diet (2,789 kcal)	6,900	22 % = 1.1 Gha	52 % = 2.6 Gha	74 % = 3.7 Gha
2. 2010	with 2001 heavy diet (3,446 kcal)	6,900	26 % = 1.3 Gha	64 % = 3.2 Gha	90 % = 4.5 Gha
3. 2050	with 2050 average diet (3,130 kcal)	9,100	32 % = 1.6 Gha	76 % = 3.8 Gha	110 % = 5.5 Gha
4. 2050	with 2050 heavy diet (3,540 kcal)	9,100	36 % = 1.8 Gha	86 % = 4.3 Gha	124 % = 6.2 Gha
5. 2050	with frugal diet (2,700 kcal)	9,100	28 % = 1.4 Gha	66 % = 3.3 Gha	94 % = 4.7 Gha

Sources and assumptions: See Appendix. The globally available land area = 5 Gha, of which 1.5 Gha crops and 3.5 Gha pastures. Gha = 1 billion ha.

[88] The same conclusion was found in a survey of 72 different scenarios for land use until 2050 with varying assumptions regarding diets, crop yields, livestock systems, and land use change; the scenarios which contemplated a less meaty diet in the future were classified as acceptable, i.e. they fit within the available land areas. See Erb et al. 2009, Table S4. Wirsenius et al. 2010 reached the same conclusion after assuming a reduction in global meat diets by 25 per cent.

33 billion vegans

Let's take the analysis one step further. What if every human being adopts a vegan life style, how many people can today's agricultural land areas then support (assuming, as always, area-efficient agriculture, and upholding the limit of 5 billion hectares)? This is not a very realistic scenario, perhaps, but it does give food for thought:

- If we assume a heavy life-style (3,540 kcal/day, but still vegan), the global vegan population which can be sustained on 5 billion hectares is 25 billion people.
- With a frugal vegan life-style (2,700 kcal/day), the agricultural and grazing land areas of this earth can support as many as 33 billion people.[89]

Thus, if we want to find large land areas for agrofuel production, we have three options: find new lands on which to grow feedstocks; hope for a technical break-through which would allow us to use second or third generation feedstocks (based on grasses or residues from forestry, or algae); or limit the share of animal products and reduce calorie intake.[90]

Of course, the basic underlying assumption of all of these scenarios is completely unrealistic, that all 5 billion hectares of today's crop and pasture

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[89] The calculus is quite simple: I divide the available land area – 5 billion hectares – with the land area requirements of the various vegan life-styles (see Appendix). Thus, for frugal life-style (2 700 kcal/day): 5 billion/0.1533 = 33 billion people; for 2050 heavy life-style (3 540 kcal/day): 5 billion/0.2008 = 25 billion people.

In fact, the outcome of my "back of the envelope"-calculation is not very different from results gained through more elaborate and ambitious – but not more reliable – procedures. See Hoogwijk et al. 2003 who use three diets (vegetarian, moderate, affluent), three population prognoses (low, medium and high, 8.7, 9.4 and 11.3 billion people by 2050), and two agricultural production systems (low external inputs, high external inputs). The scenario which is closest to my scenarios 4 and 5, is the one with high input agriculture and a vegetarian life style: this scenario leaves room for 34 billion people if all the available 5 billion hectares are used. In other words, although more elaborate, their conclusion is almost identical to mine: 34 billion vegetarians vs. 33 billion vegans.

[90] One caveat is necessary here: land area-efficient agriculture – one of the basic assumptions of the scenarios – is heavily dependent on fossil-based inputs, implying that this type of agriculture, although efficient in terms of land areas, is highly inefficient when it comes to its energy balance. Hence, although we may have resolved the conflict over land this way, we may at the same time unwittingly have reinforced climate change.

lands are equally suitable for growing food. Obviously, this assumption is false. But my scenarios should not be seen in the light of realism, but rather as a way to question the framing of agrofuels scenarios which are presented with a serious air by most attempts to model future socio-ecological metabolic profiles.

We must beware not to interpret these scenarios as if 9 billion people could live sustainably on Earth if only they cut down their meat rations and reduced the calorie intake. Although a lighter and less meaty diet would free up large land areas from food and meat production, "life style" entails much more than food, and other resources may still constitute limiting factors. Deforestation to make room for plantations (eg. eucalyptus) is likely to continue because of increasing paper demand, just to take one land-based resource demand which is likely to increase considerably; and water is already a constraint in manu locations. In addition, a growing global population is likely to take ever larger tracts of land – frequently of the most fertile kind – for the construction of housing and transport infrastructure, thereby in fact reducing the land areas available to produce food, feed, fibres, and fuels.

Concluding remarks

Speculating about the number of people that the earth can support is by no means a new undertaking: a survey lists over 65 historical assessments of the earth's carrying capacity beginning in the late 1600s.[91] The first one, by the Dutch scientist Antoni van Leeuwenhoek in 1679, considered the limit for the global population to be 13.4 billion people, a figure which sounds surprisingly up-to-date. In fact, the estimates over the centuries show no trend, the earliest scenarios are of a similar magnitude as the more recent ones, with the most frequent range for the maximum population set at 8-16 billion people. My play with a vegan population of 25-33 billion people thus falls in the upper segment of the continuum of estimates of the past 300 years.

Should such scenarios be taken seriously? Yes, I believe so, and for two reasons. First, they serve as an antidote to the fanciful elaborations which we

[91] Cohen 1995:212-215 and Appendix 3.

came across earlier in this chapter: it should be recognized that scenarios are no more reliable than the assumptions on which they are built. Although the assumptions underpinning the scenarios of Table 2.5, above, admittedly are more simplistic than most scenarios I compare them with, they capture the essential conflict when it comes to land use: land conflicts do not arise because we are too many people on this planet, but because we are living with a particular socio-ecological metabolism which requires a continuous supply of land-based resources for food, feed, fibres, and fuels.

Not all people on the planet contribute equally to the conflict over land based resources, of course: a person's responsibility for the emissions of greenhouse gases, for instance, is closely related to his or her class position in the global system as well as to personal life style choices. A rich man is simply a greater predator in terms of his impact on climate and land areas than a poor woman. And so is an omnivorous person compared to a vegetarian.[92]

But in addition to class and personal choices when it comes to life style, the global position of the society in which we live is equally significant for the footprint we impose on land areas and land-based resources; see Table 2.6. Unsurprisingly, the general pattern is that the societies of the North are using on average many times the resources used by the societies of the South.

Table 2.6. Differences in metabolic profiles c 2000

	South	North
Electricity/capita (J)	1	10
GDP/capita (USD)	1	6
Energy use/capita (J)	1	4
Material use/capita (t)	1	3
Animal-based diet/capita (J)	1	3

Based on Krausmann et al. 2008, Table 3. South = Africa, Asia (excluding Japan), Latin America, Oceania (excluding Australia, New Zealand); North = Europe, North America, Japan, Australia and New Zealand. J = joule, GDP = gross domestic product, t = tons.

Secondly, scenarios are important as they are part of a framing struggle regarding the discourse on resource limits. Fanciful scenarios, built on

[92] Also carbon footprints follow income, gender and diets. See Naturvårdsverket 2008:41.

unrealistic assumptions, colour the discourse by contributing arguments regarding how conflicts over land areas and land-based resources can be resolved. Behind such scenarios we find academic researchers no less than corporations, consultancy firms, international organisations and financial institutions, and they all take sides one way or the other through the futures they commission, elaborate or disseminate.

Nevertheless, playing mind games may aid us in foreseeing the consequences of an ever fiercer struggle over land. So far, mid-2012, and judging from the continued and historically high price levels of food and raw materials (see Figure 2.1, above) amidst ongoing financial and economic crises, it seems highly probable that the struggles over land will intensify. One of the countries where such land competition will play itself out is Brazil, the world's second most important producer of ethanol and soybeans next to the US. This is the topic of the following chapter.

Appendix. Data and assumptions for calculating land use for different diets.

The scenarios of Table 2.5 are built on the following assumptions.[93]

- Land for crops and pasture is fixed at today's 5 billion hectares, which amounts to assuming no deforestation and no use of "abandoned" or "degraded" lands.
- The agricultural system will be a replica of a high-intensive, land area-efficient farm system found in New York State.
- All pastures can be transformed into high yielding crop lands.

I measure life-styles in terms of their daily calorie intake, as estimated by the FAO, and calculate the land areas needed to provide for each life style.

- Frugal: 2,700 kcal/capita/day
- Global average today (2001): 2,789 kcal;

[93] See FAO 2006, Peters et al. 2007, and Lundqvist et al. 2007.

- Heavy lifestyle today (2001): 3,446 kcal;
- Global average 2050 (prognosis): 3,130 kcal;
- Heavy life-style 2050 (prognosis): 3,540 kcal.
-

Then I combine the heaviness of the life-style, i.e. its calorie intake, with the share of animal products in the diet. Three diets are investigated:

- a "meaty" life style: 35 per cent animal calories, equal to wealthy countries' average meat share today;
- a "sufficiency" life style, 20 per cent animal calories; and
- a vegan lifestyle.

Composition of diets

- Vegan: 50 % grains, 50 % remaining plant products with equal weights.
- Omnivorous: plant products as vegans, plus 20 or 35 % meat (unweighed average consumption of animal products in Table A1).

Population prognosis

- 9.1 billion people 2050 (UN 2009, median scenario).[94]

Agricultural production system:

[94] In the most recent population update, UN 2011:2, the 2050 medium variant is 9.3 billion, with global population levelling out at 10.1 billion by 2100. My scenarios may thus err on the optimistic side by using a lower population figure.

The calculation is based on an area-efficient, rich country model (high input/high output, high land area efficiency) with actual data for New York State (see Table A.1.).

Total land area requirement per 1000 kcal per day and year

- Animal products diet: 12.1 m^2/1,000kcal/day, 4,417 m^2/1,000 kcal/year.
- Plant products: 1.55 m^2/1,000 kcal/day, 566 m^2/1,000 kcal/year.

Table A.1. Land area required per 1,000 kcal of various foods

		m^2/1,000 kcal
Animal products	Beef	31.2
	Chicken	9.0
	Pork	7.3
	Eggs	6.0
	Milk	7.0
Plant products	Oils	3.2
	Fruits	2.3
	Pulses	2.2
	Vegetables	1.7
	Grains	1.1
	Sugar	0.6

Sources: Peters et al. 2007, and WBGU 2009:66. Each animal product's area has been calculated according to estimated feeding quotas, for instance for beef: 0.85 ha pasture, 2.4 tons hay, 1.7 tons corn, 68 kg soy; for pork 70 % maize, 23 % soy and 7 % minerals plus 3 kgs of ration/kg weight gained.

Table A.2. Land area required for various diets of 2,789 kcal/day/capita (global average 2001)

Diet	**Animal products, m^2/cap/d**	**Animal products, ha/cap/yr**	**Plant products, m^2/cap/d**	**Plant products, ha/cap/yr**	**Total land area, m^2/cap/d**	**Total land area, ha/cap/yr**
Vegan	0	0	4.3	0.1570	4.3	0.1570
20 % animal	6.8	0.2482	3.5	0.1278	10.3	0.3760
35 % animal	11.8	0.4307	2.8	0.1022	14.6	0.5329

Table A.3. Land area required for various diets of 3,446 kcal/day/capita (2001 wealthy diet)

Diet	Animal products, m^2/cap/d	Animal products, ha/cap/yr	Plant products, m^2/cap/d	Plant products, ha/cap/yr	Total land area, m^2/cap/d	Total land area, ha/cap/yr
Vegan	0	0	5.3	0.1935	5.3	0.1935
20 % animal	8.3	0.3030	4.3	0.1570	12.6	0.4539
35 % animal	14.6	0.5329	3.5	0.1278	18.1	0.6607

Table A.4. Land area required for various diets of 3,130 kcal/day/capita (2050 global average)

Diet	Animal products, m^2/cap/d	Animal products, ha/cap/yr	Plant products, m^2/cap/d	Plant products, ha/cap/yr	Total land area, m^2/cap/d	Total land area, ha/cap/yr
Vegan	0	0	4.9	0.1789	4.9	0.1789
20 % animal	7.6	0.2774	3.9	0.1424	11.5	0.4198
35 % animal	13.3	0.4855	3.2	0.1168	16.5	0.6023

Table A.5. Land area required for various diets of 3,540 kcal/day/capita (2050 wealthy diet)

Diet	Animal products, m^2/cap/d	Animal products, ha/cap/yr	Plant products, m^2/cap/d	Plant products, ha/cap/yr	Total land area, m^2/cap/d	Total land area, ha/cap/yr
Vegan	0	0	5.5	0.2008	5.5	0.2008
20 % animal	8.6	0.3139	4.4	0.1606	13.0	0.4745
35 % animal	15.0	0.5475	3.6	0.1314	18.6	0.6789

Table A.6. Land area required for various diets of 2,700 kcal/day/capita (Sufficiency norm)

Diet	Animal products, m^2/cap/d	Animal products, ha/cap/yr	Plant products, m^2/cap/d	Plant products, ha/cap/yr	Total land area, m^2/cap/d	Total land area, ha/cap/yr
Vegan	0	0	4.2	0.1533	4.2	0.1533
20 % animal	6.5	0.2373	3.3	0.1205	9.8	0.3577
35 % animal	11.4	0.4161	2.7	0.0986	14.1	0.5147

Totals may not match due to rounding.

3. Regulating Land Use for Agrofuels: A Case Study of Brazil

Figure 3.1. Sugarcane field treated with the Monsanto herbicide Roundup after six harvests, ready for replanting
Sugar plantation Ester, Cosmópolis, São Paulo. Photo KH. The forested stretches along the waterways in the distance may be Areas of Permanent Preservation.

The sugarcane-ethanol complex in Brazil is governed by a series of codes, regulations, and agreements covering how and where sugarcane is grown and harvested. This regulatory set-up includes the Brazilian forest code, voluntary regional and national agreements between the state, the sugarcane industry, and the labour unions, as well as conditions for entering the EU and US markets.[95]

The tragedy of the commons re-examined

Anyone who starts to ponder over the best way to regulate land use will sooner or later – probably sooner – come across the acrimonious debate between ecologist Garrett Hardin and political scientist Elinor Ostrom regarding "the tragedy of the commons". The phrase was used by Hardin in his extremely influential article in 1968, where he argued against population growth in terms not very different from the ones that Malthus had used 179 years earlier. Hardin refers to Malthus's contention that population "naturally tends to grow 'geometrically', or as we would now say, exponentially", and Hardin concurs: we live in a finite world, he says, and a

> finite world can support only a finite population; therefore, population growth must eventually equal zero.[96]

Exponential population growth will clash with the limits of land areas and other restricting resources, Hardin postulated, taking as his case a common pasture. While each of the "rational herdsmen" was following his own profit-maximizing path by augmenting his own herd, the outcome spelled ruin for all:

[95] This chapter is based on field-work and interviews that I conducted in the fall of 2010 in the states of Goiás and São Paulo. The interviewees are listed at the end of the chapter.

[96] Hardin 1968:1243.

> Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit – in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all.[97]

The tragedy, Hardin held, was fed by the erroneous ideas of Adam Smith that there existed an "invisible hand" which turned individual profit-maximization into a public good, thereby justifying "the continuance of our present policy of laissez-faire in reproduction."[98] To deal with this tragedy, Hardin most of all wanted to restrict population growth by "reveal[ing] to all the necessity of abandoning the freedom to breed"[99] – a position which brings him quite close to the first version of Malthus's essay. But it is Hardin's embrace of privatization of common resources which has come most in focus for his foes although Hardin in fact did make an interesting distinction – usually disregarded when assessing his position – concerning which commons should be governed by privatization and which needed state regulation: for land, he believed in private property to shield against overuse, but not when the issue was pollution. Pollution, contrary to land resources, could not be governed as easily since "the air and waters surrounding us cannot readily be fenced". Instead, what was needed here, Hardin maintained, was state action, "coercive codes or taxing devices" to make the polluter change his ways.[100]

Thus, Hardin recognized two alternatives for managing common land resources, privatization or state regulation, and he mostly preferred the former to the latter. Elinor Ostrom objected to Hardin's dichotomy and made the pont that there existed many different – albeit variously effective – governance systems of common resources, not just a sterile polarization between two options.

Hardin subsequently appeared to retreat from his first provocative formulation when he "revisited" the debate thirty years after the publication of his original article. He then recognized that he ought to have called it The tragedy of the *unmanaged* commons, a position which at first appears to

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[97] Hardin 1968:1244.

[98] Hardin 1968:1244.

[99] Hardin 1968:1248.

[100] Hardin 1968:1245.

bring Hardin quite close to Ostrom's stance. But he still only accepted two regimes, even for "managed" commons:

> A "managed commons" describes either socialism or the privatism of free enterprise. Either one may work, either one may fail.[101]

From this we can learn that Hardin still suffered from binary thinking, either-or, but he did not exclusively believe in privatization – although this is how he usually is understood – he also recognized a role for state regulation.

Ostrom argues that it is usual for the kind of abstract reasoning that Hardin exemplifies to be based on "idealized markets or idealized states".[102] Her own account, on the other hand, is based on case studies, from which she deducts general rules of understanding of what works, and what does not, when it comes to governing common resources. The official motivation for laureating Ostrom with the "Nobel prize" in economics in 2009 sums up her position neatly:

> based on numerous empirical studies of natural-resource management, Elinor Ostrom has concluded that common property is often surprisingly well managed. Thus, the standard theoretical argument against common property is overly simplistic. It neglects the fact that users themselves can both create and enforce rules that mitigate overexploitation. The standard argument also neglects the practical difficulties associated with privatization and government regulation.[103]

Insightful as this is, Ostrom's perspective is nevertheless limited, in her own words, to instances where

> the users can substantially harm one another, but not [to] situations in which participants can produce major external harm for others.[104]

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[101] Hardin 1998:683.

[102] Ostrom 1990:216. She is right: Hardin's argument is totally free of any empirical basis, he just assumes the situation he "analyses".

[103] See http://www.nobelprize.org/nobel_prizes/economics/laureates/2009/popular-economicsciences2009.pdf.

[104] Ostrom 1990:26.

This restriction in Ostrom's take is frequently overlooked, but for my Brazilian case study it will soon become clear that we need a much more complex understanding in order to govern the large number of national and international actors involved. Brazilian sugarcane ethanol is precisely a case where "major external harm for others" is frequent, the land use change taking place as a consequence of the expansion of sugarcane does not only occur locally but also regionally, nationally and indeed globally; as land is fungible, land use change is also a global process.

So, while the scale of Ostrom's perspective is restricted to local and perhaps regional settings, land use change and land use regimes need to be seen in a much wider context, from national to international and global levels. Ostrom's much celebrated perspective thus gives us less reason for hope than what is customarily recognized.

Central to my concern regarding land use and land use change is that regulations cannot be limited to a question of who has access to what common good, and who can block the access for whom; equally essential to the possibility to enter the global market is the performance of feedstocks all along the production chain in terms of a number of concerns, from labour conditions to carbon emissions.

In fact, a precondition for Brazilian sugarcane ethanol to be acceptable to major importers – states as well as corporations – is that it qualifies in all of these respects, a *sine qua non* for being acknowledged as an alternative in the global hunt for substitutes to fossil fuels.

Working the sugarcane fields

The way the sugarcane sector in Brazil is depicted by the sugarcane industry is seductive: clean, carbon neutral, geopolitically secure, without ecological drawbacks, the ideal raw material for fuelling the world's automobiles. As we are led to understand in a recent publication by UNICA – the Sugarcane Industry Association in São Paulo, the Brazilian ethanol industry's leading lobby group – ethanol is socially beneficial by creating jobs and wealth in the countryside and simultaneously improves Brazil's income distribution.[105]

[105] UNICA 2009:8.

However, already a cursory visit to a sugarcane district during harvest time will disclose a completely different picture, at least where manual labour still is essential: the cutting of the sugarcane is arduous, dirty, and hazardous work, and the living conditions of the workforce is degrading. It does not help that the ecological consequences also are dubious, especially when new land is cleared for sugarcane and when it comes to the impact on biodiversity.

Figure 3.2. Female cane cutter in the smoking field
Denusa plantation, Indiára, Goiás. Photo KH.

All sugarcane that is cut manually is first burned on the preceding night in order to facilitate the cutting and eliminate the parts of the cane which are useless for sugar production. In this way, productivity is increased, but so are pulmonary infections and diseases, also for people not directly involved in the cutting but living in the vicinity of the sugarcane fields, or in urban settlements nearby; the frequency of reported pulmonary problems almost doubles during the burning season in Ribeirão Preto, São Paulo, one of the prime sugarcane regions of Brazil.[106]

Several hundred thousand workers are employed as cane cutters during the harvesting season (from April to October), the majority are young men in the age bracket below 30 years, many are migrants from the North and North East of Brazil, others live in the vicinity of the sugarcane plantations; approximately 10 per cent are women.

According to measurements of average work days, this is the day of a cane cutter: He/she walks 8,800 metres, bends down and strikes close to the ground with his/her machete 133,332 times, makes 36,630 rotations of his/her spine, looses 8 litres of sweat. He/she carries the 12 tons of sugarcane in 800 instalments of 15 kilos each, and arranges them in easily measured lines.[107] The average production has increased substantially over the decades, today 12 tons per worker and day is held up as norm in a race towards ever higher performance: in the 1950s average daily production was 3 tons, in the 1960s 6 tons.

The only work tool is the machete, which the cutter sharpens and adapts to his/her own cutting technique. On the sugarcane plantations that I visited, most of the minimum requirements were followed (protective equipment, bus transport, lunch breaks in the shade), exceptional cases if we are to go by most studies of the dreadful working conditions of cane cutters.[108]

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[106] Silva 2010, Silva & Ribeiro 2010.

[107] Alves 2006.

[108] A combination of legally binding and voluntary rules and regulations establishes the conditions for the manual labourers on the sugarcane plantations (see Compromisso nacional 2009, Convenção coletiva 2010, NR 31 2005, Protocolo de cooperação 2007):

Code prohibiting slave labour. Article 149 of the Brazilian penal code "Reduction of conditions analogous to slavery" metes out a punishment of 2-8 years imprisonment for anyone who enforces compulsion, exhaustive working days, degrading working conditions, or limits the possibility for indebted employees to leave their employment. The Ministry of labour provides a website where violators of this code are listed, see http://www.reporterbrasil.org.br/pacto/listasuja/info/en. In May 2010, 293 corporations were

Accidents caused by stress, exhaustion and over-exploitation are common, workers' heartbeat in the sun is exceedingly high, as is the overall strain. More than 20 workers are reported to have died in the fields or from being over-worked 2004-2007.[109]

Slave labour – actually workers suffering from slave-like conditions – is reported in appallingly many instances: for the whole of Brazil 6-7,000 workers were liberated on average *each year* 2005-2009, half of them on sugarcane plantations. During the same period, approximately 30 people were killed *each year* in local struggles, and numerous conflicts about access to and ownership of land occurred, involving an average of 750,000 people *each year*.[110] These struggles take place all over Brazil, there are no exceptions for "modern" regions – São Paulo, for instance – as compared to the poorer areas in the North East. A much reported case of slave labour included Cosan, the leading sugarcane corporation in Brazil, which has Shell

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on the "dirty list" (Lista suja) for violating this agreement. Corporations and farms on the list are blocked from federal public finance, and some private banks also follow suit.

Regulatory Norm 31. A national norm regarding "Safety and Health in Agricultural Work" was adopted in 2005. The cane cutter in Fig. 3.2 carries gloves, glasses, shirt, boots and leg protection, all part of what Norm 31 stipulates, in addition to her non-regulatory hat. However, she does not use the facemask that she needs to protect herself from the smoke.

Collective agreements. Collective labour agreements for the sugarcane sector stipulate how salaries are paid, piece rates for different quality of sugarcane, working hours and working days, the right to safety protection (and other rules of Norm 31) as well as the right to leave-of-absence for menstruating women (without remuneration).

Voluntary agreements. A voluntary agreement to mechanize the harvesting of sugarcane in the state of São Paulo by 2014 has been signed between the state government and UNICA (for land with slopes less than 12 degrees). The agreement is more demanding than the national regulation which stipulates full mechanization only by 2021. For slopes over 12 degrees, the time limit for mechanization is 2017 (as compared to the national goal of 2031).

A national agreement to improve labour conditions was concluded in 2009 between trade unions, the sugarcane industry, and the federal government to secure "decent work and quality of life" in the work on the sugarcane plantations. The agreement explicitly refers to Norm 31 but also prohibits the use by the employers of recruiting middle men (gatos) who often trick migrating cane cutters into debt on their way to work, a prohibition which also is part of collective agreements.

[109] Rede Social de Justiça e Direitos Humanos 2008.

[110] CPT 2010:16, 173.

as one of its major partners.[111] Cosan blamed its recruiter of labour (the so called "gato", cat) for the slave conditions of the workers; but according to both national and collective agreements to which Cosan is party, no middlemen are allowed in the recruitment of workers.[112]

Figure 3.3 The cutters' performance is measured and registered by the foreman
Sugarplantation Ester, Cosmópolis, São Paulo. Photo KH.

Pay is according to a piece rate system by tons cut, but in order to facilitate the measurement the foremen goes by the metres cut of five rows ("linhas") of sugarcane. The minimum pay in Brazil in 2010 was 510 reais (300 USD) and a cane cutter could earn twice or more than that during the months of the

[111] Mendonça 2010.

[112] The practice continues, however, and "gatos" now advertise "Excursions to São Paulo" since open recruitment is no longer permitted. Interview Maria Luisa Mendonça.

cane harvest. On a yearly basis, however, the pay is not impressive, even for Brazilian conditions.

Figure 3.4. Male cane cutter
"Cane cutting kills nobody, otherwise I'd be dead by now". Paulo Panceroli, 61 years old, has been cutting cane for over 50 years. Plantation Ester, Cosmópolis, São Paulo. Photo KH.

All in all, although there are good intentions on the legal as well as the voluntary level, reality is still extremely exploitative. The average "useful" life of a manual cane cutter is only 15 years, which makes his or her working life in the sugarcane fields shorter than during the times of slavery in Brazil, where slaves at least lasted 20 years.[113]

[113] Silva & Ribeiro 2010:3. Exceptions exist, especially in the macho culture of cane cutters. As an example, a trade union representative told me he had cut sugarcane for 20 years and managed 12 tons/day. Interview Valdemar Garrido. This level of production may earn the cutter the "golden machete" premium – padão de ouro – sometimes amounting to a

The future: better working conditions, fewer jobs

The trend towards mechanized harvesting will change most of this, however, and push the attention relating to sugarcane ethanol towards its ecological dimension at the expense of the situation of the labour force. Already today, approximately half the sugarcane harvest is mechanized, with higher rates in the South West, and lower in the North East.[114] Although manual labour can be expected to continue on the plantations with lands less suitable for mechanization – and for some tasks which always will be handled manually, also in otherwise mechanized plantations due to steep slopes, stony grounds, or land areas with difficult access, as well as the (primarily female) task of picking up what the harvesters miss to collect, called "bituca" – mechanization is being introduced in ever more plantations.

Mechanization is most frequently presented as a result of demands from overseas markets which do not accept that a supposedly clean agrofuel is produced under slave-like conditions reminiscent of the 16th century. Also domestic actors follow suit, for instance the public energy company

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motorbike, more frequently "uma cesta básica" (one basic food ration). Interview Antônio Canuto and Isolete Widriweski.

[114] Surprisingly, there has been a movement to stop mechanization, or at least to slow it down. With this purpose, a law was proposed in 2008 at the state parliament of Goiás in order to limit mechanization rates to 50 per cent of a plantation until 2020, and to 70 per cent by 2030. In other words, 30 per cent of the harvesting was to continue to take place manually, at least for the coming generation.

The concern here is employment, which the proposed code wants to protect. See Projeto de Lei 2008, proposed by a member of the Partido Democrático Trabalhista, PDT, part of the ruling PT (Partido dos Trabalhadores, Labour) alliance. No mention is made in the proposal of working conditions or health problems related to manual cane cutting.

The move to break mechanization is reminiscent of the Luddite movement in Britain which 200 years ago, 1811-1813, smashed power looms to protect their jobs in the textile mills, and it will be just as unsuccessful, as one of my interviewees stressed. Recalcitrant sugarcane plantations will have to conform to the overall trend, the "market" will not permit continued burning and manual cutting. Interview Eduardo Assad. Furthermore, the state of São Paulo is not alone in demanding mechanization, Minas Gerais concluded a similar agreement in 2008 with a number of the stakeholders, including corporations and trade unions, see http://www.siamig.org.br/dmdocuments/Protocolo%20Minas%20Gerais%20-%2013-08-08.doc.

Petrobras, and the days of large-scale burning may well be numbered as mechanized harvesting does without it.

But although such pressure may constitute the main driver, there also exist other factors that have contributed to this shift. For one, the profit motive: a harvester replaces 80-100 workers, and the average cost per ton harvested is almost halved.[115] Another factor pushing in the same direction has been conflicts on the plantations, especially the major strike which occurred in 1984 in São Paulo.[116]

Workers restistance to the dire conditions have also contributed to the shift as workers are known to resist by different actions that will decrease the yield of the mill without endangering their own pay. For instance, small-scale obstruction (called "resistência miuda") can consist of hiding uncut sugarcane below the heaps of cut cane that the workers gather for transport to the mill, or by cutting too high above the ground to gain speed and save strength; since the pay is according to metres cut, only the factory owner will suffer.[117]

Also the fact that the children of today's cane cutters prefer to stay away from the sugarcane fields and aspire to find employment elsewhere rather than being subjected to the degrading working conditions on the sugarcane plantations have pushed the sugar and ethanol industry in this direction.[118] It has simply become difficult to find willing workers in sufficient numbers.

However, although mechanized harvesting would do away with some of the worst traits of manual cane cutting by eliminating most of the cutters, there also exist problems related to mechanization, especially when it comes to its environmental consequences. Land will be more compacted, which increases water and wind erosion; and "efficient" mechanization requires that there are no obstacles in or along the fields, leading to large open and monotonous tracts of land, further endangering biodiversity (although the termination of burning will enhance it).[119]

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[115] Interview Fábio Alves de Moura.

[116] Moraes 2007, Alves 2006, and Silva & Ribeiro 2010:7.

[117] Silva 2008:21, and Silva & Ribeiro 2010:7-8. Interview Maria Aparecida de Moraes Silva.

[118] Plancherel et al., n d, and Assad de Ávila et al. 2010. Interviews Mário Ávila and Silvia Assad de Ávila, Maria Aparecida de Moraes Silva.

[119] Interview José Paulo Pietrafesa.

Figure 3.5. The harvester cuts the cane into short stubs

Figure 3.6. The tractor loads the cane unto the truck for transport to the mill

Figure 3.7. At the mill, the truck unloads and the cane is washed

Brazil's forest codes of 1934 and 1965

The Brazilian constitution of 1988, enacted after the termination of the military dictatorship in 1984, accepts varying legal forms of ownership of land, but underlines the social function of ownership:

> all [citizens] have a right to an ecologically balanced environment, a good of common use to the people.[120]

This turn of words – a good of common use – was not new, already the opening article of the forest code of 1934 safeguarded the common social value of forest resources:

> The forests of the national territory, seen as a whole, constitute goods of common interest to all the inhabitants of the country.[121]

[120] See Article 225 of the Constitution, and Sauer 2010.

In 1965, during the military dictatorship, a new code was enacted which declared in Article 1 that Brazil's forests "are goods of common interest to all the inhabitants" and that the rights which ownership bestows on the owners should be used "with the limitations that the code" establishes.[122]

Although such statements may be read as an attempt to subjugate private ownership to national purposes, and hence as a limitation on private property rights, it should be recognized that stressing "common interests" also may be interpreted as going against the grain of the "agrarian credo" which holds that land belongs to the tiller. This credo, in turn, leads to stressing the need for land reform and for an equitable distribution of land holdings, rather than seeing land as a commodity to be exploited for the common good. In Brazil, obviously, the urge to make use of land is placed above the rights of the land-less rural population.[123]

Still, the forest code, as it stands today, has quite far-reaching demands on private property owners, who must set aside two separate land areas for preservation and to protect biodiversity: a Legal Reserve (Reserva Legal, RL) and an Area for Permanent Preservation (Área de Preservação Permanente, APPs).[124]

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[121] Quoted in Ahrens 2003:5.

[122] See Presidência da República 1965. The 1965 code has been amended repeatedly over the years, most importantly the extension of the reserve requirement in the Amazon biome from 50 to 80 per cent for private properties. A new forest code, proposed in 1999, is still (June 2012) making its way through the Brazilian Congress, deeply contested; see below and Sparovek et al 2010.

[123] The "agrarian credo", a constituent part of the peasant world view, is discussed in Jacoby & Jacoby 1971, chapter 3.

[124] For the sake of comparison: 3.6 per cent of Swedish productive forests are today protected from use. In a brave move, a further 1.4 per cent has been suggested to be set aside, bringing the total up to 5 per cent. See http://www.naturvardsverket.se/Start/Naturvard/Skydd-av-natur/Skydd-av-skog/Skyddsvarda-statliga-skogar/.

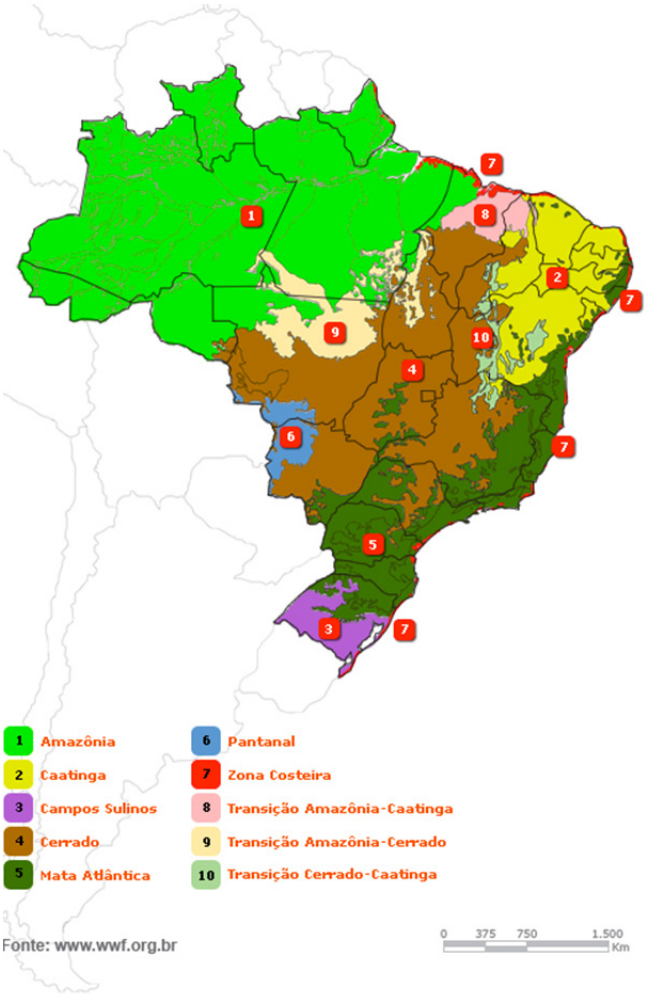

Figure 3.8. Brazilian vegetation zones (biomes) c 1500
Source: www.wwf.org.br.
In Brazilian legislation, a distinction is made between the state of Amazon, (Amazonas), the biome Amazon (Amazônia), and the "legal Amazon" (Amazônia Legal). The Amazon biome covers almost half of Brazil's territory, 49 per cent, including all of today's states of Acre, Amapá, Amazonas, Pará and Roraima, and parts of Rondônia (98 %), Mato Grosso (54 %), Maranhão (34 %), and Tocantins (9 %). The Legal Amazon is the totality of all the states which harbour the Amazon biome except Maranhão which has part of its land area outside; the Legal Amazon equals 61 % of Brazil's territory.

The Legal Reserve varies among the biomes of Brazil (see Figure 3.8):[125]

- In the Amazon, 80 per cent of private property holdings are to be set aside; for the Cerrado biome within the Legal Amazon, the share is 35 per cent.
- For the remainder of the Brazilian territory, the reserve should be 20 per cent. This lower requirement also applies to the Cerrado outside of the Legal Amazon.
- The Areas of Permanent Preservation are stipulated in metres on each side of water bodies (rivers, lakes) and the requirements depend on the width of the river.[126]

The forest code can be seen as trying to protect biodiversity in sensitive land areas (especially the Amazon) and in connection with water bodies, whilst also fighting erosion and protecting the water cycle. Here, the conservationist perspective is seen as more important than the economic concerns.

Simultaneously, the code partly liberates other land areas for economic exploitation[127] which is obvious from the varying requirements that it applies to the different Brazilian biomes, most importantly the Cerrado (inside as well as outside the Legal Amazon; the Cerrado was largely intact at the time of the code, while some of the other biomes already had been seriously damaged).

Although the Amazon is regarded as containing the world's richest biodiversity resources, it is the Cerrado which has been named one of the 25 global "biodiversity hotspots" on account of its high biodiversity density in combination with the threats that it is facing.[128]

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[125] The Legal Reserve may be secured outside of a given piece of land as long as it is situated in the same hydrological basin.

[126] Article 2 of the forest code stipulates the following Areas of Permanent Preservation along rivers: 30 metres for rivers 10 m wide, 50 m for rivers 10-50 m wide, 100 m for 50-200 m wide, 200 m for 200-600 m wide, and 500 m for rivers wider than 600 m. The APPs should also include steep slopes, hilltops, and high altitudes (> 1800 m above sea level).

[127] "Exploitation" is the term used by the Convention on Biological Diversity for economic activities.

[128] See Myers et al. 2000. A biodiversity hotspot is defined as a high biodiverse region which has lost 70 per cent of its original habitat. In addition to the Cerrado, this also holds for the Atlantic Forest, biome N^{o} 5 in Figure 3.8.

All in all, deforestation in the Amazon may be considered to carry more drawbacks in terms of release of climate gases per hectare and loss of biodiversity, but that certainly should not be taken to imply that the continuing deforestation of the Cerrado is acceptable.[129]

Assessing the Brazilian forest code at different scales

Although the forest code in no way has stopped the deforestation taking place in Brazil, it has had an influence on where and how it has evolved. A certain slow-down of deforestation in the Legal Amazon has been noticed during the last couple of years: while the annual deforestation recorded in the 1980s was 2 million hectares/year, it has since been much reduced and by 2010 and 2011 it was down to 660,000 hectares.[130] In the Cerrado, however, with much less attention, deforestation went on at the rate of 760,000 hectares 2008-2009, also down from an estimated annual rate of 2 million hectares.[131]

The deforestation frontier is thus centred on the Cerrado as much as on the Amazon, and the total deforestation in the Cerrado has advanced more than in the Amazon, both in absolute and in relative terms. While the Amazon is estimated to have lost approximately 70 million hectares (or 20 per cent of its total land area), the Cerrado had by 2008 suffered a loss of 98 million hectares (or 48 per cent of its total land area).[132] From being the dominant land cover in large parts of Brazil (see Figure 3.8), the Cerrado has been turned into a seriously weakened biome.

The forest code, while formally extending wide-ranging protection to the Amazon biome and to the Legal Amazon in general, simultaneously

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[129] The carbon dioxide content per hectare (above and below ground) is approximately 80 Mg/ha for Cerrrado and 270 Mg/ha for the Amazon, a considerable difference. See Neves do Amaral et al. 2008:122-123.

[130] Sawyer 2009:150. See http://www.obt.inpe.br/prodes/prodes_1988_2009.htm and http://www.obt.inpe.br/prodes/r2011.htm.

[131] Embrapa 2008:10, and Fischer et al. 2008:42.

[132] www.inpe.br/noticias/arquivos/pdf/Resumo_Principais_Conclusoes_emissoes_da_pecuaria_vfinalJean.pdf.

leaves the remaining biomes of Brazil open for deforestation. Thus, the forest code presents contradicting objectives where the economically most promising land areas – such as the Cerrado – are being less restricted than the Amazon, a biome that has figured centrally in the international environmental debate for decades.[133]

Another way to evaluate the forest code is to measure the degree of compliance with the required Legal Reserves and Areas of Permanent Preservation, and here the verdict is still more damning. A recent assessment concludes that

> the legal framework does not effectively achieve the objectives of protecting water and native vegetation on private farmland in Brazil.[134]

The basis for this strong conclusion is that a large share of the land that should be set aside for biodiversity and conservation purposes in fact does not appear as Legal Reserve or APPs. Assessed in relation to its objective, the forest code has been a gigantic failure.[135]

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[133] The forest code only applies to privately held land properties. The land areas already set aside as Indigenous lands (Terras indígenas) and for conservation purposed (Unidades de Conservação), which together cover 20 per cent of Brazil's land area, are outside the purview of the code. See Sparovek et al. 2010:6049.

[134] Sparovek et al. 2010:6050. Of the 233 Mha of Legal Reserves theoretically required, this survey could not find at least 42 Mha; of the 100 Mha required for the APPs, at least 43 Mha could not be detected. See Sparovek et al. 2010a:5.

[135] This is not a new understanding of the ineffectiveness of the code. Already based on information of the forest cover in 1996 – sixteen years ago – it was shown that most Brazilian states did not have enough forested areas to comply with the requirements of the code: *none* of the states of the Legal Amazon had sufficient forest cover left; the more lenient demand of 20 per cent Legal Reserve could only be found in another 13 out of 21 states, which means that 8 states did not even have this more limited protection. See Alston & Mueller 2007:37-38; the APPs were not measured in this study.

The 1999/2012 forest code

A reformulated forest code has been a contentious issue ever since it was first proposed in 1999.[136] It has been called the "Chain Saw Code" ("Lei motoserra") which gives you an idea of how the critics view it: a sell-out and an end to the protection of land areas and the preservation of biological diversity.[137] At the time of writing (June 2012), the code has been accepted by Congress, but the President Dilma Rouseff has vetoed parts of it and its present status is uncertain.[138]

The new forest code constitutes an attempt to align Brazil's legal setting with, first, the actual situation on the ground, where, as we have seen, large-scale failures in terms of the stated objectives of the old code exist; and, secondly, with Brazilian interests to provide ever more land areas and land-based resources for the growing global socio-ecological metabolism.

In this way, the new code should be seen as an adaptation by the Brazilian state to the foreseeable future demand from the global market directed towards its rich land resources, and the proposed new code underlines in its opening article, just as its predecessors, that forests, and other forms of vegetation, constitute "goods of common interest to all the inhabitants of the country".

The previous forest code was formulated in a completely different context, and the proposed code makes more land areas available for exploitation by exempting small-scale property owners from the requirement to Areas of Permanent Preservation; in principle no APPs would be required

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[136] See Câmara dos Deputados 1999.

[137] See Cruz 2010, and FASE 2008. For similar but less dramatically worded assessments of the proposed new code, see a recent issue of *Science* (329:276-277, 1282): "Brazilian law: Full speed in reverse?" and "No return from biodiversity loss".

Likewise, the Brazilian Academy of Sciences and the Brazilian society for the advancement of Science have issued a joint statement (25th of June 2010) in which they characterize the proposal as being framed "by stakeholders who would irreversibly hurt our natural ecosystems and the environmental services they perform".
See http://www.abc.org.br/article.php3?id_article=719.

[138] For the present (April 2012) version of the proposed forest code, see http://www.camara.gov.br/proposicoesWeb/prop_mostrarintegra?codteor=987261&filename=REDACAO+FINAL+-+PL+1876/1999.

if only all properties were divided into farms of less than fifteen fiscal units.[139]

It was first feared that the new code would lead to a reduction of the Legal Reserves by as much as 30 million hectares (or three times today's total sugarcane land area) on account of a suggested diminuition of the Legal Reserves from 80 to 50 per cent of any holding in the Amazon,[140] but this proposal was later revoked. Still, the reserves shall not be protected from "economic use" as long as it occurs "sustainably", and a similar opening is provided in relation to the APPs.

Most contentious of all is that the proposed code offers a wholesale amnesty for all illegal land use which occurred before June 2008.[141] This means that all breaches of the code which have been committed are retroactively pardoned, a severe strike against law-abiding property owners in the Amazon and elsewhere.

The officially embraced logic propelling the new code is that the protection has to be weakened in order to make available lands to allow Brazilian agriculture to expand, but this has been questioned as there already exist vast land areas which could be used for agricultural purposes if only the area-efficiency of cattle raising was improved.[142] As a statement by the Brazilian Academy of Sciences and the Brazilian society for the advancement of Science states, the new forest code "is based on the false premise that there is no land available for the expansion of Brazilian agriculture".[143] A small intensification of cattle raising would liberate vast land areas and thus make the new forest code redundant.[144]

The freeing up of land by intensifying the use of pastures is similar to the highly controversial issue of using "degraded" and "abandoned" land for sugarcane. My interviewees responded to this proposition quite differently: from the very positive, "there are lots of degraded lands available, 60 million

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[139] Article 4.XI.6. Fiscal units (Módulos fiscais) are differently defined for each municipality. The span is wide, from 5 to 110 hectares per unit. Fifteen fiscal units can thus be anywhere from 75 to 1,650 hectares, depending on the productive potential of the land.

[140] Sparovek et al. 2010a:8.

[141] WWF Brasil 2011.

[142] Sparovek et al. 2010a, and UNICA 2009. Interview Gerd Sparovek and Donald Sawyer.

[143] See http://www.abc.org.br/article.php3?id_article=719.

[144] So would a shortening of the time Brazilian ranchers take to bring cattle to slaughter, from today's 5 years to the average US period of a year and a half. Interview Donald Sawyer.

hectares, mostly pastures"[145], to the unambiguous refutation: there are no such land areas available. As one interviewee put it: "É pura mentira!"[146]

Sugarcane and land competition in Brazil

A central aspect when assessing the forest code relates to how one sees the process of expanding sugarcane cultivation. Is it a process of peaceful co-existence among food, feed, fibres, and fuel crops, or is it rather a conflictual process where different land uses collide with each other: new crops with old crops, old crops with old pastures, new pastures with forests?

Here, the very size of the Brazilian territory contributes to belittle the problem: although the land areas where expansion has taken place are large in absolute terms, they are quite small, almost insignificant, compared to the Brazilian territory as a whole. This is taken advantage of by the Brazilian government which uses scale – the gigantic land areas supposedly available for use – as a pacifying response to all talk of conflicting land use.[147]

Take the increase of sugarcane cultivation which recently has occurred in Brazil: today the total land area of sugarcane – half for ethanol, half for sugar – is 8-9 million hectares, twice as much as only a decade ago. This has turned sugarcane cultivation into one of Brazil's most widely spread crops, superseded only by soybeans (which occupied as much as 24 million hectares 2010) and maize (13 million hectares 2010).[148] As a consequence, sugar was Brazil's fourth most important export product in 2010 (after iron ore, oil, and soybeans).

However, the Brazilian government can show that this still is only a marginal share of Brazil's surface, only one per cent. Even if we consider doubling sugar production by 2017 – this is the government's plan – the new land areas will only require another one per cent of Brazil's territory. Table

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[145] Interview Eduardo Assad.

[146] It's a simple lie! Interview Maria Luisa Mendonça. In any case, it was stressed to me, lands far away from the sugar mills are of no use since the harvested cane must be brought to the plant immediately after cutting in order not lose sugar content. Interview Sérgio Sauer.

[147] "No Brasil há muita terra", Brazil has lots of land, was repeatedly the response I got when voicing concern over sugarcane expansion. Interview Eduardo Assad.

[148] See Conab 2010.

3.1 shows how this is portrayed in the official presentation of the Brazilian zoning exercise to identify suitable land areas for sugarcane.

Table 3.1. Sugarcane cultivation and Brazil's land area, hectares and %

Land	Millions ha	Share of Brazil's territory, %
Total land area	852	100
Potential agricultural and pasture land	554	65
Used agricultural land	236	28
Land areas suitable for sugarcane	65	8
Sugarcane land areas today	8	1
Sugarcane expansion until 2017	7	1

Source: Zoneamento Agroecológico de Cana-de-Açucar 2010.

The actual competition sugarcane → soybean → pastures → forests disappears amidst the overwhelming numbers. And should not scale as such be sufficiently reassuring, an authoritative state-of-the-art publication from the FAO, the UN Economic Commission for Latin America, ECLA, and the Brazilian development bank BNDES clearly assures us that the expansion of sugarcane "occurs on pastures".[149]

Such affirmations are subsequently taken advantage of by UNICA to convince the EU and the US that Brazilian sugarcane ethanol will meet any environmental requirements. In a letter to the EU Commission, UNICA erroneously claims that the sugarcane zoning "forbids" sugarcane expansion in land areas rich in biodiversity. This is misleading for two reasons: first,

[149] See BNDES & CGEE 2008:14. The statement is, as we will see, misleading, but it legitimizes the BNDES to support sugarcane expansion and ethanol production through the largest programme of its agro-industrial portfolio, close to 6 billion reais (3.5 billion USD) in 2009. See BNDES 2010. José Goldemberg, a physicist at the University of São Paulo, who wrote the introduction to the study, has been secretary of state in the Brazilian ministry of the environment and participated in a lead role at the Rio Earth Summit 1992.

The BNDES is important, were it to block access to finance such a move would probably have a greater impact on sugarcane plantations and ethanol producers than codes and regulations as such. But BNDES is not known for being strict when it comes to abiding by rules and it frequently disregards the misconduct of its partners in the Brazilian sugarcane-ethanol chain: out of 89 sugar plants which had obtained finance from the BNDES in the last years, only 15 had not been involved in labour, environmental or fiscal conflicts. See Repórter Brasil 2011:14.

the zoning is an indicative planning instrument with no legal power whatsoever; and, second, it does not prohibit expansion in the Cerrado.[150]

The successful intention of UNICA was to assure that the EU Commission and the US Environment Protection Agency included Brazilian sugarcane ethanol among the list of acceptable feedstocks to meet their respective mandatory blending requirements.

However, reality on the ground is very different from dreams of an ever-expanding agricultural frontier, where sugarcane never replaces existing crops, and where indirect land use change does not occur. A study of land use change in the main sugarcane regions of Brazil shows on the contrary that sugarcane expansion has replaced crops as well as pastures; the displacement was about equal in land area between the two previous land uses, with sugarcane expanding over crops being slightly more common than over pastures. Deforestation, on the contrary, only accounted for one per cent of the new sugarcane land areas.[151] But this is a snap-shot – not an analysis of a process – and it disregards that the Cerrado in many instances had been cleared previously to make room for citrus and soybean.

So, the fact that only a minor share of the lands taken over by sugarcane were forested should not lead us to conclude that there is no land competition. On the contrary: Brazilian sugar cane expansion replaces crops

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[150] See Comments by UNICA to the European Commission's Consultation on Indirect Land Use Change Impacts of Biofuels, 29 October 2010, http://english.unica.com.br/download.asp?mmdCode={1B7F9877-BDD0-4B66-8959-1E4BB6012AE8}.

[151] See Aguiar et al. 2009. The study covered the main sugarcane states of Brazil for two cropping seasons, 2007/08 and 2008/09: São Paulo, Minas Gerais, Paraná, Mato Grosso do Sul, Goiás and Mato Grosso. The equal shares attributed to crops and pastures in this study may however be spurious: other assessments find that most land use change occurs on pastures. For instance, an assessment of sugarcane expansion during the cropping season 2007/2008 found that 67 per cent of the sugarcane was planted on pastures, 67 %, while crop lands accounted for another 31 %, primarily soybeans and maize; only 2 per cent expanded over the Cerrado. See Neves do Amaral et al. 2008:123. Yet another study, of the state of São Paulo 2001-2006, concludes on a similar note that 71 per cent of all sugar cane expansion occurred on pastures, with 14 per cent replacing maize, soybean, coffee, rice, citrus and bananas. See Pires de Camargo et al. 2008, Table 1.

Thus, although deforestation accounts for a minor share of the expansion of sugarcane, it does occur. As one of my interviewees said: "Temos prova da crime!", we have evidence of the crime! Interview Laerte Guimarães Ferreira.

almost as much as it replaces pastures, both of which release a chain of land use transformations.

To understand land change dynamics we should realize that land is not acquired, and forests are not cut down, exclusively for agricultural or logging purposes. Land is transformed in a socio-economical process where speculation and money laundering, drug trafficking and illicit mining, cattle raising and logging mix and blend with the expansion of agriculture and forestry for the production of food, feed, fibres, and fuels.[152]

A landowner who sells a plot in the South, South East or Central South may use his money to acquire many times as large a holding in the North and North East.[153] In other words, land use change is likely to have a multiplier effect, a small change on more expensive land will lead to still larger changes on cheaper land. Changing land prices are relevant indicators of these processes as the country as a whole constitutes one market when it comes to land. In the state of São Paulo, the main sugarcane region, land prices (in fixed terms) increased more than fourfold 1999-2008 following the expansion of sugarcane in that state.[154]

This is the reason why the attempt to belittle the competition over land by comparing the large land areas deforested in the Amazon with the comparatively small land areas dedicated to sugarcane is misleading. The underlying query is: how can large-scale deforestation in the Amazon be explained by small-scale sugarcane expansion? In this tradition, the study, commissioned by the BNDES concludes that "the production of bioethanol does not imply deforestation" as the land area cleared in the Amazon 1998-2007 was ten times larger than the area where sugarcane for fuel was introduced.[155] But this framing of the issue evades the more realistic assumption that when sugarcane replaces pastures, crops, and Cerrado, more expensive land sold in the South is turned into larger tracts of cheaper land in the North.

Before land use change takes place, land normally has changed hands. With reference to the Amazon, the chain of events is described thus (see Figure 3.9):

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[152] Hecht 2005:385-386, Sawyer 2009.

[153] Sawyer 2008:1750.

[154] Novo et al. 2010:783.

[155] BNDES & CGEE 2008:195.

> The land in a particular place may start as public land and be invaded either by large 'grileiros' [land grabbers], by individual squatters, or by 'sem terras' [landless]. Ranchers may purchase large blocks of land from 'grileiros' or may buy a number of small colonist lots. The ranches can be invaded by squatters or 'sem terras', or, if the land is economically attractive for soybeans, the properties can be sold to capitalized farmers.[156]

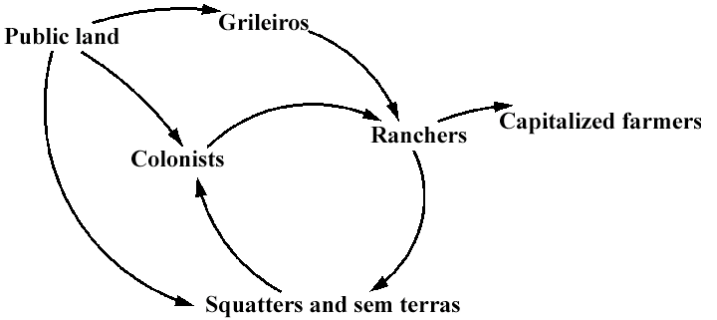

Fig. 3.9. Transformations in the ownership of land over time in the Amazon
Source: Fearnside 2008, Fig. 3.

The process of land use change does not respect national borders: as land areas are taken over from pastures or food crops by sugarcane and soybeans, land acquisition outside of Brazil also follows. One indication of this is the growing presence of Brazilian commercial farming capital in Bolivia.[157] Here, as in the expansion of sugarcane in general, there are various actors engaged, from state banks which provide finance to public agricultural research agencies which promote high-yielding seeds.[158]

The list of international corporations and joint ventures is impressive: large transnational corporations in the energy and agro-business field – from Dreyfus and Cargill to Dow and Shell – are competing for Brazilian land resources with countries such as China and India, sometimes in joint ventures, for instance between Japan and Brazil (Petrobras).[159]

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[156] Fearnside 2008.

[157] Hecht 2005.

[158] Mackey 2011.

[159] Wilkinson & Herrera 2010:751-752, and Repórter Brasil 2010:58-59.

There is also a domestic component to this international effect. The Brazilian state subsidises the expansion of commercial crops – primarily soybeans and sugarcane – and simultaneously opens the door for international agro-corporations. This support goes from cheap credits, via the construction of infrastructure, especially roads and railroads, which open up new land areas for commercial agriculture, to connecting the major production regions with the coast via two ethanol pipelines ("alcooldutos").[160] Today, after spending public funds "for decades", the Brazilian state is offering domestic and foreign capital land it can portray as "ready, productive and technologically efficient".[161]

Regulating agrofuels on a global scale

The Brazilian laws and regulations relating to land use must be seen in their international context: since Brazil aims at selling agrofuel on the global market, it will be subject to the laws, regulations and certification schemes which are being established at the user end, most importantly by the US and the EU. To these schemes, the impact of agrofuel feedstocks on biodiversity and carbon emissions is a key concern.

Taking carbon emissions and biodiversity into account

Initially, the impact of agrofuels was assessed by applying life cycle analysis, LCAs, in order to capture the environmental impact of the production and combustion of agrofuels from field to exhaust pipe; the results were quite encouraging and agrofuels were held to be "climate neutral". But this outcome was to a large extent due to the fact that LCAs as a rule do not take all relevant factors into consideration. Although early

[160] Pietrafesa et al. 2009. The first pipeline runs from Goiás via Minas Gerais and São Paulo to the Atlantic coast; the cost is set at approximately 2 billion USD, financed by a joint venture of public and private Brazilian actors led by Petrobras and including Cosan, Odebrecht and Copersucar. The capacity will be 21 billion litres per year. A second pipeline further south is planned, linking Mato Grosso, Mato Grosso do Sul and Paraná with the coast.

[161] Pietrafesa et al. 2010:14.

LCAs did include indirect use of fossil fuels – fertilizers and other fossil-based inputs as well as fuels spent in production and transportation – they customarily disregarded the effects of direct land use change, the climate impact of changing land use on the land where the various feedstocks were grown. Bringing direct land use change into the picture significantly alters the performance of the feedstocks concerned.

In Table 3.2, the number of years before agrofuels have paid back their carbon debt is shown depending on the previous land use. With the exception of previously degraded lands, the number of years before GHG neutrality will be achieved is surprisingly high, except for Brazilian sugarcane (where the case of sugarcane on Cerrado, yielding a pay-back period of 17 years is an exception; as we have seen, most sugarcane ethanol in Brazil has expanded on crop lands and pastures and thus have pay-back periods of only a few years).

For the remaining feedstocks, the time periods needed to make up for the greenhouse gases emitted when clearing grasslands and forests, respectively, are much, and sometimes much, much longer. The worst-case scenario is transforming rainforest peat land to palm oil, with a repayment period of 423 years. This may seem like an extreme value, but another assessment of palm oil on peatland concluded that the payoff period until carbon neutrality would be as high as 900 hundred years.[162]

A recent IPCC state-of-the art study on renewable energies stresses the importance of factoring in previous land use when assessing the GHG balance. For land which already is used for crops, the carbon payback period was more or less immediate, that is no net emissions from transforming the land into biofuel feedstocks was noted. On the other hand, the conclusion regarding converting forests (not to speak of peatlands) into agrofuels is negative:

> all biofuel options have significant payback times when dense forests are converted into bioenergy plantations.[163]

[162] See SRREN 2011, Figure 2:12.

[163] SRREN 2011:2:77. Indirect land use change was not included.

Table 3.2. Feedstock performance with direct land use change included

Feedstock/fuel	Original land use	Location	Years to recover CO_2
Prairie biomass/ ethanol	Marginal cropland	USA	0
Prairie biomass/ ethanol	Abandoned cropland	USA	1
Sugarcane/ethanol	Cerrado wooded	Brazil	17
Soybean/biodiesel	Cerrado grassland	Brazil	37
Maize/ethanol	Abandoned cropland	USA	48
Palmoil/biodiesel	Tropical rainforest	Indonesia, Malaysia	86
Maize/ethanol	Central grassland	USA	93
Soybean/biodiesel	Tropical rainforest	Brazil	319
Palmoil/biodiesel	Peatland rainforest	Indonesia, Malaysia	423

Source: Fargione et al. 2008, Figure 1. Indirect land use change not included.

This does not augur well for agrofuels' claim to be climate neutral; still *direct* land use change is only the first step in assessing the impact from expanding agrofuel feedstocks on land, and also *indirect* effects should be considered, if possible. In Brazil the sequence of land use change has often been, taking São Paulo as an example: Cerrado → citrus, citrus → soybean, soybean → sugarcane; at the same time pasture → soybean and sugarcane, and forests → pasture, either in close proximity to the expanding agricultural areas – that is in the Cerrado – or further away, for instance in the Amazon.

This is not the way that the sugarcane and ethanol industry would like us to think about the potential land conflicts in Brazil, rather it prefers to give an impression that sugarcane expansion has nothing to do with what happens in other parts of Brazil. See Figure 3.10, which was shown to Maud Olofsson, then Swedish minister for enterprise, when she visited Brazil in 2008. What UNICA obviously wishes to convey is the long distance from the sugarcane zones to the Amazon (the biome, not the Legal Amazon) implying that there is no reason to fear that sugarcane ethanol would affect the Amazon negatively.

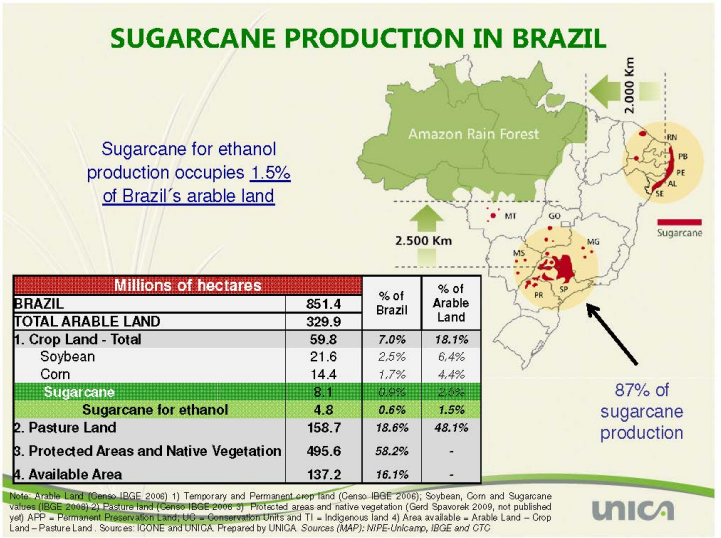

Figure 3.10. Where sugarcane is grown – and not – according to UNICA
Source: www.unica.com.br. This figure frequently appears in the presentations of Unica staff. Figures do not match fully the ones given in Table 3.1.

Brazilian sugarcane is indeed grown as depicted in Figure 3.10, but the presentation is nevertheless misleading, in two respects. First, the major sugarcane zones have biodiversity problems of their own, not inferior to those of the Amazon as we have seen. Thus planting sugarcane (or any other crops) on Cerrado lands may be as dubious an activity as planting them in the Amazon, from an ecological point of view. In other words, the UNICA pretends that there is no *direct* land use change issue in relation to the expansion of sugarcane.

Secondly, the way UNICA frames the issue in its map avoids the whole issue of *indirect* land use change.

Furthermore, the illusion of small numbers is taken advantage of again: with only 1.5 per cent of Brazil's arable land set aside for sugarcane, why should a Swedish minister worry?

It must be recognized, however, that accounting for indirect effects is not easy to do reliably, it adds insecurity to the assessments as the links and impacts are difficult to model. While direct land use change can be measured with satellite images or on the ground, indirect land use change is a

modelling exercise. The most influential study on indirect land use change to date models the impact of increasing US maize ethanol production on land use in Brazil, China, India and the US itself, and concludes that the pay-back time for US maize would be 167 years, considerably longer than with direct land use change only. See Table 3.2, above.[164]

The EU Commission recently concluded that there is significant insecurity in the estimates of what may occur in terms of indirect land use change as a consequence of EU's mandate of 10 per cent renewable fuels in the transport sector by 2020 in its Renewable Energy Directive, RED. In one simulation, one million hectares of indirect land use change took place, in another 5 million hectares, approximately equal to the whole sugarcane land area set aside for ethanol in Brazil. The gap lowest-highest figures for indirect land use change was seven times for maize ethanol, and five times for soybean biodiesel. In other words, there is no generally accepted methodology for measuring indirect land use change.[165]

Studies of agrofuels and land use change, direct and indirect, reach different results depending on the underlying assumptions: what feedstock on what land replaces what previous land use, and results in what knock-on impact when the ousted land use moves to new lands. The only common position, so far, is that land use change from expanding agrofuels will result in net negative emissions for considerable periods of time; this holds for all feedstocks, also sugarcane, and for all previous land uses (except abandoned crop lands).[166]

The bottom line: with today's technique and feedstocks, agrofuels' ecological credentials are not convincing. In fact, including direct and indirect land use change makes defending agrofuels with ecological arguments next to impossible, the time horizon is simply pushed too far into the future to be meaningful for a policy that attempts to contribute to stabilizing the climate in the short to medium term.

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[164] Searchinger et al. 2008:1239. The indirect land use change pattern is modelled on the actual crop land changes which had taken place globally during the 1990s.

[165] See EU 2010.

[166] See Berndes et al. 2010:13 and Figure 9 assessing nine different studies of the net carbon emissions of four agrofuels, sugarcane, maize, rapeseed, and soybean. One study found positive net emissions after 30 years (maize ethanol and rapeseed biodiesel); all the other assessment, 24 in total in the eight studies, found negative net emissions of varying magnitudes also after 30 years.

Furthermore, climate stability is not the only ecological issue to be concerned about when it comes to agrofuels, their impact on biodiversity has also become an issue. The reason is that biodiversity is greatly affected by the planting of feedstocks, and also this effect will vary with the land cover that the feedstock replaces. See Table 3.3.

Table 3.3. Biodiversity impact of land use change

Land cover converted to agrofuel feedstock	Positive impact on biodiversity	Negative impact on biodiversity
Recently abandoned land after intensive use	Immediately positive but not substantial until after 100 years, < + 25 %	
Recently abandoned land after extensive use	Mildly positive after 100 years, < + 25 %	Immediately negative, < – 25 %
Abandoned partly restored lands		Immediately negative, > –25 %, after 100 years still – 10 to –25 %
Grasslands extensively used		Immediately negative, > –50 %, after 100 years still – 25 %
Natural grasslands and forests		Immediately negative: > –75 %, after 100 years still – 60 %

Source: UNEP 2009:71. Impact on biodiversity is measured in terms of percentage change of mean species abundance.

Table 3.3 shows the effect of the expansion of one agrofuel feedstock – in this case wheat – on biodiversity in relation to the previous land use pattern in unusually clear and negative terms; more cautious formulations are common, although there is no doubt that monocultures of the kind we witness in the production of agrofuel feedstocks is antithetical to high levels of biodiversity: transforming diverse crop lands to sugarcane or maize will lead to serious reductions in biodiversity.[167]

Here we can detect a dilemma for the proponents of agrofuels as climate policy: while while climate change impacts biodiversity negatively, so does growing feedstocks for agrofuels. Even if you believe that agrofuels are climate neutral – a doubtful assumptions, as we have seen – their negative impact on biodiversity may be greater than the positive reaped from reducing GHG. The balance of these two counter-movements, according to

[167] Dale et al. 2010:4-5.

the only assessment which I have come across, is not favourable in terms of biodiversity:

> An analysis with a "biodiversity balance" indicator shows that the greenhouse gas reductions from biofuel production are insufficient to compensate for biodiversity losses from land use change, in most cases. This result will be even worse when soil carbon emissions from land use change are taken into account.[168]

Accepting the assessment of Table 3.3, the situation is even more negative regarding the possibility of sustainable agrofuels than when only considering greenhouse gases. A positive biodiversity effect is expected in the short run *only* if agrofuel feedstocks are planted on abandoned and previously intensively cultivated lands; for all other land uses changes, the production of agrofuel feedstocks will lead to biodiversity loss for at least 100 years.

The environmentally most advantageous conversion to agrofuel feedstocks takes place on land that already has been cleared but which now is abandoned, but the assumption that there are "unused" land areas available for agrofuel production has been questioned: apart from the fact that land classified as "marginal" and "abandoned" often is used land and not vacant – fallow lands, for instance – "marginal" lands may also be rich in biodiversity, they are not empty of species.[169] Hence, even the planting of agrofuel feedstocks on "marginal" lands – should they exist – in order to undo their negative carbon balance, may in fact damage important ecosystem services.[170]

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[168] Eickhout et al. 2008:48. Note that the negative conclusion is reached without even considering the underground carbon emissions arising from land use change.

[169] SRREN 2011:2:30.

[170] Gutierrez & Ponti 2009:221. They conclude (p 223): "The transformation of M[arginal] L[ands] for biofuel production may yield a lasting legacy of environmental disruption."

Certification schemes and mandatory regulation

As I noted in the previous chapter, large-scale ethanol production did not originate as a tool of climate policy, but has been fomented for geopolitical reasons, first in Brazil following the oil price hikes of 1973-1974, then more recently in the US and the EU to reduce their dependence on oil. Today, this objective is supported by claims that agrofuels may slow down climate change, thus legitimating the mandatory blending requirements which have been introduced in recent years.

Transferring the direct and indirect impacts of the expansion of sugarcane production into regulations and certification schemes is no easy matter. The literature abounds with statements stressing the complexity of the task, and in a survey of the issues that need to be tackled in order to make certification of agrofuels "work for sustainable development", UNCTAD has concluded that there are 127 concerns which have to be accounted for, 47 of which deal with ecological issues.[171]

If one difficulty here is the sheer number of aspects that a certification scheme has to address in order to capture social and ecological sustainability, another is the abundance of certification schemes that are being elaborated, in one count UNICA found over 30 schemes and regulatory frameworks globally; every major actor is establishing its own rules for what constitutes acceptable agrofuels. This surge in certification schemes, and the various demands and requirements directed from different markets, have met with resistance from the agrofuel industry, and UNICA talks of a "'universe' in constant expansion" (see Figure 3.11).

A spokesperson of the agrofuel industry grumbles that the many certification schemes slow down the turning of ethanol and biodiesel into commodities to be traded on an international exchange, similar to oil. In the port of Santos, in São Paulo, the industry complains, ethanol is stored separately depending on the market, one tank for Sweden, another for France, and this separation holds also when ethanol is loaded onto the exporting ships as if the liquids were qualitatively different just because they have to conform to different certification schemes.[172]

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[171] UNCTAD 2008:45-48.

[172] See *Revista brasileira de bioenergia* 2009(8):36-37: "O etanol pode ser uma 'commodity'", http://cenbio.iee.usp.br/download/revista/RBB8.pdf.

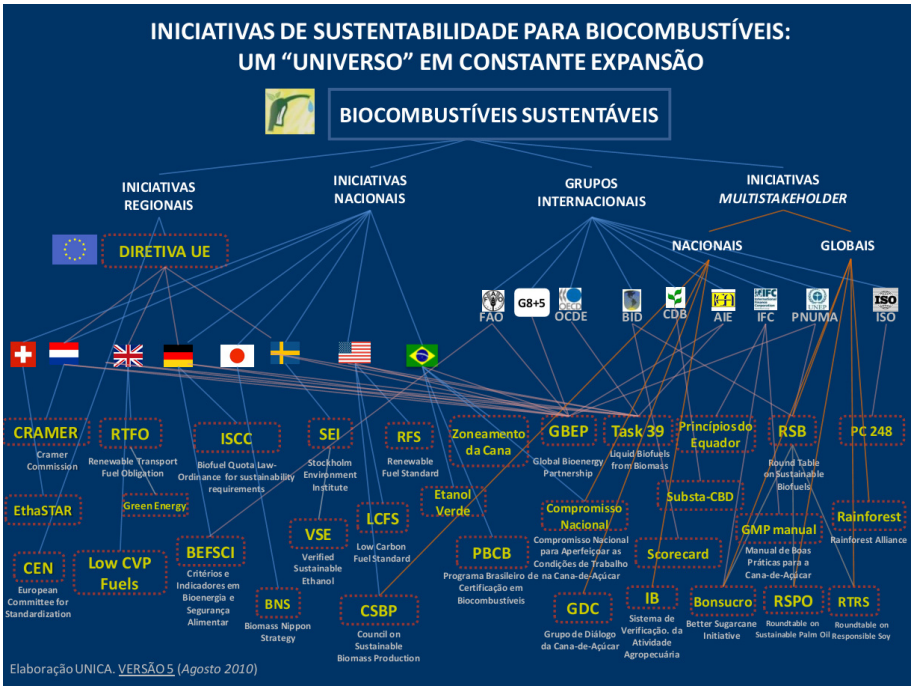

Figure 3.11. An expanding universe of certification schemes – according to UNICA

Source: http://www.iconebrasil.org.br/imagens/banco/arquivos/certification-differentiation.pdf.

To get credibility, most of these certification undertakings involve a large number of actors in the elaboration of criteria and principles, mixing energy corporations, environmental NGOs, states, and national and international financial institutions.

Consider, for instance, the Roundtable on Sustainable Biofuels, RSB, one of the most influential attempts to establish globally accepted criteria for certification. The RSB brings together environmental organisations (such as WWF and the IUCN, both initiators of the RSB), big corporations (Petrobras, Boeing. Shell), Banks (Inter-American Development Bank), ethanol producers (UNICA), rural development NGOs, UN organisations

(UNEP, UNCTAD) and governments (Switzerland).[173] After spending years deliberating, the RSB proposed 12 principles for "sustainable biofuels", covering issues ranging from land rights to greenhouse gas emissions. However, meeting the RSB's standards does not mean that the fuel in question in fact is acceptable from an ecological point of view: surprisingly, the RSB, in spite of its name, does not take a stand on the sustainability of the fuels it certifies:

> the Principles & Criteria do not attempt to quantify an amount of biofuels which could be sustainably produced, *or whether, as a whole, biofuels are sustainable*.[174]

My understanding of such certification schemes is that they do not contribute to changing the way agrofuels are being produced unless they establish what they will *not* accept: which feedstocks are unacceptable, and where acceptable feedstocks cannot be grown. Such schemes have a potential of actually directing agrofuel development in conformity with declared principles, be they social or ecological.

The US and the EU have chosen different approaches here. The US mandate, as noted in chapter 2, is an outspoken tool of geopolitics, i.e. it intends to reduce the US dependence on imported fossil fuels, as evidenced by its origin, the Energy *Independence* and *Security* Act. To foster these objectives, the US Environmental Protection Agency has "determined" that ethanol produced from maize saves 20 per cent of greenhouse gases, just as it has "determined" that sugarcane ethanol saves 50 per cent.[175] Such wholesale acceptance reinforces the already strong likelihood that the US mandate – 137 billion litres by 2022 – will stimulate increased production of feedstocks not only in the US but equally abroad, and thus cause direct and indirect land use change domestically as well as globally, on a large scale.

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[173] See history of RSB's first phase 2006-2009, http://rsb.epfl.ch/page-51764-en.html.

[174] RSB 2010:3, italics added.

[175] EPA 2010:5. This decision by the EPA prompted 190 scientists to warn the US Congress that standards and benchmarks for agrofuels that are to contribute to climate stability have to be carefully thought through: "The lesson is that any legal measure to reduce greenhouse gas emissions must include a system to differentiate emissions from bioenergy based on the source of the biomass." Going one step further and adding the indirect land use change is perhaps asking too much of the regulation since any such calculation would have to be based on hypotheses regarding land use patterns globally. See Open Letter 2010.

The EU RED is also part of this trend – 10 per cent renewable energy in transport by 2020 – but it appears to be more restrictive in accepting feedstocks to meet its more modest objectives (see above): no feedstocks grown on "land with high biodiversity value", nor on lands with high carbon stocks will be included. The land areas which are off limits are quite specific in the RED. Agrofuels should not be grown on:

- primary forests and other wooded lands;
- land areas set aside for nature protection and for the protection of rare, threatened and endangered ecosystems;
- highly biodiverse grasslands;
- wetlands and continuously forested land areas with trees higher than five metres and a canopy of more than 30 per cent; and
- peatland.[176]

This would arguably make it quite difficult to find suitable new land areas to meet the EU blending requirement. For instance, is Brazil's Cerrado, with its high biodiversity value, permissible for agrofuel expansion if Brazil wants to adhere to EU requirements? Biodiesel from Indonesian and Malaysian palm oil plantations in the rain forest should in any case be unacceptable.[177]

Without such negative screening, certification schemes are liable to "green wash" rather than provide reliable and verifiable rules for the sustainable production of agrofuels. One reason has to do with the aggregation of criteria and conditions: how do you assess an agrofuel when some factors are acceptable and some are not? For instance, a survey of 17 social and environmental criteria for judging Brazilian ethanol concluded that "only" two criteria were problematic: biodiversity and competition with

[176] EU 2009, Article 17:3-5. The RED is frequently misquoted as mandating 10 per cent agrofuels, but the directive includes all renewable energy sources, such as wind, solar and biogas.

[177] In an assessment commissioned by the EU Commission of the most likely suppliers to the EU for the mandated agrofuels – countries such as Indonesia, Malaysia, Brazil, and Argentina – national regulations in the supplying countries were found to be acceptable as far as restricting agrofuel production on protected areas and forests was concerned, but were found wanting when it came to meeting the other requirements of RED: biodiversity, protection of peatland and grasslands. See Biofuels Baseline 2008 (2011):79-81.

food production.[178] Is this to be viewed as a serious limitation of Brazilian sugarcane ethanol, or should the feedstock be approved based on the fact that most of the criteria were met?

Another problem with the certification approach is that some principles have almost zero possibility of being met if you take them at face value. Is it a realistic requirement that agrofuels should avoid impacting negatively on biodiversity, as stipulated by Principle 7 of the RSB? It is an open question if any of today's feedstocks will pass this test.

To the delineation of which *lands* could and which could not be used for agrofuels feedstocks, we must add the differences among the various *feedstocks*, they are not equally good or bad. One list of which feedstocks to choose – called "biofuels done right" – only accepts five feedstocks in order not to compete with food, damage biodiversity, or contribute to greenhouse gas emissions:

- perennial plants on degraded lands;
- crop residues;
- wood and forest residues;
- double crops and mixed cropping systems; and
- municipal and industrial wastes.[179]

Most remarkable in this list is that none of today's favoured feedstocks – sugarcane and maize for ethanol, rape seed, soybeans and palm oil for biodiesel – will qualify (unless they are part of mixed or double cropping systems which tend to rule out large-scale plantations and mechanization). In fact the list could be read as a serious objection to the way agrofuels are developed under present conditions, following along pathways with "several

[178] The study concluded in spite of the unknown relations that there were "no prohibitive reasons […] identified why ethanol from São Paulo principally could not meet the Dutch sustainability standards". See Smeets et al. 2006:2.

[179] Tilman et al. 2009. The list is almost identical to the one published by the International Energy Agency "Technology Roadmap for biofuels for transport" two years later, where only the following feedstocks are accepted in order to minimize "the risks of land use change and resulting emissions": wastes and residues, perennial energy corps on unproductive or low-carbon soils, and co-production of energy and food crops. See IEA 2011:18. With such a limited list of acceptable feedstocks, one would be excused to think that IEA – an organ of the OECD – would rather see a continuation of the present fossil-nuclear energy system than its replacement by agrofuels.

wrong options",[180] which means that the risk that agrofuels will increase greenhouse gas emissions, endanger biodiversity, and push out food production is imminent and should be the overriding concern. Put differently, today agrofuels are certainly done wrong.

Concluding remarks

The pressure on Brazilian land areas for sugarcane and other essential feedstocks (such as soybean, or eucalyptus for paper) is part of a growing global scramble for land areas. Such pressures have a tendency to permeate the global agricultural system, erasing the border that distinguishes domestic from international, and international from global. As we have seen, Elinor Ostrom realized that in situations like this, with the land use impact felt over large distances and across borders, small self-regulating governance systems are of no guidance.

The national codes and agreements which regulate Brazil's sugarcane industry (for instance the forest code, the sugarcane zoning plan, the voluntary agreement on working conditions on the sugarcane plantations) are essential but they are only partly successful in terms of their actual implementation and the outcome on the ground. However, their failure could also be interpreted as a success: the far-reaching requirements of the Brazilian forest code and the various public and private, voluntary and compulsory agreements and regulations have convinced the US and the EU that Brazilian ethanol is pure, clean and no threat to biodiversity.

Although environmental concerns may not the main drivers here, they nevertheless provide the ecological credentials needed. As a consequence, agrofuels, in spite of all of their drawbacks, are poised to go on expanding, especially since the steps already taken by the EU and the US to increase the share of agrofuels in their respective energy mixes are mirrored by national regulations in many countries (see Table 2.2, above).

In this perspective, certification schemes, in order to impact actual land use and land use change, must focus on combining a short list of acceptable feedstocks with an equally restricted list of land areas where they can be

[180] Tilman et al. 2009:271.

grown, not very encouraging for the geopolitically driven attempt of finding an alternative to fossil fuels in the short and mid-term.

As we have seen, it is possible to imagine a totally different pathway for the future of agrofuels in countries with a large potential for producing feedstocks such as Brazil: by intensifying cattle grazing, large tracts of pastures could be freed for agrofuels in Brazil, which would permit a multiplication of sugarcane areas without entering into an immediate conflict with other land uses for food, feed, and fibres.[181]

Even if an intensification of cattle-ranching – even zero-grazing was suggested to me as an option in land-abundant Brazil – would free land for sugarcane and soybean without *forcing* ranchers to look for new pastures, it is likely that they would do so anyway since their lands would gain in value when agrofuel feedstocks expand. Thus, agrofuel expansion would still set a process of indirect land use change in motion, leading to the conclusion that agrofuels are not the answer to the search for climate and environmentally friendly energy carriers.

On the other hand, if it is geopolitical considerations and not environmental preoccupations which are at the forefront of the drive to promote agrofuels, this drawback will not constitute a decisive blockage to their continued expansion.

Interviewees (September-October 2010)

Assad, Eduardo, Senior Researcher, Embrapa, UniCamp, Campinas

Ávila, Mário and Silvia Assad de Ávila, Researchers, Centre for Sustainable Development, CSD, Universidade de Brasília, UnB, Brasília

Canuto, Antônio and Isolete Widriweski, Coordinators, Comissão dos pastores da terra, Goiânia

Ferreira, Laerte Guimarães, Coordinator, Laboratório de Processamento de Imagens e Geoprocessamento, Universidade Federal de Goiás, Goiânia

Garrido, Valdemar, Presidente, Sindicatos dos trabalhadores e trabalhadoras rurais de Indiara, Goiás

de Moura, Fábio Alves, Supervisor agriculture, Denusa, Indiara, Goiás

[181] Berndes et al. 2010, chapter 5 make this argument as well as several of my interviewees.

Mendonça, Maria Luisa, Executive Director, Rede Social de Justiça e Direitos Humanos, São Paulo

Panceroli, Paulo, Cane cutter, Ester Plant, Cosmópolis

Pietrafesa, José Paulo, Reserach Coordinator, UniEvangélica, Anápolis

Sauer, Sérgio, Professor, UnB, Brasília

Sawyer, Donald, Advisor, Instituto Sociedade, População e Natureza, ISPN, and Vice-Director, CSD, UnB, Brasília

Silva, Maria Aparecida de Moraes, Professor, Universidade Estadual Paulista & Universidade Federal de São Carlos, São Carlos

Sparovek, Gerd, Professor, ESALQ, Universidade de São Paulo, Piracicaba

Figure 3.12. Sugarcane field after burning and cutting
Burned and cut cane ready for transport to the mill. Sugarcane plantation Denusa, Indiara, Goiás. Photo 2010 KH.

PART II

ECOLOGICALLY UNEQUAL EXCHANGE

I have argued that land areas and land-based resources will become of ever greater importance to the global socio-ecological metabolic process. This implies that the access to, and the control over, such resources will be a central concern to the dominating economic powers.

In this part of my study I want to investigate if the centrality of land areas and land-based resources is reflected in the way that economies trade with each other, in their actual trading patterns: do rich and powerful economies appropriate land areas from poor economies? How can this exchange be measured?

To measure exchange I need to divide the economies of the world into different categories, which is no clean-cut matter: Centre/Periphery, rich/poor, developed/underdeveloped/developing, North/South, high-income/low-income, they all carry two drawbacks: first, they entail a sense of historic progress, a certain flair of eurocentrism, where Centre and North carry connotations of "developed" and "better", in one word, "modern"; and second, the dichotomization does not reflect reality well, economies end up

as special cases, occupying in-between categories such as semi-centre, semi-periphery, or middle-income.[182]

I prefer the terms coined by the global justice movement, global north/global south, indicating that there are rich people in poor countries just as there are poor people in rich. But going down this road would lead me to another blockage, the fact that trade statistics is based on states, which forces me to rely on data for "the amorphous blurs known as national economies" to use Jane Jacobs's phrase.[183]

In the following chapters I am restricted to the classifications applied by other researchers and they typically use income-based categories, which I in those cases also have to make do with. Furthermore, when it comes to energy statistics, the best available information is often provided by the International Energy Agency – an OECD institution – which uses OECD and non-OECD membership to classify countries, something I also will do occasionally. In addition, most of the measures of embodied carbon relate to the UNFCCC and use its listing (Annex I and Non-Annex I countries, respectively) or follow its Kyoto protocol (Annex B and Non-Annex B countries, respectively) to distinguish countries with and without obligations to reduce CO_2 emissions.

In this confusing multitude of concepts and delimitations I have opted for an ecumenical stance and will use the concepts freely and interchangeably, more or less following the categories applied by the sources on which I rely. Thus when I discuss the theory of deteriorating terms-of-trade for raw materials and primary commodities it is appropriate to use Centre/Periphery, since this is the context where this dichotomy was first introduced. Using less than perfect terms may also be one way to pay homage to the pioneers who first framed unequal exchange.

[182] The World Bank now operates with four country categories, according to GDP: low income, ≤ $1,005; lower middle income, $1,006 - $3,975; upper middle income, $3,976 - $12,275; and high income, ≥ $12,276. See http://data.worldbank.org/about/country-classifications.

[183] Jacobs 1985:44.

4. Framing Unequal Exchange

That international exchange may be biased in favour of some traders at the expense of others is not a new insight, but rather as old as trade theory itself: exchange among economies which are different – different climate, different endowment with productive resources such as land, labour, and capital – meant benefiting one trading partner more than the other. In this sense, all trade is unequal, and Paul Krugman even calls it "inevitable" in his influential textbook *International Economics*:

> It is clear that the trade between advanced countries and developing countries is marked by 'unequal exchange'.[184]

But he does not conclude from this clear-sightedness that poor countries should attempt to become more self-sustained or inward-looking in their development strategies. No, the correct comparison, Krugman claims, is not between importing and exporting economies, but rather with what "it would have taken to produce your imports yourself".[185] If a poor economy has to expend more resources to produce a certain good, it had better import it from an economy which can produce it with less. The fact that the poor economy is exchanging more land, labour, or capital for less is of no concern. In other words, this kind of trade theory is more interested in the allocation of a certain volume of production than with the development trajectory of poor economies.

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The framing of unequal exchange has taken place along two parallel logics, one related to labour and one related to energy. The real significance of

[184] Krugman & Obstfeld 1994:269.

[185] Krugman & Obstfeld 1994:22.

exchange, it is held in both of these traditions, cannot be measured by the monetary value of the exchanged goods, but will only be grasped by measuring the exchange in another metric: embodied labour hours in the Marxist economics tradition, most famously by expounded by economist Arghiri Emmanuel; embodied energy in the ecological tradition, where Howard Odum's is the key contribution.

The two approaches are similar in that both argue from the point of view of a theory of value – that is they each claim that the real value of the goods exchanged is different from what the monetary value discloses, and that embodied labour or embodied energy, respectively, is to be preferred to other metrics in order to unveil what really is going on under the guise of equal exchange. In this sense these traditions mirror each other in their attempt to capture "the appropriate measure of value", be it labour or energy.[186]

My interest in discussing unequal exchange is not to assess the "real value" of the exchange but to measure exchange in a non-monetary metric which serves my focus on land areas and land-based resources, leading me to prefer measures of embodied exchange of biophysical resources.

From the point of view of the history of the concept of unequal exchange, however, we can find its origins in quite a straightforward argument after World War II advising poor, raw materials exporting economies to avoid the trap of engaging in an international division of labour which placed poor countries at a disadvantage. The overriding task of economic policy in the periphery was held to be to stimulate industrialization, but there was no consensus how this could be attained. Just to go along with traditional theories would be ill advised, the Argentinian economist Raúl Prebisch wrote in 1950. The "outdated schema of international division of labour" carried "a flaw" in recommending the same policies to poor and rich countries:

> The enormous benefits that derive from the increased productivity have not reached the periphery in a measure comparable to that obtained by the peoples of the great industrial countries.[187]

[186] Lonergan 1988:130 and 133-134; see also Emmanuel 1972, and Odum 1996.

[187] Prebisch 1950:1.

Prebisch claimed that the positive stance towards exposing your economy to international competition rested on committing the error of "generalizing from the particular". The already industrial countries constituted a particular case, according to Prebisch, and suggesting that today's Periphery should do as today's Centre was doing was "based upon an assumption which has been conclusively proved false by facts", namely that "the benefits of technical progress tend to be distributed alike over the whole community" and that hence the "countries producing raw materials obtain their share of these benefits through international exchange, and therefore have no need to industrialize."[188]

The "assumption" that Prebisch inweighed against – that trade benefits all parties – goes back to classical economist David Ricardo who 133 years prior to Prebisch argued in favour of opening up countries to international competition. Ricardo presented a new argument for exposing a national market to international competition, and one which played in the hands of his native country, Great Britain, the dominating industrial power. As we saw in chapter 1, Britain's socio-ecological metabolic regime had already become dependent on importing land areas and land-based resources in great quantities; now it also needed to find markets for its industrial produce.

Ricardo's position was based on a model economy which assumed that capital could not cross borders. This is the most essential pre-condition for Ricardo's argument as otherwise – "if capital freely flowed to those countries where it could be most profitably employed" as Ricardo himself wrote[189] – there would be no difference in prices between different countries, and hence no reason to trade. As a consequence, everyone would suffer, Ricardo claimed: the seller from being restricted to a smaller market, the buyer by having access to fewer goods at higher prices.[190]

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[188] Prebisch 1950:1.

[189] Ricardo 2006/1817:95.

[190] Ricardo also stressed another benefit of trade which came to the fore much later, the peace argument, and he framed it with the same logic that Adam Smith used when he argued for the existence of a market mechanism which like an "invisible hand" turned individuals' self-serving behaviour into a common good (Ricardo 2006/1817:93):

"Under a system of perfectly free commerce, each country naturally devotes its capital and labour to such employments as are most beneficial to each. This pursuit of individual advantage is admirably connected with the universal good of the whole. [...] while by increasing the general mass of productions, it diffuses general benefit, and binds together, by one common tie of interest and intercourse, the universal society of nations throughout the

Hence, Ricardo argued, all countries ought to open up to trade, to the benefit of all. Even countries that had no advantages in terms of productivity, climate, resources or knowledge were well advised to specialize and trade with their superior competitors as this would increase the overall welfare of the two trading countries. In words that have become part of standard economics textbooks, a country should exploit its *comparative* advantages – even if all of them were *absolute* disadvantages. Not so, according to Prebisch, ”outward-oriented development” was ”incapable of permitting the full development of [Latin American] countries.”[191] As a result, a more inward-oriented policy proposed itself.

Prebisch based his argument on a UN study of declining raw materials prices elaborated by economist Hans Singer, who showed that the purchasing power of primary commodities had been declining 1876-1947 by 31 per cent.[192] Singer explained this tendency with the low price and income

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civilized world. It is this principle which determines that wine shall be made in France and Portugal, that corn shall be grown in America and Poland, and that hardware and other goods shall be manufactured in England”.

Neither the Rome Charter of 1957, the founding document of today’s European Union, nor the preamble of the statutes of the World Trade Organisation from 1995, has put the pacifying impact of international trade in more alluring terms. But note that the only producer of manufactures mentioned by Ricardo was England.

[191] Prebisch 1984:177.

[192] Toye & Toye 2003 and Brolin 2006 give detailed accounts of whether Prebisch or Singer was the first to establish a tendency of falling terms-of-trade for raw materials. The verdict: Singer first formulated the argument in an anonymous UN study 1949, which subsequently was used by Prebisch the following year for his recommendation regarding Latin America. Singer seems to be the originator of the Prebisch-Singer Hypothesis, which perhaps should be called the Singer-Prebisch Hypothesis.

Singer himself has claimed that he was inspired by his teacher in Cambridge 1934-36, economist John Maynard Keynes, who shared the idea ”that primary commodity prices would have a long-run downward trend”. Singer 1984:279. Singer’s friendly reference to Keynes for inspiration may owe something to the fact that Keynes ”tirelessly” (and successfully) petitioned to have Singer released from his internment by the British authorities as an ”enemy alien” after fleeing from the Nazis. See Skidelsky 2000:78. Keynes wrote to a friend in his typical style in July 1940, two years before Stalingrad and while the Battle of Britain was still raging (quoted in Harrod 1963:497):

“Our behaviour towards refugees is the most disgraceful and humiliating thing which has happened for a long time. Also rather disconcerting to find that we have such obvious

elasticity of primary commodities: when prices fall or incomes grow, the demand for food and raw materials increases but not very much; in the case of manufactures, however, the situation is the opposite, the demand for industrial goods grows faster than the income.[193] In addition, Singer stipulates a general trend of increasing efficiency whereby technical progress in manufacturing leads to

> a reduction in the amount of raw materials used per unit of output, which may compensate or even overcompensate the increase in the volume of manufacturing output.[194]

In other words, a country which tries to develop by increasing its exports of primary commodities will be confronted by reduced purchasing power in terms of the industrial goods that it can acquire. This, then, is the Prebisch-Singer Hypothesis in short: specialization and division of labour along the raw materials/industrial goods axis would lead to unequal development.

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fatheads still in charge [...] if there are any Nazi sympathisers still at large in this country, we should look in the War Office and our Secret Service, not in the internment camps".

Robert Skidelsky 2000:207, however, claims that Keynes was more concerned with *cyclical* price movements and that the purpose of the trade organisation he wanted to see as part of the 1944 Bretton Woods agreement (which resulted in the World Bank and the International Monetary Fund but not in the International Trade Organisation that Keynes had suggested) was to stabilize wildly fluctuating prices, not to counter a falling trend. In any case, the trade organisation which was established in 1947, the General Agreement on Tariffs and Trade, GATT, did not receive a mandate to stabilize prices or incomes but was on the contrary tasked with removing blockages to trade in manufactures (but not in primary commodities, a fact which I explain in chapter 8).

[193] In economists' parlance: raw materials have low (< 1) and industrial goods high (> 1) price and income elasticities.

[194] Singer 1950:479.

Testing the Prebisch-Singer hypothesis

Prebisch's and Singer's warnings that trade can constrain countries by keeping them poor and dependent on raw materials have sounded repeatedly in the development discourse – although not in the mainstream economics textbooks – for sixty years. From the unequal development of purchasing power follows that trade may lead to a transfer of resources, and that international exchange thus may constitute a process which amasses riches and power at one end of the globe while simultaneously creating poverty and powerlessness at the other.

The real test of the Prebisch-Singer Hypothesis (PSH) is not theoretical, however, but empirical. Singer himself updated his analysis repeatedly, and at the same time broadened the approach by adding to his original argument – focused on raw materials exports – the position of the countries in the global hierarchy. While relying on exporting primary products is bad – he noted a decline of terms-of-trade by more than 2 per cent per annum 1972-1986 – exported manufactures from the Periphery also suffer a gradual erosion of purchasing power, minus 1 per cent per year 1970-1987.[195] Thus, the Periphery comes out poorly irrespectively of what it exports: primary commodities are bad, and manufactures are not good.

What Singer is doing here is in fact combining two approaches – terms-of-trade decline as a consequence of the products traded, and as a consequence of the hierarchical position of the economy – into one argument. He thereby confirms both what is called the PSH I (considering the nature of primary commodities, frequently attributed to Singer), and the PSH II (considering the characteristics of countries in the Centre vs. Periphery, Prebisch's focus already in his 1950 study).[196]

[195] Sarkar & Singer 1991:338. The terms-of-trade of the export of manufactures from the Periphery is measured in relation to its imports of manufactures from the Centre.

[196] Ocampo & Parra 2003:8.

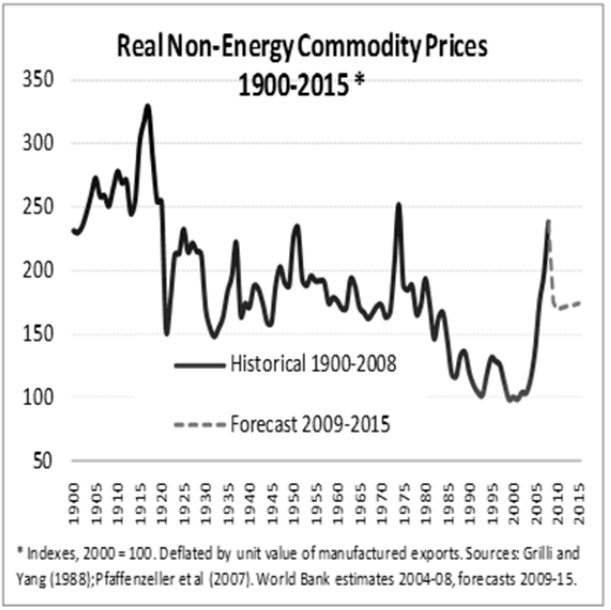

Figure 4.1. Historical terms-of-trade 1900-2008 with a forecast for 2015
Source: Brahmbhatt & Canuto 2010. Note that the forecast for the post-2008 period – the dashed line – has not been borne out so far.; compare Figure 2.1.

That raw materials indeed have lost purchasing power during the last century is graphically shown in Figure 4.1, the most recent update of the data from the last century. As can be seen, there has not been a smooth and continuous downward trend, but rather four dramatic shifts of the terms-of-trade of primary commodities, first upwards, the abruptly downwards, first boom, then bust: World War I, World War II, the raw materials boom in the 1970s, and then again during the present phase which began in the early 2000s. As shown by other studies of the 20th century, the overall loss of terms-of-trade of primary commodities (excluding oil) 1900-2000 amounted to as much as two thirds, not an inconsequential weakening of purchasing power.[197]

[197] See Ocampo & Parra 2003, and Zania 2005. These studies use price indices of 24 non-oil primary commodities, a procedure which has become common.

The evidence is strong for the existence of the PSH in spite of continuous attempts to refute it.[198] What is more, the PSH also seems to be valid for an even longer historic period, at least if we are to believe the only *really* long-term study that I have come across, spanning three centuries. Of the 25 major commodities that are included here – with varying longitudinal data, some series beginning as early as 1650, some as late as 1900 – almost half have shown consistently deteriorating terms-of-trade: aluminium, coffee, hides, jute, silver, sugar, tobacco, tea, wheat, wool, and zinc. For instance, in the case of coffee, it has lost an average of 0.77 per cent of purchasing power annually for 300 years. The remaining commodities showed no trend, which, it merits underlining, also implies that none of the 25 commodities had improving purchasing power trends in the very long term.[199] But such long-term trends are certainly not necessary in order to advise against depending on raw materials exports, a decade of falling purchasing power should be enough to cause alarm.

One last issue regarding the PSH should be addressed. Looking at the terms-of-trade of primary *commodities* tells us little about the situation of individual *countries* if we do not investigate how dependent each economy is on what resource mix, how much of its imports and exports are primary commodities and industrial goods, respectively. Thus, we may postulate, a country may be dependent on primary commodities but still come out all right in terms of purchasing power, it all depends on what it exports and what it imports.

This sounds as an important point, but the fact of the matter is that the most influential measure of the terms-of-trade of the *countries* of the Periphery also shows a consistent negative trend, although of a smaller magnitude than the negative trend for primary commodities: the loss of terms-of-trade for *countries* of the Periphery was one third of the loss suffered by primary commodities in general, still negative although less

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[198] See for instance Kellard & Wohar 2006 who set the condition that a price index must be falling at least during 70 years of the last century in order for them to confirm the PSH. Although the majority of their indices – 15 of 24 – in fact did fall during extended periods of the 20th century, they still conclude that the evidence for the PSH "is less than overwhelming". No matter what one thinks about this 70 years' threshold – and I personally believe it to be too demanding – the debate is certain to continue.

[199] Harvey et al. 2010:375. The 14 commodities which have shown no trend are bananas, beef, coal, cocoa, copper, cotton, gold, lamb, lead, nickel, oil, pig iron, rice, and tin.

severely so.[200] In other words, irrespective of if we look at raw materials or the countries that export them, a negative terms-of-trade trend has been established.

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What about the future? If we were to go by earlier boom-bust cycles, we should expect to be entering a new phase of deteriorating terms-of-trade for primary commodities after the speculative price hikes of the last few years. However, this pattern is not what we saw in chapter 2 – admittedly the time period is too short to allow strong conclusions – rather the contrary: an unusually fast recuperation of the prices of raw materials and other land-based resources (such as food) after the dramatic but brief fall of 2008-2009. I attribute this break with previous movements to the new importance of land-based resources for food, feed, fibres, and fuels.

There is another reason why the downward trend of primary commodity prices is likely to be over: the rise of new industrial giants is likely to have a major influence on terms-of-trade as they pour cheap industrial goods onto the world market, thus contributing to making deteriorating terms-of-trade of raw materials a thing of the past.[201] The logic is simple: the exports of China and others will cause global *manufacture* prices to fall, making primary commodities (expressed in industrial goods) costlier. As a result, the PSH will be turned on its head: terms-of-trade will develop to the benefit of the exporters of primary and land-based commodities, just as happened in the period leading up to the financial crisis in 2008, and then anew today.

[200] Grilli & Young 1988:35. This conclusion holds for the period 1945-1986.

[201] I first encountered this argument in Kaplinsky 2006.

Unequal exchange of labour

To development economists in the Marxist tradition, Singer's approach does not hold much water: focussing primarily on the goods exchanged, and on market prices, he is criticized for disregarding the internal class and power relations, and thus misunderstanding the preconditions for growth and development. One influential representative of this view was economist Paul Baran, who already in 1957 dismissed the importance of deteriorating terms-of-trade (in spite of the fact that he recognized that the hypothesis could hold true). The problem with giving deteriorating terms-of-trade an important place in the explanation of the divergence between the Centre and the Periphery, according to Baran, was that it could lead us to preferring *improving* terms-of-trade. But higher prices would lead to higher profits, and such were not necessarily to be welcomed, Baran wrote, formulating a warning for what today is called the "resource curse" or the "paradox of plenty":

> [I]t cannot be stressed too strongly that the relevance of the magnitude of profits to the welfare of the peoples inhabiting the underdeveloped countries or to their countries' economic development depends entirely on to whom these profits accrue and on the use which is made of them by their recipients.[202]

By implication, deteriorating (or improving) terms-of-trade would not decisively affect the situation one way or the other. In this political economy strand of development thinking, underdevelopment is seen as a process primarily caused by internal class relations. Poor countries were poor because the dominating class did not mobilize and make productive use of the potential surplus that they had access to, Baran stressed, and enumerated four characteristics which explained why the potential of poor countries was not being realized:

[202] Baran 1967:233.

> *One* is society´s excess consumption (predominantly on the part of the upper income groups [...]), the *second* is the output lost to society through the existence of unproductive workers, the *third* is the output lost because of the irrational and wasteful organization of the existing productive apparatus, and the *fourth* is the output foregone owing to the existence of unemployment caused primarily by the anarchy of capitalist production and the deficiency of effective demand.[203]

Not much space for external factors in explaining underdevelopment, it seems. However, at about the same time another economist, also influenced by the Marxist tradition, Arghiri Emmanuel, constructed a case which combined internal and external circumstances, focusing on the unequal exchange of labour. Emmanuel referred back to Ricardo's argument that trade benefits all trading partners, "a wonderful game, in which each partner has every chance of winning without the slightest risk of losing" in the sarcastic words of Emmanuel.[204] Emmanuel then sided with the PSH II (i.e. the variant which targets the country and not the character of the goods traded) when he stated that the exchange that ought to be studied is the one between countries, not the exchange of specific products:

> Are there really certain products that are under a curse, so to speak; or is there, for certain reasons that the dogma of immobility of factors prevents us from seeing, a certain category of countries that, whatever they undertake and whatever the produce, always exchange a larger amount of their national labour for a smaller amount of foreign labour?[205]

In sum, it is not the fact that poor countries export agricultural products that explains why they are poor, nor does the fact that rich countries export manufactures explain their wealth. To refute this thought, Emmanuel asserted, "one has only to mention Australia, New Zealand and Denmark, on the one hand, and Spain, Italy and Japan, on the other". Instead, Periphery countries are poor because they have an abundance of labour which keeps wages low, and low wages lead to the use of more labour in the products exported than the products imported. It is a vicious circle breeding

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[203] Baran 1967:24.

[204] Emmanuel 1972:xiii.

[205] Emmanuel 1972:xxxi. The "dogma of immobility of factors" refers to Ricardo's assumption that capital cannot cross borders.

underdevelopment and poverty in the Periphery and development and wealth in the Centre, and Emmanuel held that the unequal exchange was the central mechanism for creating an ever-widening gap Centre-Periphery:

> I think it is possible to state that unequal exchange is the *elementary* transfer mechanism, and that, as such, it enables the advanced countries to begin and regularly to give new impetus to that *unevenness of development* that sets in motion all the other mechanisms of exploitation and fully explains the way that wealth is distributed.[206]

This is somewhat contradictory: if it is the place of a country in the global hierarchy which is the essential issue – as Emmanuel claimed in the previous citation – then the unequal exchange of labour cannot be the elementary transfer mechanism which creates uneven development.

In any case, it has become a standard tenet of development economics – Marxist and Keynesian alike – not to accept an international division of labour where the Periphery sticks to its primary commodities. The importance of avoiding unequal exchange is underlined by economist Samir Amin who presented an estimate of what the Periphery would have received from its exports had its labour obtained the same salaries as in the Centre (and had it thus not been relegated to supplying raw materials to the Centre):

> The hidden transfers of value from the periphery to the center, due to the mechanism of unequal exchange, are of the order of $22 billion, that is to say, twice the amount of the 'aid' and the private capital that the periphery receives. One is certainly justified in talking of the plundering of the Third World.[207]

Ecologically unequal exchange

As noted, the mainstream thinking of the post-war period was coloured by the drive for economic growth, frequently regarded as tantamount to development. This perspective led Emmanuel to complain that too little land was cultivated, too few rail road lines built, too little cement and steel

[206] Emmanuel 1972:265.

[207] Amin 1976:144.

produced, too few cars. In short, Emmanuel maintained, "our world still largely lies fallow".[208]

Today, such lament seems inappropriate, to say the least, the socio-ecological metabolic transition which I discussed in chapter 1 has resulted in rapidly growing global energy and material flows, leading to a material use which by all indications is far beyond carrying capacity for most ecological systems.[209]

That systematic and unequal exchange of land-based resources has taken place for a long time is a trivial proposition in world system analysis and global environmental justice studies.[210] But it was only in 1985 with Stephen Bunker's influential study of the Brazilian Amazon that this understanding of ecologically unequal exchange began to gain prominence, as he postulated a difference between extractive and productive economies in terms of their opposed "dynamics of scale".

According to Bunker, an extractive economy suffers increasing costs of production as it expands, while a productive economy gains from decreasing costs as it grows, hence laying the ground for an unequal exchange between the two. The reason for this imbalance is found in the nature of the two economies: while the productive economy becomes more efficient as its scale (i.e. volume of production) increases, the logic works itself out quite differently for extractive economies:

> In extractive systems [...] unit costs tend to rise as the scale of extraction increases. Greater amounts of any extractive commodity can be obtained only by exploiting increasingly distant or difficult sources.[211]

Bunker's "dis-economies of scale" for raw materials and land-based commodities – as volume increases, unit production costs rise – ought to lead to *a tendency* for extracted resources to become more expensive (in terms of the industrial goods that they are exchanged for), i.e. the opposite of what the Prebisch-Singer hypothesis (and most of the statistical data) suggest.

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[208] Emmanuel 1972:262.

[209] Krausmann et al. 2008:652. See also MA 2005 for a dismal summary of the state of the world's ecosystems.

[210] See Hornborg & Crumley 2007, and Hornborg et al. 2007 for representative contributions.

[211] Bunker 1985:25.

This is surprising: the theory which launched the discussion on ecologically unequal exchange could in fact be interpreted in the opposite light: exchanging extracted resources which are becoming ever more expensive – Bunker's assertion – should have a tendency to benefit countries specializing in such exports when they exchange them for industrial goods which are assumed to become ever cheaper. If this does not in fact take place, we need a theory to explain why.

In his 1985 study, Bunker did not provide any explanation of why dis-economies of scale do not result in the opposite tendency of unequal exchange from the one he postulates, but one answer could be that as long as there are alternative sources for accessing extractive resources, prices may be kept low as corporations abandon old raw material sources once they become difficult to access or expensive to exploit, and turn to new territories and locations where the ease of exploitation is greater and the costs thus lower. Of course, as resource exploitation progresses around the globe, this solution to Bunker's paradox will come up against its own limits in terms of increasing difficulties and costs of finding and exploiting primary resources, and an inverted terms-of-trade trend will finally come through.

In later work, Bunker returned to the paradox, this time with a solution: as the growing socio-ecological metabolism has needed raw materials from ever more distant – and hence costly – sources,

> capital has responded to this contradiction by increasing the size and speed of transport in ways that reduce the ton-mile cost of moving large volumes of raw material.[212]

Thus, although an extractive economy suffers from dis-economies of scale as the exploitation of land-based resources is forced to reach for ever more distant locations, the actual prices do not reflect this logic as it is countered by ever cheaper transports. In other words, the dis-economies of scale of raw materials are made up for by the economies of scale of transports which accompanied, and facilitated, the colonial and post-colonial appropriation of distant raw materials.

In this understanding of ecologically unequal exchange, steps taken to secure transport routes are key elements, and each phase of imperial domination can be related to a particular transportation strategy: the Dutch,

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[212] Bunker & Ciccantell 2005:xiii

Spanish and Portuguese advanced navigation techniques and built vessels with larger carrying capacities; the British constructed steam-powered ships and trains, and made sure that the infrastructure increased simultaneously: the Suez canal was built 1859-1869; the US connected the east and west coasts by rail, and opened up the Panama canal 1904-1914; the Japanese developed bulk transport overseas, a strategy more recently used also by China.

The outcome was that primary commodities were hauled longer and longer distances, an important but disregarded aspect of globalization: in 1960, less than 20 per cent of all iron ore mined was shipped over the oceans; by 1990, this share had grown to more than 35 per cent, a development propelled especially by resource-poor Japan. Since then, transport has kept on growing. See Table 4.1

Table 4.1. Transport of bulk commodities c 1960 and c 2000, tons and %

	1960	**2000**	**Change (%) 1960-2000**
Number of dry bulk carriers	471	5,554	1,179
Total tonnage (dwt in millions)	9	290	3,200
Transported petroleum billion ton-miles	1,650	8,180	496
Transported iron ore billion ton-miles	34	2,545	7,485
Transported coal, billion ton-miles	264	2,509	950

Based on Bunker & Ciccantell 2005:217-218.

Concluding remarks

Bunker stresses that countries present ”variable mixes of extraction and production” and uses his perspective to ”explain the extreme and progressive underdevelopment of the Amazon.”[213] Thus, his analysis applies primarily to

[213] Bunker 1985:13.

regional economies, and ecologically unequal exchange may have as much to tell about local and intra-national unequal development as about disparities between nations.[214]

Many countries, which seemingly are coherent units, are in fact split along various fault lines: Brazil's South vs. its Northeast, China's coast vs. its interior, India's North vs. its South. Also Sweden portrays such a rift south-north, and it goes a long way back. As the Swedish chancellor Axel Oxenstierna is said to have exclaimed when Sweden was a regional power in the early 1600s, pointing to Norrland, the mineral rich northern province of Sweden:

> Norrland is India within our own borders if only we understand to make use of it.

Bunker himself, however, held that he was complementing Emmanuel's understanding of unequal exchange with an ecological dimension of *country* trajectories. Towards the end of his study he says:

> If we amplify [Emmanuel's] notion about wages to include all measure of unequal exchange, then we can say that *countries* where labor value and natural values are seriously undercompensated will tend indeed to be underdeveloped.[215]

On the one hand this lapse into a national scale is understandable, since almost all available statistics use nations as their units of analysis; on the other, however, it is problematic, as national borders may be less than ideal for understanding the actual ecological exchange which takes place, especially some of the more egregious forms of environmental load displacement which I will touch upon in chapter 7.

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[214] This restriction in Bunker's analysis is underlined by Hornborg 2007a:8.

[215] Bunker 1985:252, italics added.

5. The Importance of Measures

Measures to capture the relationship between the economy and nature can be divided into those that assume that economic and natural resources are exchangeable for each other, and those that assume that there is no such substitutability as a rule. Following this distinction, two concepts of sustainability exist, one weak (based on substitutability) and one strong (complementarity), each conception associated with a separate discipline, the weak with environmental economics, the strong with ecological economics.

Table 5.1 presents some of the salient differences in the world views of environmental as compared to ecological economics. Ecological economists maintain that there is a sharp dividing line between themselves and environmental economists, based upon the latter group's disinterest in, not to say ignorance of, natural science.[216] "The basic observation", says economist Inge Röpke in her history of ecological economics as a discipline, is "banal and difficult to disagree with":

> The human economy is embedded in nature, and economic processes are also always natural processes in the sense that they can be seen as biological, physical and chemical processes and transformations.[217]

But although the banality of this observation may be striking, it nevertheless gives ecological economics its defining characteristic: while environmental economics is concerned with efficiency and assumes substitutability between economic and ecological resources, ecological economics has a completely different set-up of assumptions and concerns. Most importantly, ecological

[216] This is brought home by the fact that two influential and early studies of ecological economics include physical concepts in their titles: Georgescu-Roegen 1971 (the entropy law) and Martínez-Alier 1990 (energy). Similarly, the original 1977 sub-title of Daly 1992 reads "The Economics of Biophysical Equilibrium and Moral Growth". As Martínez-Alier 1990:viii underlines: ecological economics = biophysical economics.

[217] Röpke 2004:296.

economics rejects the weak sustainability understanding, where the deficit in one sphere, say nature, can be made up for by surpluses in other spheres, say economic or social. In other words, ecological economics maintains that the various spheres must be measured separately from each other, with metrics which are adapted to the characteristics of each. Not even the economy is captured well by the gross domestic product, GDP, as it only includes market activities and does not differentiate positive from negative activities. Adding a price tag to the GDP for ecological destruction does not improve the situation; on the contrary, efforts to "green" the GDP rather end up making the indicator still weaker and less transparent.

On the other hand, physical indicators are appealing to ecological economists as they negate the assumption of weak sustainability, that is, they do not attempt to lump together economic, social and ecological aspects in one measure but keep them separate.

Table 5.1. Conceptual differences between environmental and ecological economics

	Environmental economics	**Ecological economics**
Main task	Efficiency: efficient distribution of scarce resources	Scale: the capacity of the ecosystem to sustain the economy
Main assumption	Substitutability	Complementarity
Conception of sustainability	Weak	Strong
Main indicators	GDP corrected for environmental costs (Green GDP)	Physical indicators in relation to ecological carrying capacity

However, if we look closer we will find that both perspectives – environmental economics and ecological economics – make use of aggregations which hide as much as they disclose. For instance, environmental economists apply monetary measures to value ecosystem services, just as ecological economists attempt to capture the demand from the economy on the same services in one physical measure where many different functions are summed up: even approaches which claim to be free of economism may still apply aggregated physical metrics, which leads to a risk of reducing all ecological situations to one dimension, albeit physical

and not monetary.[218] This is what happens when we express a number of ecological concerns in hectares or tons to indicate their ecological load.

Many ecological measures nevertheless try to come up with one sole indicator for the ecological sphere as a whole, which opens them to the objection that they measure incommensurable ecological states. They are thus reductionist but strong in the sustainability dimension.

It should be recognized that such simplifications have advantages: they allow complex and contradictory tendencies to be expressed in simple figures, yielding an easily transmitted impression of clarity. The most successful of these simplified measures is the GDP, which in the public domain serves as indicator of wealth and development in addition to its purported value as a measure of the level of economic activity; on the other hand, non-reductionist indicators run up against the difficulty to present easy to grasp summaries of the state of nature.

The Millennium Ecosystem Assessment, MA, exemplifies the strength and weakness of the non-reductionist sustainability approach. The MA analysed 24 ecosystems – called life supporting systems – divided in three groups: provisioning services, eg. food and fiber; regulating services, eg. climate and water; and cultural services, eg. tourism and spiritual values. These systems are neither substitutable for each other, nor for services or goods provided by the economy; none of the services is valued in monetary terms; and the MA does not attempt to present an overall summary picture. The conclusion therefore is limited to the rather general, but alarming, statement that

> approximately 60 % (15 out of 24) of the ecosystem services examined [...] are being degraded or used unsustainably.[219]

The approach of the MA goes against the grain of one of the leading trends in environmental economics, assigning monetary value to environmental services, but it also questions the trend in ecological economics in finding easily understandable macro-indicators for the economy-nature interface.

Thus, we are stuck, it seems to me, between the Scylla of clarity in confusion (the green GDP, aggregated physical measures) and the Charybdis

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[218] Such indicators, whether monetary or physical, I call ”reductionist” as they reduce complex reality into one common metric (money, hectares, tons, litres).

[219] MA 2005:16

of confusion in clarity (the long list of physical measures of the state of the environment, the many social indicators).

One reason why you could end up welcoming environmental economics in spite of its shortcomings is that it at least manifests an interest in the relationship economy-nature, contrary to the dismal record presented by mainstream economics as a whole, as testified by a review of the major themes that leading mainstream economists have studied. Biologist Paul Erhlich has noted that a number of crucial problem areas – crucial to environmental as well as ecological economics – have been neglected, he could not find any of the following key-words in the titles of the most quoted articles in 41 of the most prestigious economics journals during the last 35 years:

> abatement, adaptation, aquifer, biotic, biosphere, cap and trade, carbon, carrying capacity, climate, depletion, discount(ing), ecology, ecosystem, entropy, ethics, footprint, forest, fossil, free-rider, fuel wood, genuine investment, genuine wealth, global, globalization, justice, market failure, Montreal, natural capital, natural resource, nuclear, open access, overdevelopment, ozone, Pigouvian, pollution, population, property rights, public good, shadow price, social capital, soil, solar, steady-state, substitute(ability), tax shifting, timber, toxic, trade, tragedy, treaty, utility, valuation, war, warming, water, well-being.[220]

Maybe it is this lacuna when it comes to what is studied and discussed among traditional, neo-classical economists which led ecological economist Herman Daly to defend his controversial choice of joining the World Bank in 1988 thus:

> my present livelihood as a World Bank economist has to date given me somewhat less cause for shame than my previous livelihood as a university professor of economics.[221]

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[220] Ehrlich 2008. The 41 economics journals did not include any environmental or resource economics journals. 146 articles, each with at least 500 citations, qualified for inclusion in the sample. To be fair: in the titles of the 146 articles surveyed, the terms “energy”, “migration”, and “externalities” appeared once, and “environment”, “consumption” and “distribution(al)" twice.

[221] Daly 1992:14. He added: “This personal judgment is of course subject to revision as life goes on.” Two years later, Daly changed his verdict and left the World Bank.

Compared to mainstream neo-classical economics, the environmental branch may be considered to be a step in the right direction: environmental economists at least realize that there is a problem-area regarding the relationship between the economy and the environment, and although they assume substitutability this does not preclude them from recognizing that one kind of resource may be exploited at such a rate that other kinds of resources will not be abundant enough to compensate for the loss. One example, taken from a group of well-known environmental economists exemplifies this:

> We also find evidence that several nations of the globe are failing to meet a sustainability criterion: their investments in human and manufactured capital are not sufficient to offset the depletion of natural capital.[222]

Here, not even substitutability suffices to secure (weak) sustainability. Is it a symptom that even environmental economists realize that something is seriously wrong? To me as an ecological economist, of course, the thought that humans and machines as a rule could "offset the depletion of natural capital" is a perfect example of the limitations of environmental economics and its weak sustainability concept.

Ecological services valued in money

Environmental economists show their concern for nature preferably by applying economic concepts to nature, specifically to the ecological services provided. This is brought out quite openly in a (popular, non-academic) explanation of the topic "valuing ecosystem services" written by two environmental economists:

[222] Arrow et al. 2004:167.

> A new paradigm is emerging in environmental economics. It views the natural environment as a form of capital asset, natural capital. This is fully in keeping with what is happening in other areas of economics, where alternative forms of capital are central to analyses that have become influential – human capital, intellectual capital, and social capital being notable examples.[223]

Although it is correct to say that an econom(ist)ic language has succeeded in permeating other disciplines (sociologists talk of social capital rather than trust and social cohesion; strengthening of education becomes investing in human capital), and although you may well consider nature to be a provider of ecosystem services, nature also distinguishes itself from economic forms of capital by the fact that it as a rule cannot be created by human endeavour (although it certainly may be destroyed by it).

This should also be clear to environmental economists, if they consider the scope of ecosystem services that need to be valued. Here is one list of relevant "services" to be accounted for: food, sources of wild medicinal plants, water purification, flood control , erosion control, carbon sequestration, habitat for wildlife, reservoir of biological diversity, nutrient recycling, detoxification of chemicals, recreation and outdoor adventure, aesthetic enjoyment, solitude, and spiritual fulfilment.[224]

To ecological economists, putting price tags on all of these services would be misplaced, but environmental economists seem to think that almost any monetary measure – irrespective of its weaknesses – is to be preferred to none. They openly admit to applying an anthropocentric definition of the eco-services they will attribute monetary values to:

> Broadly defined, ecosystem services are the benefits people obtain from ecosystems.[225]

Similarly, a joint study by the World Conservation Union, the Nature Conservancy and the World Bank boasts of its lopsided approach:

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[223] Heal and Barbier 2006:1.

[224] Bingham et al. 1995: 77.

[225] Heal & Barbier 2006:2.

> The focus of this paper is decidedly anthropocentric: the ecosystem benefits we consider are those that contribute to human well-being.[226]

One is left wondering if other ecosystem benefits exist which do not contribute to human well-being one way or the other, and which therefore are left out of the calculus. A clear example of the point I made above: environmental economists are not interested in – or not familiar with – the natural sciences.

Although there are environmental economists who do recognize that substitutability is a problematic assumption, they remain locked in the logic of weak sustainability. Take one of the most noted assessments to date of the value of ecosystems services to the global economy.[227] The authors recognize that "ecological services are only substitutable up to a point", an important concession as it means that the monetary value of these services would move towards infinity as the irreplaceable service approaches zero. Still, they carry out bold calculations and conclude, far from infinity, that the value of ecosystem services was in the range of 16-54 trillion USD annually. Although the global GDP was only about 18 trillion USD, the monetization of the global ecosystem services resulted in a surprisingly weak recommendation:

> We must begin to give the natural capital stock that produces these services adequate weight in the decision making process, otherwise current and continued human welfare may drastically suffer.[228]

In defence of their procedure, the authors argue that fixing a price tag to ecosystem services is:

> necessary in order to address the question of what is the optimum 'scale' or size of the economy relative to the ecological life support system. To address

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[226] IUCN et al. 2004:4.

[227] Costanza et al. 1997:257. The ecosystem services considered were gas regulation, climate regulation, disturbance regulation, water regulation, water supply, erosion control and sediment retention, soil formation, nutrient recycling, waste treatment, pollination, biological control, refugia, food production, raw materials, genetic resources, recreation, and cultural services.

[228] Costanza et al. 1997:259.

> this question one must be able to directly compare the value of ecosystem services lost with the value of other economic services gained.[229]

This is, however, not correct: scale is not measured in monetary terms but in physical. The question of scale has everything to do with ecological systems' capacity to absorb waste and provide services, and nothing to do with how the market values such services, nor with whether they can be replaced by economic activities.

Welfare and sustainability

Valuing global ecosystem services in monetary terms can still be seen as a cautious undertaking, compared to what is being attempted when economists argue in favour of metrics that cover economic, social and environmental aspects of reality in an attempt to capture sustainability in its weak meaning.

Index of sustainable economic welfare (ISEW)

One such metric based on substitutability surprisingly has Herman Daly as its originator, the Index of Sustainable Economic Welfare.[230] Here the GDP is recalculated to arrive at an indicator that captures economic as well as welfare considerations, while simultaneously taking nature into account.[231] The general pattern is that GDP and ISEW follow the same path of growth from 1950 to about 1970, i.e. during the golden era of capitalist development post World War II. During this epoch there is no reason for elaborating the ISEW as the GDP on its own quite well captures the change in (weak) sustainability. But beginning in the 1980's, the two measures move apart. In

[229] Costanza et al. 1998:68.

[230] See Daly & Cobb 1990, Appendix.

[231] The ISEW does not include re-investments (as re-investments do not constitute economic growth but only a replacement of an already existing but depleted stock of infrastructure), defensive or negative expenditure (such as environmental protection and cleaning up). Then, environmental costs are deducted. Finally, the income is weighted by the income distribution (a more equal distribution entails a higher level of welfare). Also note that the ISEW is not actually an index but a monetary measure.

spite of economic growth, the other components – especially income distribution and environmental degradation – tend to press the ISEW down: while GDP grows, the ISEW indicates that (weak) sustainable economic welfare is declining.

Assuming substitutability, as does the ISEW, actually makes the it even "weaker" than the GDP as it includes more realms of reality in its single indicator. Furhtermore, the ISEW is set in a national frame, and no account is taken of the fact that environmental loads are displaced through international trade.

The ISEW, being a monetary measure, is comparable to the GDP, and this seems to be its entire justification. As Herman Daly explained it was elaborated because he and his co-author

> wanted to engage orthodox economists in discussion, and knew that unless we to some extent played by their rules they would ignore us. [232]

And they go on to explain:

> In the Middle Ages holy thought had to be expressed in Latin; today it must be expressed in numbers.[233]

But instead of being convinced by this "holier than thou" line of argument, I feel even more doubtful about the usefulness of this alternative to the GDP.

Net adjusted savings

There is a danger in engaging with economists on their terms, as evidenced by the procedure adopted by the World Bank in elaborating its own alternative measure of welfare, Net Adjusted Savings. The measure was initially called Genuine Savings Indicator, but "genuine" or not, there is complete substitutability between the economic and ecologic spheres, just as in the ISEW.

The way to go about maximizing future income growth (the World Bank definition of sustainability) "when exploiting natural resources" is to:

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[232] Daly & Cobb 2007.

[233] Daly & Cobb 2007.

> save an amount equal to the rent from those resources to sustain the highest possible level of consumption.[234]

All concerns regarding the scale of the economy and the limits established by nature disappear, the only consideration is that a society saves a monetary value that is equal to the rent that it foregoes when the natural resources are exploited; if this is achieved, a society has a positive Net Adjusted Savings, i.e. its development path is "sustainable".

The World Bank measures "genuine savings" in a country by adjusting GDP for depreciation (which is the same procedure that the ISEW uses, i.e. the net domestic product replaces the gross), adding investments in human capital (as measured by spending on education) and finally deducting the costs for depletion of minerals, energy, forests, and damages from local and global air pollution. A catch-all item is added, called "intangible capital" which is assumed to capture institutional quality and social capital, a kind of residual category for all that is unknown.

The conclusion is that intangible capital explains as much as 85 per cent of the total wealth of rich countries, while produced capital only accounts for 14 per cent, and natural capital for a dismal one per cent!

Two observations are warranted here. First, that the whole method is questionable since the residual category has the overwhelming explanatory power: if intangible capital, which we cannot invest in, is the main explanation why countries reach sustainability, very little space is left for politics. Second, nature disappears into insignificance, a surprising outcome for a measure which purported to complement GDP with an environmental dimension. But it is not the first time that environmental economists lose sight of the crucial role of nature for the socio-ecological metabolic flows, for instance when environmental economist William Nordhaus downplayed the possible impact of climate change on the US economy by arguing that agriculture only accounted for an insignificant 3 per cent of GDP.[235] But although agriculture may account for a small share of the monetary economy, it nevertheless is a precondition for life as such, its share of GDP is simply not a meaningful measure of its importance.

In spite of such obvious drawbacks, the Net adjusted savings indicator has an aura of reliability since growth and savings rates for all countries are

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[234] World Bank 2005:102.

[235] Quoted in Daly 1996:63-64.

adjusted downwards, in some cases transforming growth into retrogression, especially for oil-rich countries of the Middle East and North Africa. But then comes the crunch: after identifying the reason for declining "real wealth" in the depletion of "natural capital", i.e. oil, the World Bank goes on to recommend more investments *in the economy*.

When monetary logic takes over

A claim made by adherents of monetary metrics is that although many indicators and measures are far from perfect, they nevertheless enable us to make better and more informed decisions. Let us see how this works out in relation to cost/benefit analyses.

Cost-benefit analyses

Environmental economists like to compare costs against benefits over time in order to assess the consequences of economic growth on the environment. In such calculations, the discount rate applied in the analysis largely decides the outcome, especially if we consider long time periods, which is common with respect to ecological issues. For instance, the only real difference explaining the opposing conclusions reached by two influential studies calculating the economic costs of climate change is their choice of discount rate. While Nicholas Stern argues in favour of taking action now to mitigate climate change – costing one per cent of world GDP – William Nordhaus comes out strongly in favour of doing basically nothing. Their models of climate change are more or less identical, but they part ways when it comes to discount rates: low – implying valuing the future highly – in the case of Stern, and high – valuing the future lightly – for Nordhaus.[236]

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[236] Dasgupta 2009:54-56. Stern used 1 per cent as discount factor while Nordhaus opted for 4 per cent. Dasgupta observes that this means that Nordhaus is valuing future losses seventeen times lower than Stern.

Recently, Nordhaus has attempted to dissociate himself from the bad company and the non-action that his previous arguments concerning climate change invited, and he now claims, after "studying this subject for many years", that a pro-active stand is warranted: "Policies implemented today serve as a hedge against unsuspected future dangers that suddenly emerge

But is Stern right in fixing the discount rate so low that it becomes practically of no importance? The answer depends on two things: first how you value the future and future generations: if you value them as highly as you value today's generations, then you should abstain from discounting at all.

The choice also should depend on what you think will happen in the future in terms of resources available to coming generations to mitigate and adapt to climate change: if future generations will be wealthier, then it makes sense to use a positive discount rate; should they on the contrary be poorer than the present generation, the discount rate should be negative. In other words, then we should do more now, while we still have resources. Inter-generational justice simply prescribes more action today.[237]

Summers's World Bank memo

Over 20 years ago, in December 1991, a memo was leaked from the World Bank, signed by the then chief economist Lawrence Summers, advocating the transfer of polluting industries and toxic waste to poor countries. The argument, Summers wrote, was based on "impeccable […] economic logic".[238] He stated three reasons why the transfer of waste from rich to poor should be undertaken:

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to threaten our economies or environments. So, if anything, the uncertainties would point to a more rather than less forceful policy – and one starting sooner rather than later – to slow climate change." See Nordhaus, WD: "Why the Global Warming Skeptics Are Wrong", *NY Review of Books*, March 22, 2012.

[237] Dasgupta 2009. Stern's own argument is actually that a negative discount rate makes sense, since he believes that incomes will fall over time: poorer people in the future will suffer more from the effects of climate change, and have fewer means to deal with them, than less poor people today. See Stern 2006:36-37.

Perhaps a religious world-view, as expressed by Daly & Cobb 1990:239, is worth listening to: "As far as we know God is not impatient for all lives to be lived soon. We believe the divine discount rate is zero."

[238] The memo was sent by Summers but is rumoured to have been drafted by his staff member at the World Bank Lant Pritchett, who subsequently became a member of the Copenhagen Consensus under the leadership of statistician Björn Lomborg. For Summers' memo, see http://www.globalpolicy.org/component/content/article/212/45462.html.

- "a given amount of health impairing pollution should be done in the country with the lowest cost, which will be the country with the lowest wages".
- "The costs of pollution are likely to be non-linear as the initial increments of pollution probably have very low cost".
- "The demand for a clean environment for aesthetic and health reasons is likely to have very high income elasticity".

Summers's first argument is tantamount to valuing people's lives by their earnings, not a very respectable opinion, and furthermore one which is at odds with the declaration of human rights which declares all humans equal.

His second point is based on non-linear increases of costs of pollution, which may very well be a reasonable assumption[239], which leads him to suggest that waste should be dumped on poor (not yet polluted) countries and peoples, because the damage costs there would be less. Summers's concern here is with distributing (i.e. spreading) a given environmental load in as "efficient" a manner as possible and he does not seem preoccupied by the scale of the problem, hence illustrating one of the main points of Table 2.1: environmental economists have not realized that the crucial issue is the scale of the economy vis-à-vis nature.[240]

What about Summers's third point which in non-technical language reads that only rich people care about the environment? This is a pet idea of environmental economists, arguing that economic growth is actually a boon to the environment: as people get rich(er), they will care more, and, hence, they will be prepared to pay more for the environmental services they now treasure more.

Summers's career was not hurt by his memo: after leaving the World Bank he was appointed secretary of the treasury under President Clinton, and subsequently became chairman of the board of Harvard University. He is now chief economic advisor to President Obama.

[239] Perhaps I should add that even better – in the sense of better reflecting reality – is to assume not only non-linear increases, but also the existence of thresholds and of non-predictable cost curves. This should lead us to conclude, in total opposition to Summers, that we need to operationalize the precautionary principle.

[240] Daly recounts a discussion he had with Summers while both were on the staff of the World Bank. When asked by Daly "What is the optimal scale of the macro economy relative to the environment?", Summers replied: "That is not the right way to look at it." See Daly 1996:6.

The view that only rich people care about (can afford to care about) the environment is unexpectedly also part of geographer David Harvey's explanation why ecological concerns have come to be seen as important by (some) people in the North:

> The rising tide of affluence in the advanced capitalist countries after World War II increased middle-class interest in environmental qualities and amenities, "nature" tourism, and deepened concerns about environmental dangers to health.[241]

Harvey argues in class and social terms, and counter-poses people's needs against the needs of nature and ecosystems, portraying the ecological position as extreme and lop-sided:

> The demand [by environmentalists] to cease the production of all toxins, hazardous wastes, and radioactive materials, if taken literally, would prove disastrous to the public health and well-being of large segments of the population, including the poor [...] And the right to be free of ecological destruction is posed so strongly that it appears to preclude the positive right to transform the earth in ways conducive to the well-being of the poor, the marginalized and the oppressed.[242]

I read such statements as reflecting an anthropocentric system of values which pits social and human needs against those of the environment; the former are always given priority at the expense of the latter. Paradoxically, Harvey, in spite of all his Marxist rhetoric, ends up close to mainstream economists: first things first, and that is growth; the environment always has to wait. The central issue regarding the scale of the economy, the volumes of the global socio-ecological metabolic flows, are of less (no) concern; it is not only environmental economists who disregard natural science.

Lest we accept such arguments in favour of postponing reckoning with the ecological costs of economic growth, we should realize that we are dangerously close to the logic proposed by Summers for a spatial re-arrangement of the global production system by yielding to the pro-growth justification: when everybody is better off, we will deal with the environment. Summers's logic approves of an already established and

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[241] Harvey 1996:380.

[242] Harvey 1996: 400.

consistent practice of dumping waste on poor and marginalized peoples, also within the countries of the North, such as the depositing of toxic and nuclear waste on land areas primarily inhabited by indigenous or minority populations.[243] No wonder, then, that Summers's infamous memo has become "canonical"[244] for the environmental justice movement: he *is* representative of mainstream economics, and also less well-known economists advocate an "efficient" distribution of environmental loads in a logic which is no different from Summers's;[245] Poor countries are actually advised to embrace being "pollution havens" in order to stimulate their own development, pushing Summers's argument to the extreme. As we are told in a naked apology for environmental load displacement, welcoming the appropriation of ecological space by the North:

> We must also be aware that L[ess] D[eveloped] C[ountrie]s may have a greater social tolerance and greater absorptive capacity for pollution which can be considered a legitimate source of comparative advantage and lead to the conclusion that the relocation of dirty production to LDCs is 'good' for the country in question.[246]

The logic underlying the argument is that pollution does not have to be sustained for ever, once growth takes off, it can "fortunately" be mitigated as the South then will become more environmentally conscious and impose more environmentally-friendly regulations and taxes, just as the North did. The problem, it is claimed, is "transient"[247] or "small"[248] or, according to the World Bank, "not trivial but also not dominant".[249] This happy-end result, we are led to understand, is caused by the benefits which the pollution-intensive foreign investments will bring:

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[243] See Martínez-Alier 2002:168-194 for illustrative cases from the USA and South Africa.

[244] Martínez-Alier 2002:194, note 10.

[245] For instance, in a comprehensive survey of the literature on environmental load displacement, the authors argue against "an economically inefficient level of pollution". See Brunnermeier & Levinson 2004:10.

[246] Cole et al. 2008:539. To be on the safe side, the authors provide this argument twice, in identical wordings (in footnotes 4 and 7).

[247] Mani & Wheeler 1998:244.

[248] Copeland & Taylor 2004:67.

[249] World Bank 2008:30.

"Ultimately, income growth will be the answer."[250]

Economists such as these refuse to study what is, and transfer their attention to what might be. In this way, the appropriation of ecological space, although real, is a small, passing phenomenon which needs no serious policy intervention of any kind, it will go away by itself.

In the meantime, "efficiency" requires that waste and pollution should hit societies and peoples according to their respective capacities for dealing with them. Since this capacity to accommodate pollution is assumed to be greater in the global south than in the global north, this is also where the waste ought to go.[251]

Measures of ecological exchange

My prime concern is to measure the exchange of land areas and land-based resources in order to assess the extent to which ecologically unequal exchange occurs. Five metrics will be used. As I discussed earlier, physical indicators are appealing to ecological economists as they negate the assumption of weak sustainability, although they still may be suffering from a certain degree of reductionism. Let's see how my five measures fare on these counts, sustainability and reductionism.

Ecological footprints (EF)

Ecological footprints (EF) are defined on the Global footprint network webpage as a measure of "the amount of biologically productive land and water area an individual, a city, a country, a region, or all of humanity uses to produce the resources it consumes and to absorb the carbon dioxide emissions it generates".[252] Land areas appropriated are calculated as the sum

[250] Mani & Wheeler 1998:245. The upbeat conclusion does not reflect upon the fact that the authors have excluded greenhouse gases from their analysis.

[251] In chapter 7, I will return to the issue of environmental load displacement and appropriation of ecological space for waste.

[252] See http://www.footprintnetwork.org.

of the areas occupied for renewable resources – forests, croplands, fisheries and grazing lands – plus a hypothetical land area for the absorption of carbon emissions, all expressed in "global hectares" with average land productivity.

This procedure means that various land areas are substitutable for each other, which entails a certain reductionism as many land areas in fact cannot perform the same ecological functions; to use my previous terminology, land areas are not perfectly fungible. But, as I also argued, they are sufficiently fungible to allow us to use concepts as encompassing as global hectares.[253]

A problematic aspect of the EF approach from the point of view of measuring the exchange of land areas is the fact that the carbon component of the footprint is a measure of hypothetical CO_2 absorption and does not measure actual land use (in contrast to the other components of the footprint, except the fish area). Already in the early 1990s when the footprint was being elaborated, two ways to calculate a "fossil footprint" were discussed: one option was to use the land area needed to grow agrofuels to replace fossil fuels; the other option was to calculate the land area needed to absorb the carbon dioxide that was emitted from the use of fossil fuels.[254]

In the end, as we have seen, the latter method was chosen, as the consequences of using the absorption areas were seen to be conservative compared to using agrofuel land area-equivalents. In other words, the total

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[253] More controversial is that the EF also includes an area for fish catch, here fungibility is questionable. See Borgström Hansson 2003:167-168.

In a recent article, 29 researchers, including the originators of the ecological footprint approach, William Rees and Mathis Wackernagel, argue that "the footprint of nuclear land should not be calculated using the fossil fuel equivalent method, as this equivalency does not reflect any measurement of actual demand on the biosphere." See Kitzes et al. 2009:1999. This is true, but the same logic would also question the method for calculating the carbon footprint.

[254] Another controversial issue is how to account for nuclear power. Initially, the footprint of nuclear power was calculated as the land area that would have been needed to absorb the emissions of CO_2 from an equivalent volume of electricity produced by fossil fuels. But since actual fossil fuel electricity production units had very different efficiency levels, no reliable estimate of the relevant ecologically productive land area could be calculated. This is the reason for deleting the nuclear power footprint given by the WWF 2008. For a nuclear dependent country like Sweden, omitting the nuclear power footprint has reduced the total EF of Sweden by as much as 14 per cent, from 6.1 glha to 5.1 glha 2003-2005.

footprint is smaller than it would have been had agrofuel substitutes been used to calculate the carbon land area.[255]

The EF only accounts for part of the total human footprint – renewable resources and carbon emissions – and then compares this with the total land areas available without taking account of the needs of other species in terms of ecologically productive land areas. This is part of the claim for relevancy that the approach presents: if humankind is overusing the available land area without calculating the needs of competing species the real predicament of making human life styles "fit" within the available space is exacerbated.

But it also gives the impression that the appropriation of land areas is less serious than it is. For instance, when the Global footprint network, GFN, concludes that human needs are 151 per cent of the available renewable resources, this is in fact a serious understatement as it leaves out the needs of all other species apart from humans. Similarly, when the GFN calculates the global overshoot day – September 27, 2011 – and concludes that it occurs three days earlier for each passing year, the actual overshoot takes place much earlier.[256]

Water footprints (WF)

The Water footprint (WF) of a nation is calculated in analogy with the Ecological footprint, using three sources of water: rainwater (called green water); use of ground or surface water for irrigation (blue water); and a

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[255] Wackernagel & Rees 1996:72-74. The land area needed to absorb the carbon dioxide from 100 GJ (100 billion joule) was set by Wackernagel & Rees at one hectare; if that land area instead had been used to grow feedstocks for ethanol they estimated it would only have yielded 80 GJ. Thus, by choosing the carbon sequestration figure, the EF is smaller than it would have been, had the land area for equivalent ethanol production been used. Today, however, and using Brazilian techniques and land yields, the equivalent sugar cane area is smaller, and introducing Brazilian sugarcane data – 139 GJ per hectare – would give a smaller footprint than the one used by the EF. See Table 8.1, below.

Furthermore, there are more alternatives to consider for accounting for the fossil footprint, for instance calculating the *past* bio-capacity embodied in today's fossil fuels; such an exercise would yield larger land areas for the fossil footprint than with today's method. See Kitzes et al. 2007:6. Thus, the EF may still be seen as a conservative estimate of the actual human appropriation of renewable land-based resources.

[256] See //www.footprintnetwork.org/en/index.php/GFN/blog/today_is_earth_overshoot_day1.

measure pollution estimated by the volume of clean water needed to dilute polluted water to acceptable standards (grey water).[257]

Grey water is not used water but a hypothetical volume, similar to the land areas estimated for a hypothetical absorption of CO_2 included in the ecological footprint.

Physical trade balances (PTB)

A measure of the impact of the economy on the environment that is gaining increasing currency is materials flow analysis (MFA). The measure consists of four metabolic flows, fossil energy, ores and industrial metals, construction minerals, and biomass. See Figure 1.1, above. From the MFA data, I use the traded goods, expressed as Physical trade balances, PTB.

The MFA is suitable to measure resource flows, but its composition makes it less than ideal for capturing the ecological aspects of this flow. In fact, MFA reduces ecological load to one common physical indicator – tonnes – and does not differentiate among its constituent parts; consider the implication of putting mercury on an equal footing with sand and concluding that the small flow of mercury constitutes less of an ecological problem than the much larger flows of sand.[258]

Another drawback of the MFA is that it excludes two material flows which are central from an ecological point of view, water and air emissions, on account of their huge volumes: had they been included, the other four components of the MFA would have been dwarfed. This is perhaps

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[257] See Hoekstra & Chapagain 2008, and Hoekstra & Mekonnen 2012.

[258] Adriaanse et al. 1997: 6. One response to this weakness of the MFA is to abandon all ambitions to use it as an *ecological* indicator and simply see it as "'value-neutral' physical accounts that include all materials, regardless of their economic importance or environmental impact." Mathews et al. 2000:2.

Other proponents of MFA also recognize the problem: "we must ask whether the total weight of materials processed by a socioeconomic system is a viable indicator for 'environmental impact' at all." Amann et al 2002:6. The authors respond to their own query in the affirmative, although not very convincingly. Assuming, they write, that technology remains fixed and does not change, then "increases in resource input imply increase in environmental impact." (ibid.) But the assumption is unrealistic, why would technical change suddenly stop, as Friedrich Engels asked already 1844. See chapter 1, above.

understandable, but it does not reinforce the ecological significance of the MFA.

Human appropriation of net primary product (HANPP)

While material flow analysis measures the socio-ecological metabolism in physical terms, it does not relate it to a "limit of growth"-discourse. But it is possible to complement MFA by another physical metric to establish how far away, or indeed how close, we are to the limits of the natural system supporting the economy. This is the Human Appropriation of the Net Primary Production (HANPP), a measure which estimates the share which the economy uses out of the available ecological resources.

The point of departure is the *potential* net primary product, NPP, of land measured via satellite images, normally in areas of 10x10 km, and calculated in an appropriate physical metric, frequently carbon flow per year. From this indicator, the *actual* available net primary product is deducted; the difference constitutes the HANPP. The remaining net primary product is then what is available for all other uses on earth after humans have had their share.[259]

Estimations of the relative size of global HANPP varies, from the highest and most frequently quoted, 40 per cent[260], to the most recent firgure, 22 per cent.[261] In other words, humans appropriate 22-40 per cent of the potentially available net primary production on earth, leaving only 60-78 per cent to all remaining species and ecosystem functions.

These estimates are for the world as a whole, but as Figure 5.1 shows, the regional distribution of HANPP is extremely uneven and does not follow country borders; HANPP rather indicates population density. This gives us another indication that ecologically unequal exchange is not always meaningfully captured by national data and metrics.

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[259] Vitousek et al. 1986, Erb et al. 2009, and Haberl et al. 2007.

[260] Vitousek et al. 1986:373 added a dire prognosis to their assessment of HANPP: assuming business as usual, in two decades' time humans will appropriate half of the net primary product.

[261] Haberl et al. 2007:7.

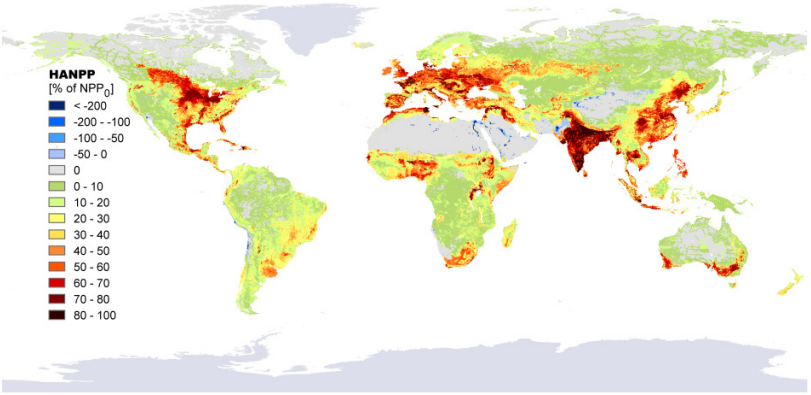

Figure 5.1. Human appropriation of net primary production 2000, % use of potential NPP
Source: http://www.uni-klu.ac.at/socec/inhalt/1191.htm. The orange, red and black areas indicate regions where the HANPP is above 40 per cent, reaching total human appropriation in the densely populated regions of the globe, irrespective of average level of income.

Carbon footprints (CF)

Carbon footprints have gained increasing attention for reasons related to climate politics and to the discussion about environmental load displacement. The Kyoto Protocol deals with domestic emissions of GHG, but a significant part of the emissions occur in the production of goods for export: should not those emissions be attributed to the countries whose demand set the factory wheels spinning, rather than to the countries where the goods were produced?

If we let the place of production constitute the point of recording the emissions, we are likely to hold the Periphery responsible for specializing in carbon-intensive products, while the importing countries of the Centre will appear to be less of a problem for the climate.[262] By measuring how carbon emissions of an economy are used for domestic consumption and exports, respectively, while also taking into account the carbon emitted to produce

[262] Peters et al. 2011.

the goods imported, the CF allows us to calculate the net balance in embodied traded carbon.

Concluding remarks

Monetary metrics cannot tell us what ought to be done to assure sustainability in the strong sense, and even scholars who argue for monetary measures are doubtful as to how far they reach:

> Many would question whether monetary valuation alone adequately captures what decision makers need to know to confront irreversible ecosystem modifications that could have serious long-term economic and social repercussions.[263]

Instead, by opting for strong sustainability we are better assisted by physical measures in order to be able to define limits, or levels of acceptable environmental pressure, or veto thresholds, or safe minimum standards, or border values, or headline indicators, all of which can be used to indicate what it is that political measures should attempt to achieve: strong sustainable development.[264]

Four of the measures I will use to assess ecologically unequal exchange – Ecological footprints, Water footprints, HANP, and Carbon footprints – have an important feature in common: they capture the *embodied* ecological content of the goods traded, not what they actually contain when they cross the borders. What we can see or measure in terms of area or water or carbon content of the goods traded is only a small part of the ecological resources which actually went into producing them. In other words, we have to impute these values by estimating the resources which were used up along the production chain. Our metrics are thus *embodied* hectares, litres, and tons.

But also the Physical trade balances, which give the actual weights of traded goods, are in fact only indicating part of the total, as the *indirect* weight is unaccounted for. For instance, when we weigh the exports of

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[263] Bingham et al. 1995:75.

[264] See Martínez-Alier et al. 1998:284, and IUCN et al. 2004:29 for a discussion of these concepts.

copper from Chile or Zambia, only the weight of the refined copper which passes the border is included, not the much heavier loads which were deposited domestically along the route from the mine to the port.

More to the point of my investigation of the role of land areas and land-based resources is how the varying metrics capture the aspect of traded "land". See Table 5.2. With my purpose of measuring ecologically unequal exchange of (embodied) land areas, the Water and Carbon footprints stand out as the least useful.

Table 5.2. A comparison of measures of ecological exchange

Measure	Ecological relevance	Transfer of resources	Land relevance	Availability of data
EF	High	Embodied	High	Low
WF	High	Embodied	Low	Low
PTB	Low	Real	Medium	High
HANPP	High	Embodied	High	Low
CF	High	Embodied	Low	Medium

Comparing the various metrics on the basis of one specific application of them – to measure ecologically unequal exchange – should however not be taken as an overall assessment of their usefulness or relevance, the metrics are different precisely because they have been elaborated with different purposes in mind.[265] For instance, the HANPP is spatially specific when it measures human appropriation of net primary production on a given territory, but it is not equally useful in order to establish "sustainability thresholds". It should be clear that 100 % HANPP would be "destructive" as no space is left for other species than humans, but what about 22 per cent, or 40?

Ecological footprints, on the other hand, while providing such thresholds – either in relation to global standards or in relation to national land areas – are not locally relevant but rather capture the ecological overshoot, that is the appropriation of global or national resources.

[265] See Haberl et al. 2004 for a comparison of HANPP and EF.

6. Measures and Interpretations of Ecologically Unequal Exchange

It is now time to use the five measures which I discussed in the previous chapter, the ones which combine strong sustainability – which renders them ecologically meaningful – with data availability in terms of embedded trade flows. This combination makes them good candidates for assessing ecologically unequal exchange, EUE.

Measuring ecologically unequal exchange

A word of caution before I start. When estimating EUE, imports of ecological resources are seen as positive, and exports as negative, the opposite of what we are used to think when considering trade flows (where exports of goods and services are positive, and imports negative). In ecological terms, however, and this is what counts here, imports allow a country to access ecological resources, while exports signify that a country gives up ecological resources. Hence,

EUE = Ecological Imports – Ecological Exports.

A Negative EUE means that a country is sending away more ecological resources than it is receiving; a positive EUE implies that a country is obtaining more ecological resources from the exchange than it gives up.

Following the theory of ecologically unequal exchange discussed in chapter 4, a simple hypothesis may be formulated: the sign of the EUE is positive for economies of the Centre and negative for economies of the

Periphery. This is the hypothesis that now will be tested with five different metrics.

Measure 1. Ecological footprints (EF)

In Figure 6.1 I have calculated the EUE for 2006 with the help of Ecological footprints. Compare China and Brazil to the US and Japan for the clearest differences: China and Brazil have large negative EUEs, the US and Japan large positive EUEs. This pattern substantiates my hypothesis: the North is appropriating ecological resources from the South.

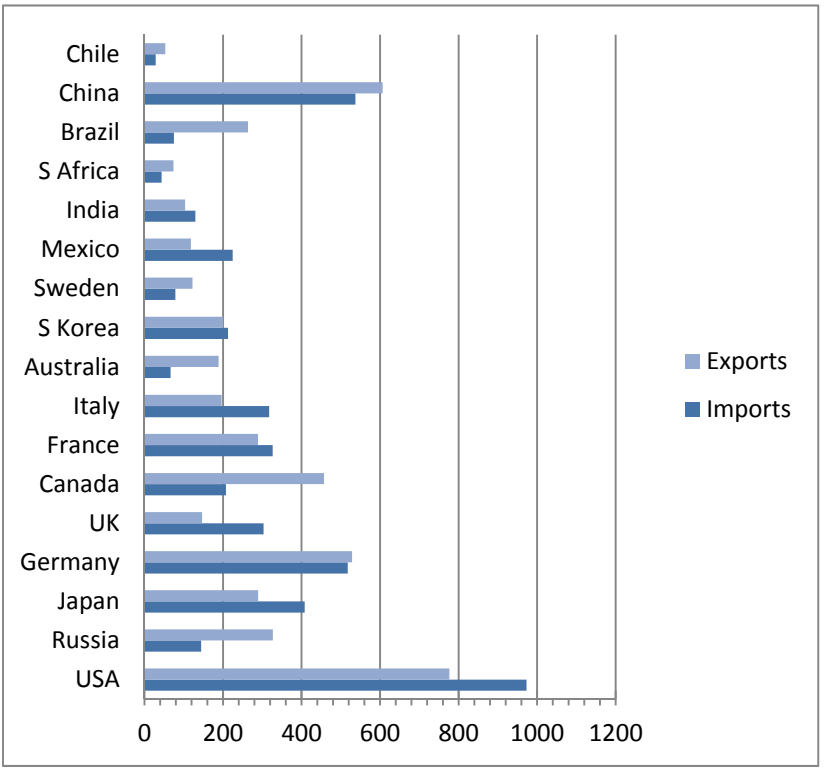

Figure 6.1. Ecological footprints of trade 2006, million global hectares
My calculation. Data courtesy Global footprint network. The countries included are the 13 major trading nations and the most recent members of the OECD (Chile, Mexico, and South Korea) plus Sweden.

However, there are exceptions, and they indicate that countries which are relatively resource rich, and thus resource dependent, such as Sweden, Canada and Australia, have negative balances.

Measure 2. Water footprints (WF)

The WF indicates which countries are net exporters of agricultural products and which are the importers; this relationship seems to be the most important for explaining the pattern of exchange, where the large food and feed crops exporters have negative water balances, while we find agricultural importers on the positive side.

The pattern does indicate that there is EUE, but it does not follow the traditional division of the globe North/South. On the contrary, water footprint balances show that arid regions gain from trade. See Figure 6.2.

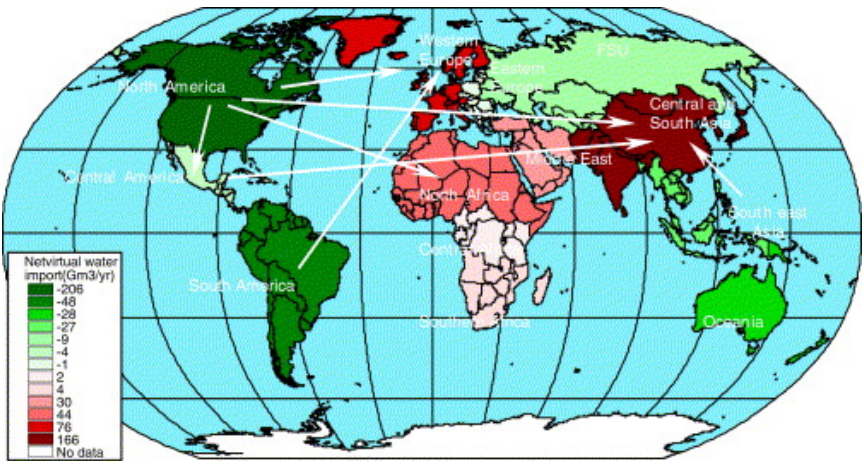

Figure 6.2. Water fotprint balances of 13 world regions, average 1995–1999

Source: Hoekstra & Hung 2005:Figure 2. The arrows show the net virtual water flows between regions (>20 Gm3 yr−1). Green coloured regions = negative net water imports = net water exports = negative EUE. Red coloured regions = net virtual water imports = positive EUE.

Measure 3: Physical trade balances (PTB)

Physical trade balances (PTB) for the last forty years are given for industrial and developing countries, respectively in Figure 6.3. For the nine points in time which have been calculated, industrial countries have a positive, and developing countries a negative PTB. The pattern is consistent over the whole period: the North's PTB has been growing ever more positive (imports > exports), while the South's PTB has remained negative.

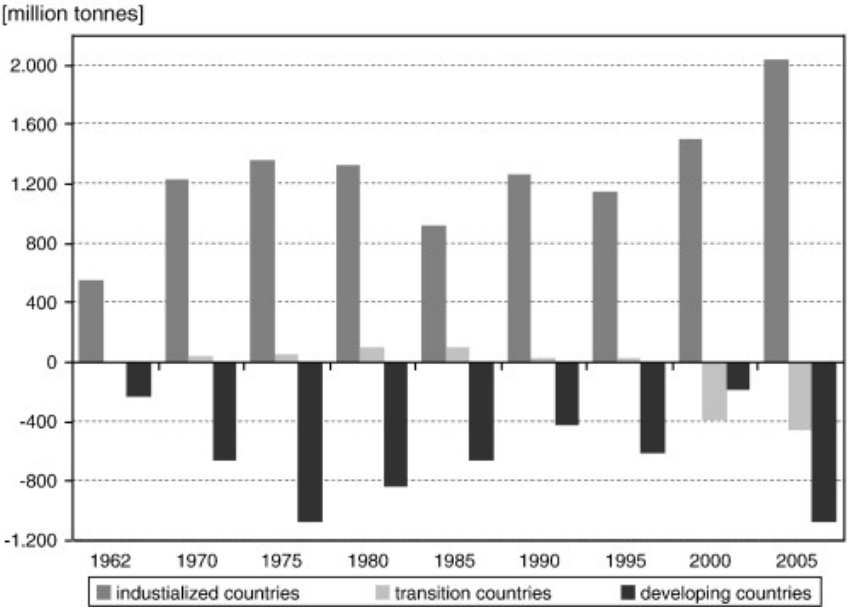

Figure 6.3. Physical trade balances of industrialised, transition and developing countries 1962-2005, million tons
Source: Dittrich & Bringezu 2010:1846. Note that the positive and negative flows do not blance out, which inidcates data weakness.

Measure 4. HANPP of traded biomass (HANPP)

I have only come across one study of HANPP, dealing with trade in biomass, where the EUE is possible to measure. See Table 6.1.

Table 6.1. Share of embodied HANPP in biomass trade 2000, %

Net-exporters (Negative EUE)	Share of global embodied HANPP in biomass exports, %	Net-importers (Positive EUE)	Share of global embodied HANPP in biomass imports, %
USA	23	Japan	13
Australia	15	China	8
Argentina	14	Netherlands	6
Brazil	12	South Korea	6
Canada	11	Mexico	5
Thailand	4	Italy	5
Kazakhstan	3	Belgium-Luxemburg	4
Ukraine	2	Germany	4
Malaysia	1	UK	4
France	1	Spain	4

Source: Erb et al. 2009a:Table 1

Net agricultural exporters are net suppliers of HANPP (i.e. have negative EUE, left column of Table 6.1), while densely populated countries are large net importers (positive EUE, right hand column), a picture quite similar to the one we obtained above using WF.[266]

Measure 5. Carbon footprints (CF)

Figure 6.4 gives the share of embodied emissions in trade for the top 15 emitters of CO_2 (plus the global average). As a whole, a little more than 20 per cent of domestic emissions are for exports. In general, Figure 6.4 confirms the hypothesis, the sign of the balance shifts with the position of

[266] The table incidentally shows the high degree of concentration of globally traded biomass: the five largest net-exporters account for as much as 75 per cent of exported biomass, and the ten largest for 86 per cent; for the net-importers, the equivalent figures are 38 and 59 per cent.

the economy in the global system: the Centre is net-importing and the Periphery net-exporting CO_2, just as the EUE hypotheses suggests, compare, as before, USA and China.

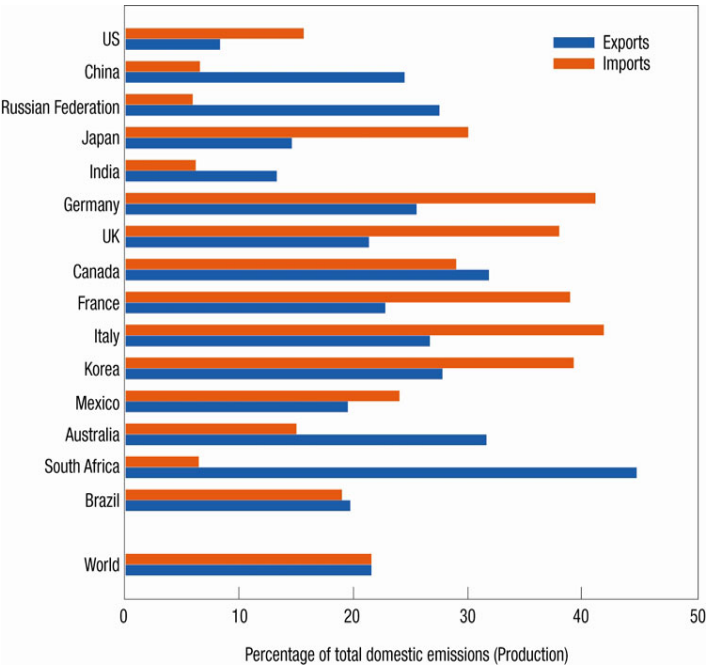

Figure 6.4. CO_2 emissions embodied in trade 2001 for top 15 emitters globally

Source: Peters & Hertwich 2008: Figure 1.

Summing up: Measuring ecologically unequal exchange

There exists a systematic pattern of ecologically unequal exchange: the Centre, taken as a whole, imports more ecological resources than it exports, while the opposite holds for the Periphery. See Table 6.2. The iconic economies in this summary are Brazil and Japan, representing the ideal pattern of the Periphery and Centre, respectively.

Table 6.2. Measuring ecologically unequal exchange

Country/ Region	Ecological footprint 2006	Water footprint/year, 1997-2001	PTB, various years	HANPP of biomass, 2000	Carbon footprint 2001
Periphery	Negative	Mixed: L America negative; Africa, Asia positive	Negative	Mixed	Negative
Brazil	Negative	Negative	Negative	Negative	Negative
China	Negative	Negative	Positive	Positive	Negative
India	Positive	Negative	Positive	Balanced	Negative
Centre	Positive	Mixed: N America & Australia negative; Europe, Japan positive	Positive	Mixed	Positive
EU	Positive	Positive	Positive	Positive	Positive
Germany	Balanced	Positive	Positive	Positive	Positive
Japan	Positive	Positive	Positive	Positive	Positive
USA	Positive	Negative	Positive	Negative	Positive
Sweden	Negative	Positive	Negative	Negative	Positive

Note: Positive EUE = Imports > Exports; Negative EUE = Exports > Imports. The table replicates the information previously presented in this chapter, with additions.

However, most metrics also show that there is more than one relationship regarding EUE. Tables 6.3 (Ecological footprint), 6.4 (Water footprint), and Figures 6.5 and 6.6 (Physical trade balance) illustrate the more complex picture for a number of countries of the Centre as well as of the Periphery.

Table 6.3. Ecological footprints: Rule and exception 2006

Rule: Periphery w/negative balance	Exception: Periphery w/positive balance	Exception: Centre w/negative balance	Rule: Centre w/positive balance
Brazil, China, Russia, S Africa	India	Australia, Canada, Chile, Germany, Sweden	Italy, France, Japan, Mexico, S Korea, UK, USA

Based on Figure 6.1.

Table 6.4. Water footprint. Top ten plus Sweden net-exporters and importers 1997-2001, Gm^3/year

Net exporters	EUE (Imp-Exp) Gm^3	Net importers	EUE (Imp-Exp) Gm^3
Australia	-64	Japan	+92
Canada	-60	Italy	+51
USA	-53	UK	+47
Argentina	-45	Germany	+35
Brazil	-45	S Korea	+32
Ivory Coast	-33	Mexico	+29
Thailand	-28	H Kong	+27
India	-25	Iran	+15
Ghana	-18	Spain	+14
Ukraine	-17	S Arabia	+13
		Sweden	+6

Source: Chapagain & Hoekstra 2004:46. $Gm^3 = 10^9 m^3$ = 1 billion m^3 = 1 trillion l.

The number of cases to substantiate the existence of EUE in favour of the Centre is convincing, and the few exceptions are sparsely populated countries with large land areas and abundant land-based resources, either agriculture or minerals, or both (Australia, Canada, Norway).[267]

Population density has been suggested as explanation for the few anomalies:[268] high density gives a positive EUE (imports > exports) while sparsely populated countries have a negative EUE (exports > imports). But also this explanation has exceptions, at least for the year 2000 and the metric in question, PTB: Laos, Iceland, Finland and the USA were all net-importers (í.e. had positive EUE) in spite of low population densities. Thus, population density yields a far from perfect fit when it comes to which countries are net-exporters or importers, irrespective of their other development characteristics.

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[267] The classification of Centre/Periphery, however is less clear-cut. I have placed the three new members of the OECD in the Centre category; in terms of their GDP/capita 2010, they are classified as upper middle income (Mexico 9,122 USD/cap) and high-income (Chile 12,431, South Korea 20,757 USD/cap), respectively. However, Brazil, which I have put in the Periphery, has a GDP/cap of 10,710 USD, which places it between Mexico and Chile. Sweden's GDP/cap was this year 48 897 USD, USA's 47 153.

See http://data.worldbank.org/indicator/NY.GDP.PCAP.CD/countries.

[268] Eisenmenger 2008:163-166. Population density is also underlined in Fischer-Kowalski et al 2007 as one of the decisive factors to explain the resource flows.

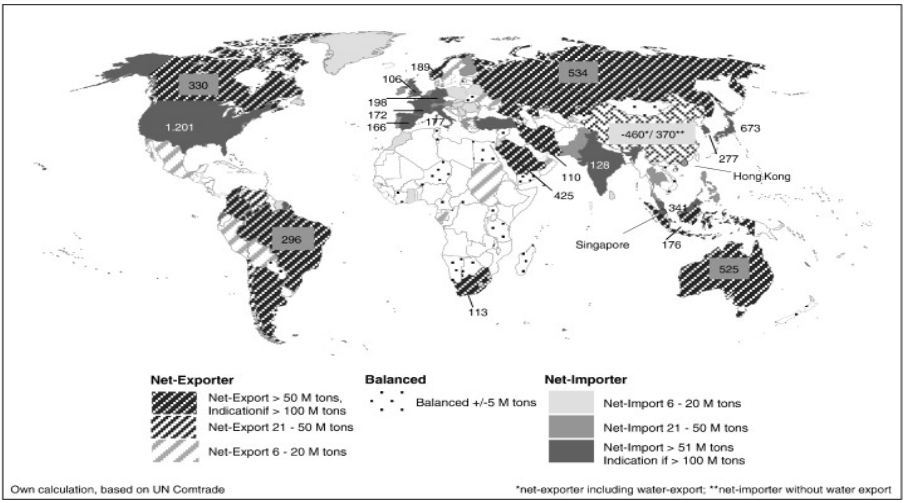

Figure 6.5. Physical trade balances 2005
Source: Dittrich & Bringezu 2010. Note that China has been given two values: a negative PTB including water, and a positive PTB excluding water.

It seems to me that the overall conclusion is that we ought to consider a combination of circumstances when discussing EUE: the position of an economy in the global system, the population density as well as its endowment with raw materials and other land-based resources.

Countries harbouring raw materials, especially if their land areas are large, have a tendency to be net exporters of embodied ecological areas/tons/litres, irrespective of their position in the global hierarchy (Brazil, Canada, Australia, Sweden, Norway); while the balance is positive for countries with few land-based resources but with lots of people, Japan and Europe being the typical cases.[269]

Furthermore, it has recently been shown that there are at least three patterns when it comes to EUE and economic growth for today's fast growing economies. See Figure 6.6.

To the left, six fast growing economies with distinctly negative PTB: Russia, Brazil, Algeria, South Africa, Argentina, and Mexico; to the right

[269] In fact all of the 27 members of the European Union have a positive PTB except Latvia and Sweden. See Eurostat 2011:3.

two fast growing economies with strongly positive PTB: China and South Korea; in the middle, nine fast growing economies with more or less balanced exchanges, including India.

Does this mean that the question regarding the importance of EUE has to be left open, development (conventionally measured) pathways show both positive and negative EUE patterns?

I believe that we can be a bit more specific when it comes to basing the development trajectory on land areas and land-based resources by introducing a temporal aspect: over time, such strategies depend on sustainable resources use or expanding resource frontiers, either within the border of the economies themselves (relevant for large countries) or in the global system as a whole; it is this latter exchange that the metrics applied here have captured. What is possible for individual economies, however, is impossible for an expanding global socio-ecological metabolism as a whole: the fuelling of a process of continuous accumulation will run up against the absolute resource limits that I have assumed (peak oil, peak soil).

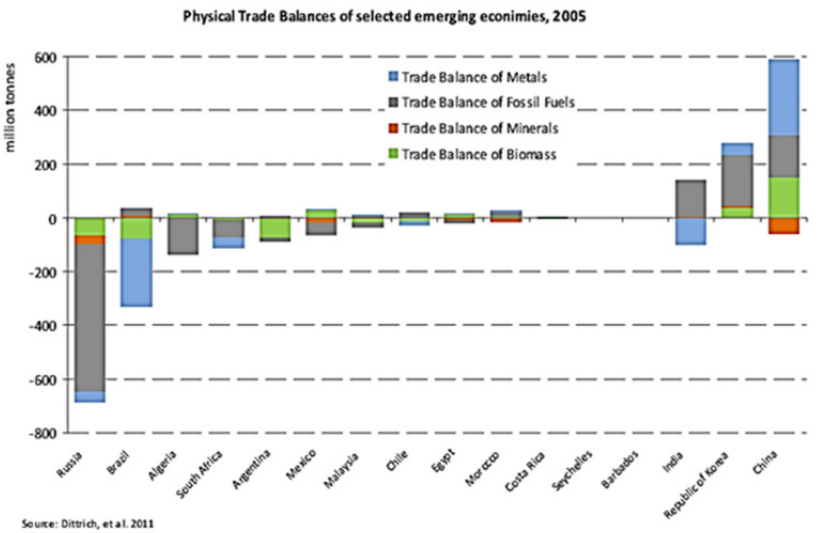

Figure 6.6. Physical trade balances of 16 fast growing economies 2005
Source: Dittrich et al. 2011, Figure 4.

One thing that is clear from the way the various metrics are constructed is that they understate the phenomenon of EUE, and furthermore present it in a biased manner. First, measures of footprints of traded goods make brave assumptions as to the production techniques of different countries in order to be able to estimate "embodied" ecological content. Since more data is available in the Centre than in the Periphery, there is a tendency to apply data from the former to the latter (a procedure known as Domestic Technology Assumption, DTA). This results in an underestimation of the "embodied" footprints of quite serious dimensions as the relative energy and resource use can be assumed to be greater in the Periphery than in the Centre on account of newer and more resource-efficient equipment as well as stricter environmental regulations in the Centre compared to the Periphery.[270] The imbalance in terms of embodied footprints is thus likely to be even more pronounced compared to what the figures and tables in this chapter have shown.[271]

Secondly, there are important resources which are left out of the calculations of the Physical trade balances, most importantly water. The water omission is justified by the fact that these flows are so large that they would dwarf all the other components of the PTB; thus an important ecological resource is disregarded in this measure of EUE.[272]

Thirdly, there is the issue of indirect flows, i.e. the resources which go into a product before it crosses the border. Ideally, indirect flows should be included in order to account for the whole production chain. As of now, however, such information is only available from a few studies, but we can still guess that the material flows which I have used most likely

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[270] In the case of Norway, the real import of CO_2 is 2.5 times higher with real technology factors as compared to when relying on DTA. See Peters & Hertwich 2006:97. Similar estimates for the Swedish economy 2000-2005 indicate that Swedish embodied imports are three times as large with the actual production data as when sticking to the DTA. See Carlsson-Kanyama et al. 2007:19.

[271] See Andrew et al. 2009.

[272] Just how big they are can be gleaned from Figure 6.5, above. Without the water flow, China has a positive exchange, but China's water exports are so large that including water shifts the balance from positive to negative. (Surprisingly, China's water exports are said to consist of drinking water; we are thus not talking of embodied water here; see Dittrich 2010:84, note 65.)

underestimate the actual EUE in favour of the North. A couple of examples indicate how important the issue is:[273]

- A study of Denmark shows twice as high material flows when including indirect flows as when they are left out.
- The weight of Chile's copper exports would increase 13-fold if we included the indirect flows, thus making Chile's physical trade balance much more negative than normally shown. For each ton exported, Chile has previously treated 25 tons, which remain outside the PTB.
- US imports are four times as heavy when the indirect flows are included.
- Germany's imports carry indirect flows which are six times as heavy as the ones reported, but their exports only carry five times indirect flows (average figures 2000-2007). This means that by including all indirect flows for Germany, its exports as well as its imports, its PTB will be four times more positive (in tons) than registered by traditional PTB data.
- A special study of the indirect flows of the USA, Germany, Ecuador, Mexico, Brazil, Chile and Colombia confirms the German study: indirect flows from the Periphery to the Centre carry heavier indirect loads, than the opposite flow from the Centre to the Periphery.[274]

These examples indicate that the Periphery is exporting relatively more raw materials (with more resource-intensive techniques and with larger indirect flows) to the Centre, than vice-versa.

Conclusion: the DTA as well as the non-inclusion of indirect flows skew the PTB data in a specific direction: imports to the Centre carry a heavier indirect rucksack than the opposite flow, and its "real" positive EUE

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[273] See Eisenmenger 2008:169, Weisz 2007, Giljum & Eisenmenger 2004, Muñoz Jaramillo 2011, and Buyny & Lauber 2010:14 and Table 1.

[274] Muñoz Jaramillo 2011:20-22. The pattern is not uniform for all the countries studied, for two of the five Latin American countries – Ecuador and Mexico – including indirect flows actually decreased their net traded deficits, thus improving their EUE measured by PTB. However, these flows are quite small compared to the other cases where including indirect flows increases the deficits decisively.

is still more pronounced than I have indicated; for the Periphery, on the contrary, its exports carry a heavier indirect weight than its imports, and its "real" negative EUE is thus even greater. As of today, therefore, the real appropriation of ecological resources by the Centre is equally underreported.

Is North-South exchange different from North-North?

One drawback of these measures of ecologically unequal exchange is that they do not relate the trading pattern of economies to their position in the global system: we do not know whether the balance of a given economy is related to its trade with other countries in the same category (i.e. intra-North and intra-South trade, respectively), or if it is caused by North-South exchange. The distinction is important, as evidenced by Figure 6.7, which shows the major embodied traded flows of CO_2.

The pattern of exchanged embodied CO_2 is completely different when we compare intra-North and North-South trade: intra-North embodied emissions – the traded flows US-Japan, US-EU, Japan-EU – are significantly two-directional, while the flows North-South are basically uni-directional. China, Russia and Saudi Arabia export significantly larger volumes of embedded CO_2 to the economies of the North than they import, which clearly indicates a negative EUE, and an equally straight-forward positive EUE for the US, EU and Japan. Take the trade China-US as example: Chinese exports to the US embodied 395 million tons of CO_2, while its imports from the US only embodied 26 million tons.

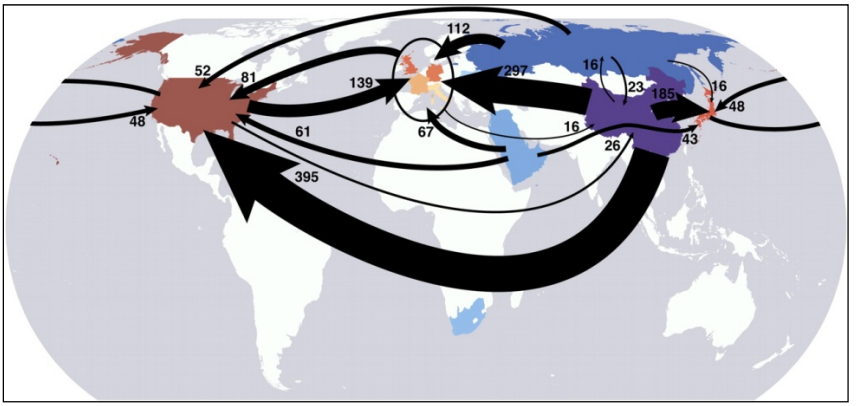

Figure 6.7. Carbon footprint in trade) from net exporters to net importers, Mt CO_2/year
Source: Davies & Caldeira 2010. The flows to and from Western Europe include France, Germany, Italy, Luxembourg, the Netherlands, Spain, Sweden, Switzerland, and the UK.

Where does EUE lead?

Recommendation I: Increase efficiency

One conclusion drawn in the literature on ecologically unequal exchange is that we should look for a more "optimal" and "efficient" allocation of production in order to minimize the footprints. For instance, we are encouraged to consider shifting agriculture to reduce the water footprint

> from land areas with low water productivity to land areas with high water productivity, thus increasing global water use efficiency.[275]

Through trade, five per cent of the Water footprint in agriculture is "saved"; without these trade flows more water would have been used in agriculture (see Figure 6.2, above). This is not a self-evident conclusion from the WF

[275] Hoekstra & Chapagain 2008:63.

approach; as its proponents recognize, shifting consumption patterns to less meat would be much more important for saving water, but such a route is ruled out as unfeasible "since the worldwide trend has been for meat consumption to increase rather than decrease".[276]

A similar interpretation in favour of "efficiency" from the field of Physical trade balances states that meat ought to be produced where the feed factor weighs the least: the weight of the feed needed for meat production in Europe is ten times the weight of the resulting meat, while the global average is only four times. The conclusion is given: to import meat from the South to the North "reduces the material input."[277] Likewise, analysis of the carbon footprint may lead to the conclusion that production ought to "occur where it is environmentally preferable and then trade the products internationally."[278]

In other words, measures of EUE may result in an "efficiency" argument, not necessarily in a discussion of equity and unequal distribution of benefits and costs, not to speak of issues related to power in relation to the control over land-based resources. The reasoning is similar to the global scenarios we came across in chapter 2 which aimed at making large tracts of land available for the production of agrofuels by transferring agriculture to countries better suited than the land areas where agriculture is practiced today.

Recommendation II: Increase self-reliance

But inter-dependency may also be interpreted as a threat, not only as efficiency enhancing. We encountered this argument already in chapter 1 when considering the historic conflicts over access to land areas and land-based resources. The danger of dependency affects countries of the Centre as well as of the Periphery, and while the logic expounded in chapter 1 pushed land-resource dependent countries of the Centre towards securing their access with any means available, from trade to war – a different logic leads to reducing the dependency by going in the direction of self-reliance.

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[276] Hoekstra & Chapagain 2008:63. This is yet another example of reluctance to discuss life style issues which could be added to the examples I discussed in chapter 2.

[277] Eisenmenger 2008:169.

[278] Peters & Hertwich 2008:1403.

For example, Canada is exporting half of its agricultural lands in the Prairie Provinces in agricultural goods, particularly to the USA; the US, on the other hand, is importing large land areas of forestry and agricultural produce, the equivalent of the combined surfaces of Germany, Italy, Spain and the United Kingdom. In these exchanges, it is argued, natural resources become "a factor in geopolitical security."[279]

To David Ricardo in 1817, such inter-dependencies, as we have seen, were welcome as they reduced conflicts and rivalries. But instead we are proposed to limit trade and opt for self-sufficieny, a route which probably resonates better in large and resource-rich, than in small and resource-poor, countries:

> all countries should protect or restore their own natural capital and enhance their self-reliance.[280]

So, there are two ways of reducing the conflict potential arising from the ever growing exchange of land areas and land-based resources: more trade (Recommendation I), and less trade (Recommendation II).

Recommendation III: Consumption trumps production

It is clear that, historically, the responsibility for global warming rests with the Centre, and both the convention and the protocol on Climate Change recognize this via the key principle "common but differentiated responsibilities", CBD.[281] The principle of CBD recognizes that although countries of the world have a common responsibility to counter global warming, the weight of this responsibility falls differently upon the signatories of the UNFCCC; in the Kyoto protocol, CBD was interpreted as requiring no emission-limitations from countries of the South as only countries of the North committed to reduce their GHG emissions.

But while this interpretation of the principle of CBD may have been a precondition for getting countries of the South to sign the convention and

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[279] Kissinger & Rees 2010:596.

[280] Kissinger & Rees 2009:2314.

[281] The CBD is stated in the preamble of the Climate convention of 1992 and repeated in the 1997 Kyoto Protocol, Article 10. See http://unfccc.int/2860.php.

later the protocol, it has now become a blockage for a new post-Kyoto agreement as the previous understanding of what CBD means is no longer acceptable to the Centre. The stalling of the climate negotiations since Copenhagen (COP 15 2009) indicates that the difficulty of the climate convention to tackle the production-consumption contradiction is one of the key blocks on the road to a new protocol: as long as the Annex I countries only accept the production perspective, the South (and even more fast growing countries like China, India, Brazil and South Africa) will refuse every binding commitment to reduce their emissions which, as we have seen, increasingly are caused by their producing for exports. But a consumption perspective might contribute to overcoming this impasse by allocating the responsibility for the emissions not to the producing but to the consuming economy.[282]

We have already seen that a consumption perspective targets the original drivers: in the case of CO_2, over a fifth of national emissions actually take place to meet demand from foreign markets (see Figure 6.4, above). A similar figure have been stated for the Water footprint: one fifth of the global footprint 1996-2005 was embodied in goods exported.[283]

The ranking of the world's top two polluters is inverted when the perspective changes from production to consumption: with a production measure of emissions, China was the leading polluter in the world 2008, and

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[282] At COP 17 in Durban 2011, governments of the Centre argued that the Periphery (that is the Non-Annex I countries) also must take on the responsibility and reduce their emissions, especially since they nowadays account for approximately half of the total emissions. The COP 17 ended with a declaration which seemed to open up for binding obligations for all parties, Centre as well as Periphery, to reduce emissions, and the Durban resolution has been interpreted as an historic break with the old interpretation of CBD: for the first time states of the Periphery accepted a binding responsibility to reduce emissions, putting themselves on an equal footing with the Centre.

However, this may be wishful thinking, a close reading of the resolution shows that the parties were careful to include the wording "under the Convention" when they decided to launch negotiations for a new "protocol, another legal instrument or an agreed outcome with legal force under the Convention applicable to all Parties" to follow upon the termination of the Kyoto protocol in 2012. Hence, the Durban declaration may just as well be seen as a reiteration of the CBD principle of the UNFCCC of 1992 as opening the door to a common commitment. See Article 2 of the Durban resolution: http://unfccc.int/files/meetings/durban_nov_2011/decisions/application/pdf/cop17_durbanplatform.pdf.

[283] Hoekstra & Mekonen 2012:3236.

the US was second; with a consumption perspective, it was the other way around.[284]

Not only does a a consumption perspective lead to a change in the ranking of countries, it may also alter the performance of individual countries. Take Sweden as a case in point: Sweden's officially reported greenhouse gas emissions (production basis data) diverge more and more from those obtained when using a consumption perspective: while the reported production data indicates a decrease, albeit small, of "Swedish" emissions of greenhouse gases, consumption based data on the contrary shows that "Sweden" increased its GHG emissions by as much as 20 per cent 1993-2005.[285] Or put differently, and for a later period: domestic emissions for Swedish consumption decreased by 13 per cent 2000-2008, but emissions caused by Swedish consumption outside of Sweden grew by impressive 30 per cent.[286] Per capita, Swedish emissions of CO_2 doubles, from 6 tons (production) to 12 tons (consumption).[287] The conclusion is that far from an absolute decoupling of economic growth from GHG emissions, Sweden has transferred emissions abroad via international trade, thus following the general pattern of the economies of the Centre.

For OECD countries in general, emissions computed on a consumption basis rose more quickly than when using the production logic, while for Brazil, Russia, India, China and South Africa – the so called BRICS – the trend is the opposite: their production-based emissions have increased faster than their own consumption emissions. In other words, BRICS are polluting for the world market.

Such displacement effects – in fact an ecological appropriation of space in the BRICS by the OECD – the OECD welcomes as constituting efficiency enhancing "trends in the international specialisation in production and relative comparative advantages of different countries."[288] The wording is reminiscent of Ricardo's trade theory, as well as of the more cynical pieces of advice regarding the benefit to poor countries of specialization in pollution in the vein of Lawrence Summers and mainstream economists (see chapter 5)

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[284] Peters et al. 2011: 25 and Figure S11.

[285] Berglund 2011:67.

[286] Naturvårdsverket 2012:8.

[287] Carlsson-Kanyama et al. 2007:29.

[288] OECD 2011:20.

Passing from a production to a consumption logic enables us to escape from this logic and allocate the responsibility of the global environmental loads differently by pinning emissions to the end-use, the real driver of the production which cause the emissions.

Concluding remarks

Summing up, and using the various indicators presented above, the *general* pattern is one of ecologically unequal exchange going from the Periphery to the Centre, but exceptions exist for individual countries in the Centre as well as in the Periphery. Some economies are growing although their EUE is negative (from Chile and Brazil to China); others have grown rich although they are dependent on raw materials exports (from Sweden and Norway to Australia and Canada); and yet others with positive EUE do not seem able to benefit from this advantage (examples: Egypt, Laos and the Philippines with EUE measured by PTB).

I thus conclude that the sign of a country's EUE appears not to be decisive for its trajectory, at least not in and by itself. Internal factors and world system position are equally, or more, important, development and growth are complicated and complex processes – to state the obvious – and the part played by exchange may not be the key consideration.

Furthermore, a longitudinal aspect must be remembered when discussing the meaning of EUE: for how long can a country build its development strategy on the non-sustainable exploitation of its land areas and land-based resources? For how long can the burden be shifted to other countries and areas?

These are rhetorical questions – the obvious answer is "not forever" – which aim at underlining the point that economies which base their growth paths on land-based resources run the risk of undermining their own resource base (see Figure 6.6, above) as they either overuse renewable resources or simply mine non-renewables.

This conclusion is reminiscent of economist Jan Otto Andersson's discussion 35 years ago concerning the implications of unequal exchange of labour. There are three kinds of unequal exchange, Andersson maintained, disjunctive, asymmetric, and non-equivalent, and they are not equally relevant to the issues of growth and development:

> Exchange between two countries is *disjunctive* when it leads to a widening of the development-gap between them. Exchange is *asymmetric* when the 'gains' reckoned in labour-time are unequally distributed between the two countries. Exchange is *non-equivalent* when the price relations between the two countries are such, that they exchange unequal amounts of labour.[289]

The choice of terms is significant: by using descriptive concepts like "asymmetric" and "non-equivalent", we are investigating a "non-normative theory of unequal exchange", to use human ecologist Alf Hornborg's phrase.[290] This is precisely what I have attempted to show here: that a purely descriptive application of physical concepts of traded embodied ecological resources may yield an objective, quantifiable description of ecologically unequal exchange. In this way, the issue of the existence of EUE is held separate from its implications in terms of development, equity or fair access to essential resources.

In this light, and substituting ecological unequal exchange for Andersson's exchange of labour, we can say that there exist several ecologically unequal exchanges, and the fact that there is non-equivalent ecologically unequal exchange, as my metrics have shown, does not necessarily mean that it also is disjunctive. That is, ecologically unequal exchange may co-exist with a narrowing of development gaps (measured conventionally), which is exactly the situation indicated by the fast growing economies of Figure 6.6 which also show negative EUE. The conclusion is similar to the one reached by Paul Baran in chapter 4: it is not the exchange as such but the use of the resources (including money) which determines the outcome.

34 years after his first formulation of the existence of three kinds of unequal exchange, Andersson returned to the issue of interpreting the meaning of unequal exchange and posed a number of questions which he did not attempt to answer:

> I am not convinced that […] objective non-equivalence necessarily must be linked to a disjunction manifested in a growing development gap. […] Are the inhabitants of a locality necessarily victims of an unequal exchange if

[289] Andersson 1976:42.

[290] Hornborg 2001:40.

> they find and start to export a natural resource such as fertile land, iron, or oil? Is bountiful Norway being exploited by oil- and gas-poor Germany?[291]

Put simply, there are more factors at play here than just a positive or negative EUE which we have to take into consideration in order to assess the implication of ecologically unequal exchange. Let's stick with the dichotomy Norway-Germany and consider the temporal aspect: for how long can a land-based resource be exploited? In other words, will Norway's economy be able to go on growing once its oil resources are depleted? Will Germany's, considering that it relied on Norwegian oil to fuel its socio-ecological metabolism?

The answer has a lot to do with the position of Norway and Germany in the global system as well as with the temporal horizon. If both economies – neither of them being known to be seriously corrupt or extremely dominated by foreign powers or international finance capital – invest their surpluses well they may be seen to have profited from the exploitation of Norway's limited oil resources: Norway from its negative EUE, Germany from its positive EUE.

But this is only an intermediate conclusion, and the happy state of affairs cannot last: as Norway's limited oil resources run out, both economies have to look for new energy sources elsewhere, for instance in the expanding agrofuel frontier worldwide. But they may have the economic (and perhaps military) muscles to do so more successfully now, after engaging in ecologically unequal exchange, than had they not jointly consumed Norway's non-renewable wealth.

Also this way out is provisional, however: we are simply pushing the frontiers limiting Norway and Germany ever further outwards, in essence postulating that there will always be a new frontier to exploit, somewhere.

This understanding of the conditional and temporal aspects of EUE is not what we found in the early formulations of the significance of unequal exchange: as we saw in chapter 4, unequal exchange was held to constitute the "elementary transfer mechanism" (Emmanuel) which secured a "hidden transfer of value from the periphery to the center" (Amin), the explanation of why some countries are "underdeveloped" (Bunker).

I have postulated – in chapter 2 – that the growing weight of land areas and land-based resources in the global socio-ecological metabolism will

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[291] Andersson 2010:122.

keep the prices of primary commodities up, and it would only be natural to expect that they could become a blessing for the countries that harbour them, thus turning the implication of unequal exchange upside down: from now on, it would be reasonable to expect land areas and land-based resources to benefit the resource-rich economies, be they of the North or the South.

Such a presumption, however, disregards that economies are not defined by their resource assets alone, not even mainly, but more importantly by their historic position in the global system. Hence, treasured land-based resources may constitute less of a blessing and more of a curse to countries of the South, while countries of the North will thrive from similar resource abundance. Compare Norway and Nigeria, Canada and Congo, Australia and Sudan. The resource curse – a strong belief among mainstream economists and in the public opinion – should be reinterpreted in recognition that resources will affect country trajectories differently depending on their world system position.

This is evidenced in Table 6.5 which lists the major exporters of agricultural produce. On the one hand, we find that large countries figure prominently, something which is to be expected when it comes to land-based resources such as these. On the other hand, the dominating countries belong both to the North and South.

Table 6.5. Top five global exporters of key agricultural products 2001-2003

Country	Percentage of world exports
USA	Cereals 31, oilseeds 41, meat 19, fibres 27 %
EU 15	Cereals 22, oilseeds 8, meat 40, fibres 9, sugar 20 %
Argentina	Cereals 8, oilseeds 9 %
Australia	Cereals 7, meat 7, fibres 17, sugar 6 %
Canada	Cereals 7, oilseeds 7, meat 5 %
Brazil	Oilseeds 20, meat 9, sugar 6 %
Uzbekistan	Fibres 9 %
Thailand	Sugar 10 %
Cuba	Sugar 7 %
Bangladesh	Fibres 4 %

Source: FAO 2004, Table 3. Average exported tons 2001-2003.

In fact, some of the world's most successful economies (in terms of growth and wealth) are to a surprisingly high degree also leading producers and exporters of primary commodities. If my hypothesis regarding the crucial role of land areas and land-based resources for the global socio-ecological metabolism is correct, these are the states which may gain in power and

influence as the centrality of land areas and land-based resources reaffirms itself.

But here we must remind ourselves of a point made in chapter 4: ecologically unequal exchange takes place as much within as among countries. Behind the veil of nations and countries we find corporations, and we should not confund nations with corporations: 60 per cent of the global cereals stocks are in private hands, while six private companies account for 80 per cent of the global trade in wheat and rice.[292]

Thus what the growing importance of land areas and land-based resources will entail in terms of development and improvement of living conditions is not a foregone conclusion, it is closely related to the political alliances and compromises entered into by the various wielders of economic and political power. The question whether land-based resources are a curse or a blessing remains open.

[292] McMichael 2009:287.

PART III

APPROPRIATION OF ECOLOGICAL SPACE

In Part I posited the return of land-areas and land-based resources to the centre of the global socio-ecological metabolic regime, based on the limiting assumptions which achieving climate stability imposes: no deforestation, no replacement of oil by fossil fuels.

Part II then gauged the trade in land-areas (and other embodied ecological resources) and found a pattern which conforms to the theory of ecologically unequal exchange.

This leads me to Part III and a more general argument regarding the appropriation of ecological space by the Centre of the global system.

Just as the global socio-ecological metabolism of today is based on securing a continuous flow of land-based resources to the Centre, it equally requires to secure a counter-flow of waste and pollution to the Periphery. Taken together all these processes may be summarized as instances of environmental load displacement, the subject of the first chapter of Part III.

The actual areas appropriated may not be impressive in some of these exchanges, but they nevertheless have in common that land constitutes the coveted resource to be appropriated, or the pre-condition for the attempted displacement.

Against this background, the concluding chapter discusses the implications of the emerging new agro-regime in terms of the search for fungible land-ares to secure the food, feed, fibres, and fuels needed for a global socio-ecological metabolism which recognizes the concurrence of peak oil and peak soil.

Power relations being what they are, it is not far-fetched to believe that such a new agro-regime will lead to an even greater strive by the Centre to appropriate ecological space, thus again making conflicts over land-areas and land-based resources the focal point of geopolitically driven land struggles.

7. From Environmental Load Displacement to Land Grabbing

Environmental load displacement, the appropriation of ecological space by the North in the South, takes two forms, one easy to observe, one more obscured. The obvious form of ecological appropriation is trade in toxic waste North → South, a phenomenon which is on the increase in spite of the international regulations which have been set in place to restrict it.

The obvious displacement: Trade and trafficking in waste

The transfer of dangerous and toxic waste from the global north to the global south is not a new phenomenon. One of the early expressions of this transfer of environmental loads is the export of agricultural waste in the shape of pesticides from the Centre to the Periphery, both for use and to be dumped. By the mid-1990s, the FAO assessed that stockpiles of this kind of waste in non-OECD countries were exceeding 100 000 tons; already by 2001 the estimates had quintupled (without taking contaminated soil and water into account). Some of the most well-known producers and exporters are the transnational chemical giants American Cyanamid/BASF, Bayer, Dow, Dupont and Monsanto.[293]

Such transfers are clear cases of the appropriation of ecological space, replicating a pattern which already was traditional in the Centre itself: it is on the poor that the waste is dumped. In this tradition, the Dell computer company contracted the US federal prison industries, UNICOR, to supply

[293] Rosenfeld & Feng 2011:172.

prison inmates to do the dismantling of its electronic waste. The purpose was evidently to avoid being criticized for dumping its waste on poor people and nations. But US prisoners felt exploited and remonstrated their low wages (0.20-1.26 USD/hour at the Atwater prison) and unhealthy working conditions. As one inmate said:

> Funny, isn't it, how this stuff is unsafe for public dumps, but not for us lowly prison inmates.

Another prisoner added:

> We are guinea pigs and slaves, and treated precisely that way.[294]

The Dell case shows that getting rid of toxic waste is no easy matter. Corporations and governments which have tried to go along with Summers's "impeccable" logic and dump their waste in the global south, have found that they clash head on with the environmental consciousness in the global north as well as in the global south. As it became known that "ships of death" laden with toxic trash from the Centre were looking for havens to get rid of their deadly cargoes, a movement against the exports of industrial waste gained force.[295] One of the most notorious cases occurred in 1986 when the city of Philadelphia rented *Khian Sea*, a ship registered in Liberia, to get rid of 15,000 tons of its incinerator ash. The *Khian Sea* left for an odyssey that was to last 27 months, attempting to offload its cargo in various continents, passing the Bahamas, the Dominican Republic, Honduras, , Puerto Rico, Bermuda, the Netherlands Antilles, Haiti (where 3,700 tons were illegally dumped), Senegal, Guinea-Bissau, Cape Verde, Sri Lanka, Indonesia, the Philippines. Everywhere, the ship was turned away, until it finally "lost" its cargo somewhere on the Indian Ocean.[296]

The logic here is clear: the rich, white North is trying to dump its waste on lands where poor, non-white people live. But what may not be immediately evident is that the North (in this case, the city of Philadelphia) had put itself in a position where it needed to secure such ecological space

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[294] See Pellow 2007:206-212.

[295] See BAN 2010.

[296] *Khian Sea*'s voyage is recounted by Pellow 2007:107-116 and Rosenfeld & Feng 2011:171.

by being forced, first, to close down its own dumps and replace them with incinerators, and, secondly, to dismantle the incinerators as public protests against them picked up. The waste simply had to be displaced somewhere outside of the US borders.

Such displacements of waste, and its concurrent appropriation of ecological space, was not well received neither in the sending nor in the receiving countries, and protests led to the elaboration of the 1989 Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and Their Deposits, recognizing the fact that such waste trajectories had a definite North → South logic. Today 172 parties have joined the Basel convention, three without ratifying it (Afghanistan, Haiti, USA).[297] But the illicit trade continues irrespective of the fact that it contravenes both OECD and EU regulations.[298]

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[297] See www.basel.int. The Convention has been criticized for being too lax: according to Greenpeace it is "providing license to an activity, which should have been considered criminal". Quoted in BAN 2010, Briefing Paper 1. This was certainly one of the drivers behind the convention, but it has since been somewhat strengthened (at least in principle) and now bans all exports of hazardous waste from OECD to non-OECD countries, including, as of 1998, for recycling. Decision 1 at the Second Conference of the Parties, March 1994.

In addition, an amendment requires de-contamination in the countries of origin before export of waste to Non-OECD countries, unlike today's practice. The amendment has been signed by 68 countries by early 2010 but it is controversial in sending as well as in receiving countries. The number of signatories should be enough for the Ban Amendment to enter into force, but this has been questioned by the US, Japan, Australia, and Canada which claim that the amendment needs to be ratified by a sufficient number of the *original* members of the Convention, not of its present membership. India and Bangladesh, two of the main sites for ship breaking, are among the countries which fight the amendment. See BAN 2010 Briefing Paper 4.

[298] See OECD decision C (86)64(Final) which stipulates Prior Informed Consent for all trade in hazardous wastes and also prohibits exports if there is reason to believe that it will not be handled in an environmentally sound manner; and EU's Hazardous Waste Directive (91/689/EEC), and Waste Shipment Regulation (93/259/EEC).

Ship-breaking as environmental load displacement

After World War II, the USA, UK and Japan were the main ship-breaking nations, but in the 1960s ship-breaking moved south, first to Southern Europe, later to Asia, starting in South Korea and Taiwan, then continuing to China, India, Pakistan, Bangladesh, The Philippines, and Vietnam. Just from these facts, we can conclude that ship-breaking constitutes a case of environmental load displacement: what was formerly dismantled in the North was passed on to the South.[299]

The ideal sites for ship-breaking are shores with gently sloping beaches but with rocky bottoms which allow the ships to be stranded during high tide, thus avoiding expensive dry docks. Today, around 700-800 vessels are "beached" in this way, half of them at the world's major ship-breaking facilities at Alang-Sosiya, Gujarat, Northwestern India, an average of one vessel a day. See Figure 7.1.

The workers engaged in this business are super-exploited: high rates of accidents, exposure to dangerous and poisonous substances – cadmium, chromium, lead, mercury, asbestos, PCB, oil, flame retardants, radioactive materials are found on the contaminated beaches and in the lungs of the workers – lack of personal protection equipment, weak or absent trade unions. For instance, in India, ship-breaking is six times more deadly than mining, the second most life-threatening industry in India in terms of its death toll.[300] In Bangladesh, one quarter of the workforce on the shipbreaking yards are children.[301] See Figure 7.2.

[299] The following is based on Demaria 2010, NGO Shipbreaking Platform 2007, BAN 2011, GAO 2008, ETBC 2012, World Bank 2010, and Rosenfeld & Feng 2011.

[300] The rate of fatal accidents in the Indian shipbreaking industry is 2/1000 workers compared to 0.3 for mines. Demaria 2010:255.

[301] Rosenfeld & Feng 2011:173.

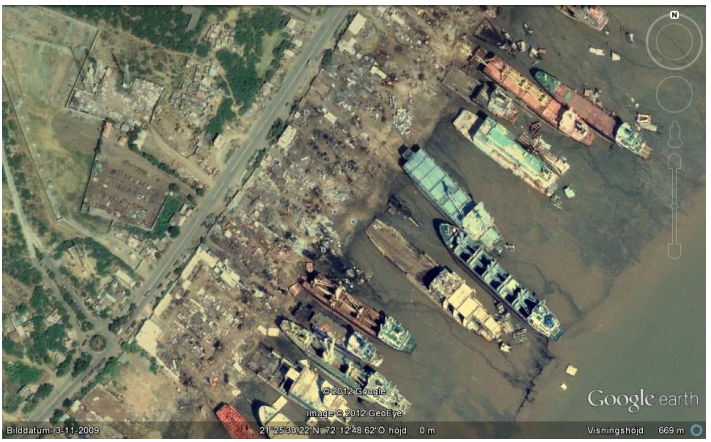

Figure 7.1 Shipbreaking Alang-Sosiya, India 2009
Source: www.googleearth.com 20120202

Figure 7.2. Shipbreaking Chittagong, Bangladesh 2000
Photo © Edward Burtynsky, courtesy Nicholas Metivier, Toronto / Stefan Röpke, Köln

A case which has attracted widespread attention is the dismantling of the cruiser SS Norway, which was shipped to India for breaking. This vessel – once one of the world's largest cruisers, second only to Queen Elizabeth II and the Titanic, originally under the name SS France – contains significant volumes of toxic materials, such as 900 tons of asbestos and PCB, and its de-contamination was estimated to cost at least 17 million euro; the scrap value amounted to only 10 million euro. Hence, "cleaning up" prior to export was seen as uneconomical by the Norwegian owners. The breaking up of the ship was refused by the Bangladeshi government before the owners turned to India and sailed for Alang-Sosiya.[302]

Also in India, the breaking up of the vessel – now re-named SS Blue Lady – was contested in the Indian courts on the ground that its export from Norway to India violated the OECD Prior Informed Consent rule and the Polluter Pays Principle, as well as the Basel Convention and the Ban agreement on prior de-contamination, all of which Norway is committed to abide by. The case was finally settled in 2007 by the Indian Supreme Court which allowed the breaking of the vessel based on an argument which pitted the environment and the interest of a minority against the economy and the interest of the majority. In its ruling, the Supreme Court argued:

> It cannot be disputed that no development is possible without some adverse effect on the ecology and the environment [...] A balance has to be struck between the two interests. Where the commercial venture of enterprise would bring in results which are far more useful for the people, difficulty of a small number of people has to be bypassed. The comparative hardships have to be balanced and the convenience and benefit to a larger section of the people has to get primacy over comparatively lesser hardships.[303]

With the principle of balancing opposed effects – benefits against costs, the majority against the minority – the Indian Supreme Court legitimized environmental load displacement and the appropriation of Indian land as part of shifting risks from the North to India; simultaneously, the court disregarded a number of international legal obligations of both sending and receiving countries.

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[302] Moen 2008:1058.

[303] Quoted in Demaria 2010:258-259.

Figure 7.3. Known and suspected routes of e-waste dumping
Source: *http://library.thinkquest.org/06aug/02342/photos/webready/routes2.jpg.*

Figure 7.4. Guiyu e-waste dismantling, China
Source: *http://tribes.tribe.net/environmentprotect/photos/c99a16ed-eda3-47ef-8863-59670dd45d1f.*

Trade in e-waste

The transfer of electronic waste is another example of appropriation of ecological space. Here, the flow goes from the global North to the global South allegedly for re-conditioning and re-use. The major importing countries, whose lands and labour forces are appropriated and exploited, are China, Mexico, India, and Nigeria. See Figure 7.3. Nigeria is reported to receive 500 containers a week with used computers from Europe and North America.

Just as in the case of ship-breaking, agents take temporary ownership of and then resell the waste to corporations in countries where the dumping grounds are located. The origin of the waste being dumped is sometimes somewhat ironic: a large share comes from "recycling" or from gifts of second-hand equipment, collected in order to bridge the "digital divide"; however, 50-80 per cent of e-waste collected in the US is not recycled at all, but simply smashed, burned and dumped in the importing country; only a small share of the waste is recycled in one form or the other, and almost none of it is re-used.

A case in point is the exporting of television sets and monitors (of the old, bulky kind) which contain lead, dioxins, cadmium, barium, beryllium, mercury, and obnoxious gases of various kinds, all of which are released as the tubes are smashed and burned. As a consequence, children and adults living in China's and the world's major e-waste "processing" region, Guiyu, have unusually high levels of lead and fire retardants in their blood, a not unexpected outcome of adhering to the impeccable logic of Lawrence Summers. See Figure 7.4.

The obscure displacement: pollution havens

A more hidden transfer of ecological space takes the shape of outsourcing of pollution- and energy-intensive industries from the North to the South, sometimes through foreign direct investments (FDIs), sometimes just as plain out-sourcing of the production to locally owned production facilities. Both routes lead to a flow of finished products and goods from the South to the markets of the North, something which for the last 35 years has been

known as the new international division of labour.[304] But while it has been recognized that an ever larger share of the global industrial production has shifted geographical location – leading to the emergence of a limited number of Newly Industrializing Countries, NICs – it has largely escaped notice that the two shifts are connected: the flow of finished products from the South to the North returns as waste. It becomes more and more of a recursive process, where outsourcing leads to imports of embedded ecological space, which subsequently returns as exports of waste, continuing the process of appropriation of ecological space.

Table 7.1. Appropriated ecological space in the South

Period	Deteriorating environmental Status in the South as measured by	Sector	Driver
1990-2000	Pesticide and fertilizer use	Primary	FDIs North → South
1990-2005	Deforestation	Primary	FDIs North → South
1970-2000	Deforestation	Primary	Exports South → North
2005	Threatened mammals	Primary	Exports South → North
1975-2000	CO_2-emissions	Manufacture	FDIs North → South
1960-2005	CO_2-emissions	Exports	Exports South → North
1975-2000	Water pollution	Manufacture	FDIs North → South
1990-2000	Noxious gas emissions	Manufacture	FDIs North → South

Sources: Jorgenson 2007, 2008, 2009, 2012, Jorgenson et al. 2007, 2009, Jorgenson & Kuykendall 2008, Shandra et al. 2009. Note that the dependent variables all deal with absolute levels of pollution or resource exhaustion in the South.

In recent years, a large body of studies has been published which frame the issue of land appropriation within a world-system approach. Here, the economic growth and power of the North brings environmental exploitation

[304] See Fröbel et al. 1977, and Warren 1980.

and degradation to the South: the North manages to "externalize" – or cost shift[305] – its consumption footprint to poor countries, either through trade or through FDIs. Table 7.1 sums up the evidence.

The more foreign corporations invest in the South and the more economies of the South export to the North, the worse the ecological status in the South becomes: pesticides and fertilizer use as well as deforestation increase, biological diversity deteriorates, CO_2 emissions grow, water pollution and noxious gas emissions rise. The relationships hold for both drivers, FDIs North → South as well as exports South → North, and for both the primary and the secondary sectors.

The appropriatoin of space also shows a consistent pattern over time: increasing presence of foreign investments from the North in the South, as well as larger shares of exports from the South to the North, co-exist with environmental deterioration in the South.

Assessing fairness in environmental load displacement with money

Although the relevant issue when it comes to appropriation of ecological space should be framed in physical terms – land areas appropriated, tons emitted, number of extinct species – some economists maintain that monetary metrics also have their place since they transmit the kind of information which political power relates to. As Herman Daly once justified using monetary measures when assessing ecosystem services:

> for those who only hear dollars, let us scream now and then in dollars![306]

A study which follows Daly's recommendation compares the countries which cause environmental destruction to the ones that suffer from it. The environmental damages considered were climate change, ozone-layer depletion, agricultural intensification and expansion, deforestation,

[305] See Martínez-Alier 2002:30 for the point that "externalities" should be seen as examples of successful cost-shifting.

[306] Daly 1998:23.

overfishing, and mangrove loss, and the time horizon extends to the end of the 21st century. See Table 7.2.

Table 7.2. Distribution of ecological loads caused 1961-2000 and suffered until 2100

	Low-income countries	Middle-income countries	High-income countries
Share of population 1961-2000, %	32	50	18
Share of damages caused, %	14	58	28
Share of damages suffered, %	20	60	20
Share of damages suffered when human lives are equally valued, %	45	52	3

Based on Srinivasan et al. 2008.

Table 7.2 shows how low-income countries have to endure more than "their share" of the overall ecological damages, and high-income countries less. In other words, the distribution of the drivers causing ecological destruction and the monetized costs of suffering from this destruction is skewed to the detriment of the poor countries: low-income countries' accounted for 14 per cent of causes but suffered 20 per cent of consequences, a gap of almost 50 per cent.

Some would be alarmed by this gap, and others would probably be surprised that it is not wider; I belong to the latter group. The reason why the disparities are so small is a double weakness in the design of the calculation. First, emissions are attributed to the countries where they are produced, not to the countries where they are consumed. But as I concluded in chapter 6, shifting from a production to a consumption perspective will have a major impact on the relative distribution of responsibility for emissions: approximately 20 per cent of the emissions of the South were caused when producing goods for the North. Thus, an even larger share of the causes ought to be attributed to the high-income countries than shown in Table 7.2, leaving a concomitantly smaller share for the low-income countries.

Second, damages are valued according to the GDP per capita, which means that damages in rich countries and to rich people are valued higher than equal damages to poor countries and their populations. This is the same logic which permeated Summers's and his fellow economists' argument in chapter 5. The study on which Table 7.2 is based recognizes this drawback, however, and uses purchasing power parity (PPP) data to diminish the value-judgement applied by valuing people according to their income, but although

this is a step in the right direction, it does not change the fact that the methodology is flawed in equity terms: you just reduce the imbalance, you do not delete it.

Furthermore, the study uses net present values – with a discount factor of 2 per cent – which reduces the value of future generations compared with the present one; also in generational terms, the model is biased.

Had the study instead used what it itself calls an "equity weighting" – i.e. assessed every human being as equally valuable in monetary terms – the low income country group would have carried more than twice the burden it does with the present valuation. As a consequence, the injustice would have come across more pronounced, with low-income countries suffering three times the damages that they themselves cause. See Table 7.2, last row. For the high-income countries, this equity logic gives the opposite result: with equity weighting, high-income countries would only suffer 3 per cent of the damage while they account for 28 per cent of the drivers.

Land grabbing

As I have argued, the distinction between strategic (for instance oil) and non-strategic (for instance agrofuel) resources is becoming less useful and we may expect ever more conflicts over fungible land-based resources. Put differently: all land-based resources are strategic now, the simultaneous increase in demand for food, feed, fibres, and fuels spell conflict over limited land areas. It is in this light I see land grabbing. Although no established definition exists, most analysts refer to large-scale acquisition of land by foreign, private or public, investors, but mixtures and joint ventures of all kinds are common and co-exist.[307]

The World Bank calls the search in land deals "land acquisitions", but I prefer land grabbing precisely on account of its negative connotation: land grabbing is the logical outcome of increasing competition over land-areas and land-based resources, and it is no coincidence if the grabbing brings to mind the "scramble for Africa" and the competing land claims of European colonial powers, which the German chancellor Bismarck tried to assuage at

[307] Cotula et al. 2009, Oxfam 2011a, and HLPE 2011 all provide definitions of land grabbing, as does the World Bank 2011.

the Berlin conference – in German more appropriately called Die Kongokonferenz, the Congo conference – 1884-1885. Here, the European powers including Sweden, represented by the Swedish ambassador baron Gillis Bildt, later to become Sweden's prime minister, agreed among themselves how to use the African continent.[308]

It may be that some, or most, of these land deals are illegitimate (albeit not illegal), but the main reason I prefer "grabbed" to "acquired" is that I see the deals as struggles over land which already is being used and claimed by local stakeholders. Thus, grabbing indicates the conflicts over land and the fact that various land uses compete with each other, not that the deals are illegal (although many of them are).

Although the present scramble is similar to the previous one, there also exist major differences. First, land is made available voluntarily and freely by seemingly legitimate governments (mostly in Africa) or by legal property holders (elsewhere), no military occupation is needed. Secondly, the actors engaged in the land hunt are partly new compared to the set-up at the height of European colonialism. But the neo-colonial nature of land grabbing should still be obvious.

Assessments of the land areas grabbed vary, with 227 million hectares the highest reported for the period 2001-2010.[309] That land grabbing is on the increase is however certain: investments in agriculture have multiplied by a factor of five in the last fifteen years, from 600 million USD per year in the 1990s to an average of 3 billion USD 2005-2007.[310] Reliability of land grabbing data may be low, but we nevertheless know enough from the confirmed cases. See Table 7.3.

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[308] For the Berlin agreement, see http://de.wikisource.org/wiki/General-Akte_der_Berliner_Konferenz_(Kongokonferenz). The story of the scramble for Africa, and the atrocities committed by the colonial powers, are vividly described by Hochschild 2006.

[309] Oxfam 2011a:5. Most other sources present considerably smaller figures. Recent assessments include HLPE 2011, Oxfam 2011, and Anseeuw et al. 2012

[310] de Schutter 2010:3.

Table 7.3.Verified land grabs 2000-2010

Land acquired in	Origin of investors	Commodities	Total land area (Mha)
Africa	Asia 39 % Africa 20 % Europe 19 %	Agrofuels 66 % Food 15 % Forestry 7 % Tourism 9 %	34
Asia	Asia 89 % Middle East 6 % Europe 3 %	Agrofuels 56 % Food 15 % Forestry 20 % Industry 6 %	29
Latin America	Latin America 37 % North America 35 % Asia 13 %	Agrofuels 33 % Food 27 % Minerals, oil 24 % Forestry 10 %	6

Based on Anseeuw et al. 2012, Figures 3-6. Verified grabs = cross-referenced.

Most land deals are reported from Africa, over half of the verified land area, 34 million out of a total of 71 million hectares (including land grabbed in Eastern Europe). The most important investors globally come from Asia, many are state agencies.

Investments in agrofuel feedstocks dominate, followed by food and forestry. All in all, these three commodities account for as much as 80 per cent of the verified grabs.[311]

The actors appropriating these land areas are varied: in Asia and Latin America the largest share reportedly falls on domestic investors, while Africa stands out with a dominant presence of foreign corporations.[312] The span is also wide, from simple speculation to securing the long-term supply of strategic land-based resources via the long-term investments of sovereign wealth funds and pension funds.

The prices paid for the land grabbed are very low, sometimes even as low as nothing. But on average, in Africa, prices ranging from 1 to 12 USD

[311] Based on verified land deals the commodity distribution was the following: agrofuels 58 per cent, food 18, and forestry 13 per cent. See Anseeuw et al. 2012, Figure 5.

[312] See Oakland Institute, FAQs on Food Security & Western Investors, June 2011, http://www.oaklandinstitute.org/sites/oaklandinstitute.org/files/OI_FAQsjune5.pdf. These figures are most likely understating the extent of foreign investment, as the World Bank notes domestic corporations may act as "fronts" and thus the "the share of land acquired by foreigners may be larger than reported." World Bank 2011:63.

per hectare have been recorded, real bargain prices for fungible land areas; in Argentina and Brazil, equivalent land prices are said to be in the range of 5-6,000 USD/ha.[313]

There also exists a great variety concerning the areas of the reported land deals according to a survey performed by the World Bank, from surprisingly small 700 hectares in Ethiopia, hardly representative for the land grab drive, to amazingly large 59,000 hectares in Liberia; the median, however, was impressive enough, 10,000 hectares.[314] This makes one of the most noted land grabs (although never realized) an anomaly: in 2008 the South Korean conglomerate Daewoo signed a contract with Madagascar for a 99 year lease on 1.3 million hectares, subsequently part of the case made against the then sitting government, possibly contributing to its overthrow in 2009.[315] But although this aborted deal was exceptional, it is not unique: the Chinese government is reported to have grabbed 2.8 million hectares in DR Congo for oil palm production, while the British bioenergy corporation Global Green Energy controls 900 000 hectares for agrofuels in Mali, Guinea, and Senegal.[316]

Some of the fast growing economies of the world have been leading this rush, with major investors based in China, India, South Korea, Saudi Arabia, United Arab Emirates, and Brazil, mixing private capital, state corporations, international agencies and finance: Mauritian based companies investing in Mozambique, Brazilian in Angola, Indian in the Philippines, South Korean in Indonesia, Singaporean in Surinam. Add to this, transnational corporations such as global food and agricultural giants Cargill, Archer Daniels Midland, Du Pont, Deere, and Monsanto; and add again oil corporations, private and publicly owned, from Shell to Petrobras, and you get a far-flung complex, embracing the whole globe.[317]

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[313] See Oakland Institute, FAQs on Food Security & Western Investors, June 2011, http://www.oaklandinstitute.org/sites/oaklandinstitute.org/files/OI_FAQsjune5.pdf.

[314] World Bank 2011:62. The survey covered only six countries 2004-2009: Cambodia, Ethiopia, Liberia, Mozambique, Nigeria and Sudan.

[315] See Holt-Giménez & Shattuck 2009:182 and "Madagascar scraps Daewoo farm deal", *Financial Times*, March 18, 2009. One of the first moves of the new government was to cancel the agreement with Daewoo, at least for the time being.

[316] See Oakland Institute (2011): The Role of False Climate Change Solutions, http://www.oaklandinstitute.org/land-deal-brief-role-false-climate-change-solutions.

[317] Dauvergne & Neville 2010:638-639, Holt-Giménez & Shattuck 2009:183, and Borras et al. 2010:577-578.

Concluding remarks

Environmental load displacement and appropriation of ecological space, measurable as ecologically unequal exchange, define the global socio-ecological metabolism: not only are land-based resources and primary commodities appropriated by the North; space to dismantle and absorb waste are equally part of this circular flow, just as central as other forms of accessing land-based resources.

Again, the land areas appropriated for dumps may not be large, but we should not confound size with importance: the waste has to be deposited somewhere, the further away from the global north the better.

Bringing land-based resources from the South to the North in systematic ecologically unequal exchange; outsourcing production from the North to the South and then importing the products; and finally returning the produce in the shape of waste to the very same countries from whence they originally came are all part and parcel of one recursive system, replicating the global metabolic rift: the resources which return as waste add further stress to an already over-exploited ecological system instead of providing the resources with which to renew it.

8. The Argument Revisited: The Return to the Land

The industrial socio-ecological metabolic regime has by now established itself around the globe as the dominant order, and the land areas where the previous agrarian regime still dominates are by comparison of less importance. This industrial regime, evidently, has been based on the availability of fossil fuels, first coal and then oil. But although it is common to describe a metabolic regime by its dominant feature, it runs the risk of neglecting the considerable overlap that exists in metabolic regimes: each new metabolic flow not so much replaces as adds another layer to the already existing set-up.

This holds especially for the substitution of oil for coal after World War II: coal has continued to be important for the global socio-ecological metabolism, its share of the global energy supply in 2009 was approximately the same as in 1973, 27 and 25 per cent, respectively. What is more important, the absolute volumes of coal have almost tripled: with a growing total energy use – from 6,111 Mtoe in 1973 to 12,150 Mtoe in 2010, an increase of 199 per cent – the absolute volumes of coal grew, from 2,235 million tons in 1973 to 6,186 million tons in 2010 (or by 277 per cent). In fact, we are living in a socio-ecological metabolic regime driven by oil-coal-gas-nuclear power, not in a regime dominated by oil.[318]

As of now, however, coal is set to become the dominating source in the short-term for the simple fact that it is available, easily and cheaply. Thus the most likely metabolic profile seems to me to be a return to the pre-oil coal regime of the 19th century. But I will discard this scenario and instead investigate my counter-proposition: no fossil fuels and no deforestation.

[318] See IEA 2011a and Figure 2.2, above, for the whole energy mix. Mtoe = million tons of oil equivalents.

Thus this hypothetical metabolic regime is squeezed between peak oil, peak soil, and no coal.

This spells, I believe, a stalemate in terms of metabolic regimes: the old industrial regime cannot continue based on fossil fuels, but a new regime cannot be borne unless it resolves the basic issue of finding new sources to satisfy its socio-ecological metabolic needs. This will lead to a pronounced conflict over land areas and land-based resources, challenging present land use patterns. The price rices recorded earlier are only the first and probably most pacific of the consequences of this conflict, land grabbing constituting yet one more indication of where we are heading.

A hypothetical future: Substituting land areas for fossil fuels

Nowhere is the conflict over land more pronounced than when it comes to assessing the possibility of substituting fossil fuels with land-based energy sources. We have already come across this in chapter 2, where various estimates of feedstock areas were presented. I will look at the overall use of fossil fuels and speculate what would happen to land use if it was replaced by agrofuels. In order to reach a conservative figure of needed areas, I shall use Brazilian sugarcane area-efficiency, the highest in the world.

The procedure is not new: fifty years ago biologist Georg Borgström calculated the land areas needed to produce a rich country's imports of food and fish. Borgström called such "invisible" land areas "ghost acres" and concluded that if every human on earth lived as the average Dutch, another planet would be needed.[319] William Catton then applied Borgström's perspective and showed that four times the US farmland were needed to replace the energy content of all fossil fuels consumed in the US 1970.[320]

I will proceed in two steps. First I ask how large land areas would be needed in order for economies to become independent of fossil fuel *imports*;

[319] Borgström 1964:233. The conclusion is similar to the one reached in chapter 4, comparing the global ecological footprint with the bio-productive land and sea areas.

[320] Catton 1980:46.

second, I bring the example to its logical conclusion and estimate the land areas required to replace *all* fossil fuels and nuclear power.

Table 8.1. Net imports of fossil fuels and the land areas needed to replace it 2007

	Net imports of fossil fuel in Mtoe[*)]	**➔ Equals TJ**[**)]	**➔ Equals Mtons sugarcane**[***)]	**➔ Equals Mha sugarcane**[****)]
OECD	1,821 Mtoe	$7{,}624 \times 10^4$	38,120 Mtons	477 Mha
Brazil	25 Mtoe	105×10^4	525 Mtons	7 Mha
China	167 Mtoe	699×10^4	3,495 Mtons	44 Mha
Germany	202 Mtoe	846×10^4	4,230 Mtons	53 Mha
India	150 Mtoe	628×10^4	3,140 Mtons	39 Mha
Japan	435 Mtoe	$1{,}821 \times 10^4$	9,105 Mtons	114 Mha
USA	714 Mtoe	$2{,}989 \times 10^4$	14,945 Mtons	187 Mha

[*)] IEA 2009, a small share of electricity imports are included in the figures for the US, Brazil and India. 1Mtoe = 4.1868×10^4 TJ.

[**)] TJ = 10^{12} joule.

[***)] Energy content 2000 MJ/ton sugarcane. *Source:* BNDES & CGEE 2008, Table 12. I have not deducted the energy used to produce ethanol as it is of the same magnitude as the energy content of the by-products from ethanol production (bagasse and electricity generation): the inputs are estimated to contain 234 MJ/ton sugarcane, while the co-generated products are 259 MJ/ton.

[****)] highest average Brazilian sugarcane yield assumed: 80 t of sugarcane/ha. Source: BNDES & CGEE 2008, Table 7.

If the OECD were to replace its net fossil fuel imports by best-case Brazilian ethanol, 477 million hectares would be needed, approximately one third of today's global crop land. See Table 8.1.

Where could such land areas be sourced? Most likely by deforestation, either directly or indirectly. Directly, as it already today is taking place in Indonesia and Malaysia, for instance, to make room for the production of palm oil; or indirectly, as in the Brazilian case, where deforestation occurs first in the Cerrado, and then in the Amazon at the end of the chain of events unleashed by the expansion of sugarcane over croplands and pastures.

Thus, if we intend to replace fossil fuels by agrofuels in order to reduce climate gases, we are likely to replace one source of carbon gases by another, land use change for fossil fuels.

On the other hand, if the motive for reducing the dependence on fossil fuels is geopolitical, we need not be concerned with the ecological

consequences, but the boosting of agrofuels would still be problematic since we would exchange the dependency on oil producing countries for a reliance on land-rich countries, primarily in South America. Eastern Europe and South East Asia; this second option may be as problematic as the present situation from the point of view of geopolitics.

I now take this scenario one step further by asking how large land areas would be needed to substitute *all* fossil energy with agrofuels. Again, the estimates are conservative as I am using Brazilian area-efficiency figures. See Table 8.2.

Table 8.2. Total use of fossil and nuclear energy and the land areas needed to replace it 2007

	TPES of fossil fuel & nuclear energy in Mtoe	**➔ Equals TJ**	**➔ Equals Mtons sugarcane Mtons**	**➔ Equals Mha sugarcane**
OECD	5,119	21,432 x 10^4	107,161	1,340
Non OECD	5,386	22,550 x 10^4	112,751	1,409
World	10,505	43,982 x 10^4	219,912	2,749

Legend: see Table 8.1.

The required land areas are not small: for the world as a whole we would need 2,749 million hectares, or 180 percent of today's cropped land area. As a complete replacement of fossil fuels, in the best of cases, would require close to twice the present global crop lands, we would have to look for new land areas for food, feed, and fibres.

Of course, if we entertain more realistic scenarios, with lower area productivity than the Brazilian case, the areas needed to replace fossil fuels will be concomitantly larger, and the contradictions among the competing land uses still fiercer.

A sequence of cumulative agro-regimes

Over the years, the role of land areas and land-based resources in the global socio-ecological metabolism has shifted. Sociologists Harriet Friedman and Philip McMichael have described this shift in terms of a series of "food regimes",[321] but I believe that "agro-regimes" is a more appropriate concept to the study of the use of land areas and land-based resources which we witness today.

The fact that land is "fungible", that land can be used for many purposes, gives the simultaneous increase in the quest for land for food, feed, fibres, and fuels its significance, and explains why an expansion of agrofuels cannot help but entering into direct conflict with other land uses (since I postulate that no new land may be cleared for agriculture).

I will restrict my discussion to the period after World War II, but even with this limited historical perspective we find three regimes. Each regime is characterized by its unique mixture of arena, driver, legitimating ideology, and emblematic product. See Table 8.3.

Table 8.3. Three agro-regimes since 1945

Agro-regime	Main Arena	Main Driver	Legitimation	Emblematic product
Food	National	States	National self-reliance	Wheat
Feed	International	States and corporations	Market efficiency	Soybean, meat
Fuel	Global	States, corporations, and finance capital	Climate Change	Ethanol, biodiesel

Agro-regimes have evolved from being basically a vehicle for producing food, via incorporating feed for the food and meat industry, to also providing fuels. But the sequence is not one of replacement but rather of accumulation, just as we found in the use of the various fuels dominating the socio-ecological metabolism.

[321] See Friedmann & McMichael 1989, and McMichael 2009a.

Still, the regimes are different and some trends are clear: the regimes have gradually migrated from the national via the international to the global arena, integrating new drivers – corporations for the feed regime, finance capital for the fuel regime – and benefitting from new justifications and legitimations.

The dominating logic of the first regime, the agro-food regime, was to achieve self-sufficiency of food in order – at least as a legitimation – to hedge against a possible return to the 1914-1945 years of blockade and the resulting rationing of food. This objective was so strong that it kept agriculture as a whole outside the General Agreement on Tariffs and Trade, GATT, 1947.[322]

But although the purpose may have been to protect national food markets, the combination of state protection with high degrees of subsidies to the agricultural sector of the North created large surpluses which were channelled to the countries of the South, where they were dumped either to outcompete local food production, and thus create future markets for food exports, or shipped as food aid (which had a similar negative impact on local self-reliance). In the terms of ecological exchange, however, we here have a situation where the North is exporting more areas than it is importing, testifying to the different logic of the agro-food regime as compared to the present agro-fuel regime where the reverse flow South → North is dominant.

The second regime, the agro-feed regime, witnessed the increase of feedstocks for meat production and for the food industry, mixing old and new agricultural superpowers (see Table 6.5, above for a representative list). The agro-feed regime brought forth new agricultural exports and exporters, creatively dubbed New Agricultural Countries, NACs, by Harriet Friedmann.[323] This change went largely unnoticed compared to the attention afforded the parallel shift in industrial production, the NICs, but the fact is that the NACs became more cental to the global socio-ecological metabolism as providers of feed for the meat industry, and as suppliers of vegetables, fruits, citrus and cut flowers to the North. Thus, the agro-feed regime saw three flows of land-based resources: food from the traditional large exporting countries, the settler colonies of old, primarily, US, Canada, Australia, and Argentina; simultaneously, new flows of feed from Argentina,

[322] Another important sector which also was excluded from GATT was textiles, allegedly also to secure the continuous supply of an essential good.

[323] Friedmann 1993:45-47.

Brazil, Canada and the US for the global food and meat industry; and, also simultaneously, a flow of high-priced fruits and vegetables from the South to the affluent markets of the North, especially its urban centres. Kenya is here a case in point, today one of the world's leading exporters of cut flowers.

In this agro-feed regime, not only food but equally feed are produced and transported around the globe, sharpening the substitutability of, and thus the competition for, fungible land areas and land-based resources.

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Viewing agriculture as embedded in a series of cumulative regimes in this way sheds new light on one of the more confusing aspects of the World Trade Organisation, which replaced GATT in 1995. What needs explaining is why agriculture was included in the WTO after having remained outside of the GATT for almost 50 years. The conventional understanding is that neither the US nor the EU had any intention of actually opening up their agricultural sectors to foreign competition; they only used agriculture as a negotiation tactics to get countries such as India and Brazil to accept other agreements – especially patent rights – which the countries of the South only would agree to if they were "paid off" by an agreement on agriculture.[324]

The tactics worked well, and the new WTO did include an Agreement on Trade Related Aspects of Intellectual Property Rights, TRIPS, which catered to the interests of the patent-holding corporations in the North. And the fact that the US and EU since the establishment of the WTO have failed to fulfill their obligations according to the agreement on agriculture has been seen as a confirmation of this interpretation: the EU and the US had never intended to give up supporting and protecting their agricultural sectors, the agreement on agriculture was just a scam to get other agreements through the negotiations.[325]

This interpretation is not exhaustive, however, it disregards that the agro-food regime had passed into a new phase at about the time the WTO

[324] UNDP 2003 provides a summary of the negotiations and the establishment of the WTO in this light.

[325] For a recent assessment of the impasse in the WTO negotiations, see Hoekman 2011. The average tariff protection for agricultural products was still 4 percentage points higher than for industrial goods in 2010, indicating the same greater willingness to protect agriculture compared to industry; the gap has remained stable since WTO started in 1995. See Datt et al. 2011:4.

negotiations were initiated late 1980s: the national logic of the agro-food regime was no longer dominant, the need of the agro-feed regime for an open world market in agricultural products was gaining strength. The state-corporate international agro-feed regime simply understood agricultural products to be just like any other commodity, no more strategic, or of greater national importance, than other goods which were traded openly on the world market.

The failure by the US and EU to follow the obligations they had incurred by the agricultural agreement indicates that agro-regimes, by being cumulative, may carry seeds of conflicting logics, food drivers clashing with feed drivers. The feed lobby got the agricultural agreement in, the food lobby made sure that it was not implemented. With the advent of the agro-fuel regime, such conflicts are likely to multiply, adding to the contradictions which already take place on the ground in the shape of direct and indirect land use change.

The climate regime and forests

The climate change discourse adds a new aspect to the fungibility of land areas and land-based resources, and this has a major impact on the agro-fuel regime, leading to an intensification of the trend towards commoditization of agriculture and land-based resources. It also legitimizes "green grabbing", the acquisition of land allegedly for ecological purposes.[326]

By recognizing that deforestation is one of the main drivers of climate change – 12-17 per cent of the global GHG emissions are related to logging, deforestation and unsustainable forestry[327] - forests were included in the climate negotiations through a mechanism which initially was called Reduced Emissions from Deforestation and Forest Degradation, REDD; subsequently, forest management and reforestation were included, yielding

[326] Corson & MacDonald 2012:273.

[327] The lower figure from World Resources Institute, covering only the global South, http://www.wri.org/chart/world-greenhouse-gas-emissions-2005; the higher from IPCC, Fourth Assessment Report, http://www.ipcc.ch/publications_and_data/ar4/syr/en/figure-spm-3.html.

the acronym REDD+.[328] The idea is that forests should be left standing or at least managed in a way which sequester carbon dioxide, and that countries who commit themselves to this will receive payment to make up for their foregone income. The carbon saved will be turned into "credits" to be sold on a market to corporations or governments which need to show that they have "reduced" their emissions, turning forest carbon, in the words of Conservation International, into "an asset class".[329]

REDD+ projects have serious problems in proving their value as sinks for greenhouse gases. First is the issue of "additionality": REDD+ must establish rules to secure that projects and programmes really result in less deforestation than otherwise would have occurred. Without guarantees that REDD+ finances additional carbon sequestration, the money will just go to pay for plantations or sequestration policies which would have occurred anyway, thus in fact only constituting a transfer of money without any climate significance whatsoever.

Secondly, "permanence" of REDD+ is doubtful. The payment for the non-use of forests must lead to a permanent improvement in the carbon cycle, but which government is able credibly undertake such long-term commitments? Not without making protecting forests part of the constitution; and even so, the balance of powers may change to the benefit of the forces who want to turn forests into commodities just as any other land-based resource.

Neither issue has been resolved, but more important in this context is that forests as climate control is yet a new competitor for the available land areas, still not so important but with a potential for becoming more so as a new climate regime is negotiated.

A third issue in relation to REDD+, and also one which clearly ties in with my discussion of fungibility of land areas, has to do with "leakage". As REDD+ projects block deforestation in one location, the price of feedstocks will be pushed up, and the paid property owners are encouraged to open up new land somewhere else. An assessment of the few carbon sequestration projects to date shows leakage levels going up to 100 per cent or more: the money earned is spent on acquiring new lands, causing indirect land use

[328] For REDD+ programmes, see http://www.un-redd.org/.

[329] Conservation International 2011:iv. CI, with Rob Walton of Wal-Mart as chairman of the board, is planning to enter the REDD+ business segment.

change of similar or even larger magnitudes.[330] It is a parallel process to the one described in chapter 3 regarding the chain-effects of expanding sugarcane in Brazil's Cerrado.

In addition to these technical points, there is also a clear allocative issue regarding REDD+ projects: who is to be compensated for the non-use of whose forest resources? Here, we encounter anew the distinction between forests – and ecological resources in general – as common property of a society as a whole (as stated in the Brazilian constitution and forest code, for instance) or as resources belonging to the direct users along the line of the Agrarian credo (see chapter 3). In the former case, the remuneration would go to the state as representative of the whole; in the latter, it ought to be shared among the immediate users of and dwellers in the forests.

State involvement is of course necessary, if only to set up the rules and regulations for projects such as these, but there exists at least one Brazilian example – a fund called Programa Bolsa Floresta – where community members living in the Amazon are directly paid 50 USD per month by the state for protecting and keeping the forest intact. Behind the Bolsa we find, as so frequently, global corporations which through their financing of the programme may claim that they are "offsetting" their own emissions of GHG. The Marriot hotel chain is one of the backers of the Bolsa, and it even uses its support as an argument for charging an extra dollar per night from its customers; in this way, the support costs Marriot less but still gives it good-will.[331]

[330] Wunder 2008:68.

[331] See Billion dollar jungle, www.climatemediapartnership.org/reporting/features/billion-dollar-jungle.

EU's raw materials initiative

Without referring to agro-regimes or to climate politics, resource analyst Michael Klare observed ten years ago:

> the emergence of a new geography of conflict – a global landscape in which competition over vital resources is becoming the governing principle behind the disposition of and use of military power.[332]

His perspective was limited to the United States, but also the European Union is concerned about its future access to raw materials. The EU's Raw Materials Initiative focusses on the growing need to access primary commodities. In a statement by the EU Commission in 2006, raw materials were singled out in menacing words:

> More than ever, Europe needs to import to export. Tackling restrictions on access to reources such as energy, metals and scrap, primary raw materials including certain agricultural materials, hides and skins must be a high priority. Measures taken by some of our biggest trading partners to restrict access to their supplies of these inputs are causing some EU industries major problems. Unless justified for security or environmental reasons, *restrictions on access to resources should be removed*.[333]

In the EU policy statement which followed in early 2011, the aggressive wording had been softened, but this cannot hide that continuous and unhindered access to minerals and agricultural resources is of pivotal concern to the EU. According to the Commission, the EU needs a "raw materials diplomacy" in order to secure a constant flow of primary commodities.[334] The wording sounds neo-colonial, as if access to the resources which other countries harbour were a right of the EU.

The reason to worry, the EU Commission explains, is that a high share of the worldwide production of "critical raw materials […] comes from a handful of countries" and it lists China, Russia, DR Congo and Brazil as the main suppliers. The critical resources contemplated by the Commission were

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[332] Klare 2002:214.

[333] European Commission 2006:7, italics added.

[334] European Commission 2011:11.

antimony, beryllium, cobalt, fluorspar, gallium, germanium, graphite, indium, magnesium, niobium, platinum, rare earths, tantalum, and tungsten;[335] it has obviously not yet dawned on the Commission that land-based resources for the provisioning of food, feed, fibres, fuels and climate stability should be included.

Not only has the EU Commission failed to grasp the real significance of the agro-fuel regime; their list of problematic suppliers is also misleading, as we can gather from Table 6.5, above: raw materials, be they minerals or agricultural, are controlled by a handful of countries and corporations in the North and, to a lesser extent, the South, they are not the sole purview of poor or unstable countries.

The EU's partial blindness is perhaps intentional: if essential raw materials and commodities are controlled by dictators and corrupt regimes, the EU could be forgiven for intervening. Just a step further and we would encounter the argument that the EU is in its right to use violence to secure its needs; after all, war is the continuation of politics by other means, as Clausewitz famously mused.[336]

The same concern which permeates the EU raw materials policy – the wish to secure a continuous flow of primary commodities – may also be framed in pacific, non-confrontational words, posing future conflicts as "risks" and "challenges". This is the approach of the global business community and its recently formed Risk Response Network.[337] The network, which is part of the World Economic Forum, WEF, underlines as one of three global "risk nexuses" climate change, food and water insecurity, and the volatility of energy prices. If this sounds familiar, it should: the WEF describes quite accurately the situation we witnessed during the period leading up to the financial crisis of 2008. When the food price spike hit, a number of countries of the South introduced bans on food exports in order to stave off domestic protests and food riots.[338]

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[335] European Commission 2011:21.

[336] Carl von Clausewitz's *On War* was originally published in German in 1832.

[337] World Economic Forum 2011. Two other "risk nexuses" were identified: The economic crises nexus, and The illegal economy nexus.

[338] Cohen & Garrett 2009 report violent protests in the following countries: Burkina Faso, Cameroon, Côte d'Ivoire, Egypt, Guinea, Haiti, Honduras, Indonesia, Kenya, Malaysia, Mauritania, Morocco, Mozambique, Pakistan, Russia, Senegal, Thailand, Tunisia, and Yemen.

The flow of food and other land-based resources to the North was threatened, indeed, but not primarily by a number of unstable states rich in raw materials. The global system is becoming more and more integrated, but also more and more vulnerable. Hence the renewed EU offensive to secure access to a continuous flow of raw materials.

The underpinnings of the agro-fuel regime

The agro-fuel regime is global, and thus it should not come as a surprise that the World Bank, an institution with a global mandate, is engaged in its regulation and legitimation. But the regime would not have arisen had it not been fomented, regulated, and financed by states, in coalition with national and international corporations, involving a mixture of perhaps unexpected participants, from civil society organisations to research institutions and universities.

It is common to view globalization as a phase of capitalist development where international financial institutions and corporations have taken over from weak and overrun governments. But, using sociologist Saskia Sassen's term, we should recognize that the present stage – and the present agro-fuel regime – is "multi-scalar", not national *or* global, private *or* public, but all of these at the same time. This may not sound as much of an insight, but what Sassen rescues out of the hype surrounding globalization is that the process is propelled to a considerable degree by national and local power (and not only by transnational institutions and corporations).

Intermediary actors play a crucial role in the establishment of this new agro-regime, symbolized by the promotion of agrofuels. Such "go-betweens" enable the appropriation of land areas and land-based resources, of which "green grab" is the latest addition: the use of ecological arguments to justify the appropriation of land areas and land based resources. The go-betweens include consultancy firms and specialists in Geographic Information Systems, GIS, supplying the map and the scientific garb needed to prepare

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Similarly, FAO 2009a:54-57 reports policy measures taken to reduce agricultural exports in Argentina, Bangladesh, Bolivia, Burkina Faso, Cambodia, China, Egypt, Ethiopia, Guinea, Haiti, Honduras, Madagascar, Malawi, Uganda, and Zambia.

for the grab, as well as experts in elaborating carbon offset projects acceptable as REDD+ projects, and agents who negotiate land deals with local communities and governments.[339]

Taking all of this together we get a collection of drivers and actors in a multi-scalar landscape, a complex – Sassen prefers the word "assemblage" – certainly something similar to what we saw in connection with the introduction, legitimation and expansion of the sugarcane ethanol complex on the national and global scales (in chapters 2 and 3). The main point is that land as an essential and limited resource has attracted the attention of ever more actors, linking the national to the international, the private to the public, the North to the South, and mixing them all.

Such complexes permeate the global agro-regime, erasing the border that distinguishes domestic from international. A telling case is the push by the then Florida governor Jed Bush to turn Miami into the ethanol capital of the world, offering it as the gateway to the US market for Brazilian agro-businesses, led by UNICA. In 2006, Jed Bush went to Washington DC to convince his brother, President George W Bush, that the US needed to adopt "a hemispheric wide approach to ethanol" with the catchy slogan "15 by 15": 15 billion gallons (57 billion litres) by the year 2015.[340] This appeared as a bold goal then, but it was still less ambitious than what later became the US mandate, 36 billion gallons (137 billion litres) by 2022.

To achieve his aim, governor Bush had to show the US authorities that Brazilian sugarcane ethanol was "environmental friendly" and that it qualified for supplying the US market, similar to UNICA's effort to convince the EU Commission (see chapter 3).

This is yet another example of how the agro-fuel regime relies on the climate change discourse in order to bring home the need to find a substitute for fossil fuels. It is through the ecological argument in favour of replacing fossil fuels by agrofuels that the new agro-regime comes of age, adorned with ecological credentials.

Questioning the scientific and ecological legitimacy of the agro-fuel regime will encounter staunch resistance as there are many stakeholders who have joined forces and pinned their hopes – and their carreers – to the alleged merits of agrofuels. Such alliances in the service of the agrofuel

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[339] See Fairhead et al 2012 for a discussion of "green grabbing", including examples of "go-betweens".

[340] Hollander 2010:707.

complex help explain the furious opposition I encountered in Brazil when I wanted to discuss the advisability of expanding sugarcane in the Cerrado. I pointed to the lack of firm knowledge about the impact on direct and indirect land use change of any expansion of the land areas for agrofuel feedstocks, and that this in turn questions the status of Brazilian ethanol as "climate neutral". At two separate occasions, Brazilian colleagues, fellow university scholars, got very upset and scolded me for raising the issue of land use change. This was none of my business, I was told in unequivocal words:

> We will do with the Amazon as we like! You people from Europe have nothing to teach us after you have cut down all your own forests! A Amazônia é nossa! The Amazon belongs to us![341]

What ignited such outbursts, I believe, is that my academic colleagues correctly detected criticism of the new agro-regime and felt themselves, as part of the agrofuel complex, implicated.

If the term "complex" brings the farewell speech of the US President Eisenhower to mind, this is intentional. Eisenhower talked of two complexes in his last message to the American people before leaving the presidency to his successor John F Kennedy, in January 1961, but it is only one side of his warning which has remained in the puplic mind. Eisenhower stressed that the "conjunction of an immense military establishment and a large arms industry is new in the American experience"; this military-industrial complex was exerting "total influence – economic, political, even spiritual – […] in every city, every State house, every office of the Federal government", and he warned that this complex could attain "unwarranted influence" resulting in a "potential for the disastrous rise of misplaced power".

What is not equally well remembered is that Eisenhower saw a twin danger in the rise of the "scientific-technological elite" to whom "a government contract becomes virtually a substitute for intellectual curiosity" in Eisenhower's well-chosen words.[342]

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[341] The occasions were a seminar at the São Paulo state agricultural university ESALQ, and an international academic conference on indirect land use change organized by the IEA and the University of Campinas, both events in October 2011.

[342] See President Eisenhower's farewell address, January 17, 1961, http://www.ourdocuments.gov/doc.php?flash=true&doc=90.

What the agro-fuel regime proves is that these two complexes have joined forces: the new agro-fuel regime needs the benediction of the scientific-technological elite.

Land use change in the future: what we can expect

It is not only my two assumptions – peak oil, peak soil – which tells us that the conflicts over land use will increase, also two other facts indicate that land use struggles will intensify. First, agricultural productivity increase appears to have reached its limits, the annual increase in area productivity of cereal production – wheat, maize and rice, the mainstay of the global diet – has declined decade by decade during the last forty years: 3.7 per cent in the 1960s, 2.5 in the 1970s, 1.4 in the 1980s, and 1.1 per cent 1990-2001.[343] This does not mean that production is decreasing, only that we cannot expect growth rates to keep up with the ever-increasing demand for food and feed, let alone hope that arable land will be freed up to allow the likely expansion of the production of fibres, fuels, and forests.

Second, the possibility of replacing fossil fuels with land-based renewables will encounter limitations as the renewable alternatives are much less area-efficient than the fossil alternatives they replace. Or put differently: the "power density" of renewables is low. While fossil fuels have a power density of 100 or 1000 Watt per square meter, biomass energy on average is well below 1 W/m^2, and US maize ethanol only achieves 0.22 W/m^2. Thus, a shift from fossil to agrofuels has the exact opposite implication in land area terms compared to the previous shift from agro- to fossil fuels: then, lower-density was replaced by higher-density, now, we are proposing to replace higher by lower. Conclusion: the strain on available land areas will be stronger still.[344]

If increases in productivity – be they in food, feed, fibres or fuels – must be ruled out as a solution to steeply rising demand for land-areas and land-based resources, the result in the absence of dramatic dietary change would most probably be that ever more land areas are cleared to produce the

[343] FAO 2006:5.

[344] Smil 2005:22. The situation is similar, although not quite as bad, for water and wind power which reach at the most $10W/m^2$.

renewable resources which are demanded in the new global agro-regime. Table 8.4 shows the impressive areas cleared historically, in all continents, creating the global landscape we have today of 1 500 hectares of crop land.

The most important data to note in Table 8.4 is that Europe and North America during the last period, 1950-1980, had decreasing areas dedicated to crop lands as reforestation occurred, while the rest of the world went in the opposite direction and saw an increase in the areas cleared for crops. Also with this metric we can see a displacement of land use: the increase in croplands in the South enables a decrease in the Centre. The measures of ecologically unequal exchange of land indicate how the contradiction is resolved: by the North importing the ecological space it requires.

Table 8.4 Cropland expansion 1700-1980, million hectares

	1700-1800	1800-1920	1920-1950	1950-1980
Africa & M East	11	56	71	127
Asia	38	90	65	120
Europe	30	50	5	- 15
Latin America	4	34	42	55
North America	6	170	27	- 3
Russia, Oceania	27	132	47	47

Based on Grübler 1998 :Table 5.3.

This shift from the Centre to the Periphery has continued unabated. Satellite images of land use change 1995-2007 show diverging trends North and South: in the North, agricultural areas decrease, while they increase in the South. During these years, crops and pastures of the North declined by as much as 412 million hectares, while they simultaneously increased in the South by an estimated 400 million hectares.[345] Again, the appropriation of ecological space is targeting the South.

In a business-as-usual scenario, the present tendency can be expected to hold. The expansion of agricultural lands during the last decades of the 20th century – that is, during the period following upon the long-term deforestation described in Table 8.4 – has continued, and it takes place mostly at the expense of existing forests, not on pastures. 55 per cent of the total expansion of agricultural lands 1980-2000 occurred at the expense of intact forests, and a further 28 per cent replaced "disturbed forests", all in all

[345] Gibbs et al. 2010:16736.

approximately 80 million hectares of forests turned into croplands. See Figure 8.1. In general, crop land expansion is not happening on previously cleared lands, such as pastures but on forests, something which takes place more or less equally on all the continents and regions of the South, it is the general trend.

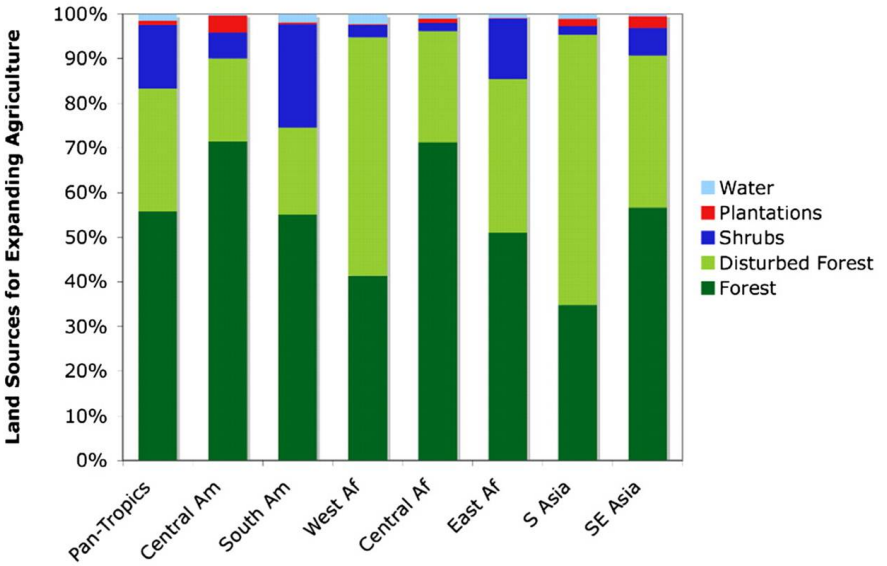

Fig 8.1. Land use change for agriculture 1980-2000, %
Source: Gibbs et al. 2010, Figure 2.

The data is alarming enough as it stands, but I must go one step further by stressing that Figure 8.1 does not show all cleared forest lands, only the part which was transformed into crop lands and pastures. By including *all* land use change – in addition to crop lands and pastures we must also add logging – the world's forests suffered an even heavier blow: approximately 195 million hectares were cleared 1990-2005.[346]

[346] See United Nations website for the Climate Change Convention, section on Land Use, Land Use Change and Forestry (LULUCF) http://unfccc.int/methods_and_science/lulucf/items/4123.php.

Such displacement is now made part of the scenarios for feeding the world's socio-ecological metabolic process: the FAO is counting on increasing land use in the South and decreasing in the North, just as the pattern we have seen during the last thirty years: while Africa and Latin America will deforest an estimated 120 million hectares by 2050, Europe and North America is estimated to re-forest 50 million hectares; the net outcome is thought to be an expansion of arable lands of 70 million hectares.[347] The World Bank, while also recognizing the trend to reforestation in the North, presents an even larger land use change, 120-240 million hectares of new crop lands by 2030, mostly in Latin America and Africa.[348]

This is the most likely tendency, then: although deforestation is slowing down compared to the post-World War II period, it will go on at a frightening pace. And it may get much worse, if the not even the reduced productivity increases which are factored into these scenarios materialize.

A counterfactual calculation shows the dimension of the problem. In the absence of productivity gains 1961-2005, the agricultural land areas needed to feed today's population would have been 1.8 billion hectares larger than they in fact are, we would have needed almost twice today's crop lands (which are 1.5 billion hectares).

In the future, given present trends, and discounting an improvement in productivity of the magnitude we had during the second half of the 20th century, another 1.5-2 billion hectares will be needed by 2050, once again more than a doubling of the global crop lands of today.[349] Thus, to the extent that there has been land areas spared from exploitation, we should be grateful for the impressive improvement in productivity during the last 50 years. But, to repeat, this is not something we can take for granted henceforth.

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[347] FAO 2009b:9.

[348] World Bank 2011:6. Alarmingly, the World Bank dubs its assessment "conservative".

[349] See *Nature* 2010:853.

Financialization of land

The expanding markets for land have awakened the interest of national and international financiers, including the World Bank's International Finance Corporation (IFC). The IFC plays a particularly important role in this process, for two reasons. First, it is the global "benchmark"-setter for "acceptable" foreign direct investments, and the rules of the IFC are taken over by a group of international bankers, the so-called Equator Banks, and included in their own safeguards. Recently the World Bank, together with the International Fund for Agricultural Development, IFAD, UNCTAD and the FAO, launched a set of investment rules under the ambitious heading "Principles for Responsible Agricultural Investments which Respect Rights, Livelihoods and Resources".[350] However, according to the UN special rapporteur on the right to food, Olivier de Schutter, these principles are a "checklist of how to destroy the global peasantry responsibly",[351] and a CSO coalition, led by Via Campesina, holds that the principles, far from being responsible, amount to green-washing,

> a move to try to legitimize what is absolutely unacceptable: the long-term-corporate (foreign and domestic) takeover of rural people's farmlands.[352]

Via Campesina is distancing itself from the financialization and commodification of land, a stand which brings to mind the vehemence with which the historian Karl Polanyi in 1944 argued against the general tendency to commodify "essential elements" such as labour, land, and money, three "fictitious commodities" which were not to be left at the mercy of the market but required proper regulation and institutions. Polanyi wrote in 1944, influenced by the catastrophes of the Second World War:

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[350] The following six principles are included: Respecting land and resource rights, Ensuring food security, Ensuring transparency, good governance, and a proper enabling environment, Consultation and participation, Responsible agro-enterprise investing, and Social sustainability. See http://www.responsibleagroinvestment.org/rai/node/256.

[351] de Schutter 2011:275.

[352] See http://www.viacampesina.org/en/images/stories/pdf/whyweopposerai.pdf.

> What we call land is an element of nature inextricably interwoven with man's institutions. To isolate it and form a market out of it was perhaps the weirdest of all undertakings of our ancestors. […] Undoubtedly, labor, land, and money markets are essential to a market economy. But no society could stand the effects of such a system of crude fictions [i.e. that labor, land and money are commodities] even for the shortest stretch of time unless its human and natural substance as well as its business organization was protected against the ravages of this satanic mill.[353]

State control of land is no hedge against land appropriation here, on the contrary: it is thanks to public rule over land resources that large land deals can so easily and swiftly be brokered with foreign and domestic investors. It does not matter that customary rights may be guaranteed, not even if they are written into the constitution, governments in the South regularly dispose of lands over which they have no formal dominion.[354]

But governments often assume that they are representing a higher justice than the law, or they just interpret the law in favour of "change" and "progress", as they define it. We saw above (in chapter 7) how the Indian Supreme Court counter-posed the interests of the few and marginalized against the benefits of development to the overwhelming majority of the Indian population in order to approve illicit ship-breaking on Indian shores. In less conciliatory language, Alan García, then president of Peru, threatened Peru's indigenous population not to stand in the way of large-scale investments in land and mining, telling them instead to go by the

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[353] Polanyi 2002/1944:187, 76-77. Also Keynes, influenced by the crash of Wall Street in 1929 and the financial breakdown of the 1930s, expressed similar apprehension should money be considered to be just like any commodity. In a celebrated section of his General Theory, he says: "Speculators may do no harm as bubbles on a steady stream of enterprise. But the position is serious when enterprise becomes the bubble on a whirlpool of speculation. When the capital development of a country becomes a by-product of the activities of a casino, the job is likely to be ill-done." Thus distinguishing the real from the casino economy was essential and Keynes suggested taming Wall Street – i.e. the casino – by introducing "a substantial Government transfer tax on all transactions […] with a view to mitigating the predominance of speculation over enterprise in the United States". Keynes 2007/1936:142-143. Today, such transaction taxes bear the name of the Keynesian economist James Tobin, who proposed them in order to slow down currency speculation after the break-down in the early 1970s of the fixed exchange rates which were part of the Bretton Woods agreements of 1944.

[354] See Wily 2010 in relation to land grabbing in Africa.

"experience of the successful peoples, the Germans, the Japanese, the Koreans, and many more":

> Reality teaches us that we should put the resources which we do not use to work and expend more effort […] indigenous people do not wear a crown, they are not first class citizens who can tell us – 400 000 natives to 28 million Peruvians – that you have no right to come here, no way. It is a serious mistake and anyone who thinks like this wants to push us back to irrationality and to our primitive past.[355]

Secondly, the IFC has designed a number of "products" in order to further speed up land grabbing, especially in Africa south of the Sahara in order to do away with "unclear or unenforceable rights to land [as they] inhibit business growth and investment across the developing world."[356] A consequence is that the IFC finances land registration in order to establish land markets. Contradictory, titling prepares holdings for grabbing, the "responsibility" shown by the World Bank in fact amounts to enabling the further commodification of land.

But the World Bank is not only facilitating and legitimating land grabbing, it has also entered the game of finding large land areas, the appropriation of which no-one would oppose since they are not being used by anyone, or so the World Bank wants us to believe by stressing the benefits of large-scale commercial investments on "marginal" and "sub-optimally" used lands.

In a scoping exercise the World Bank found 446 million hectares available world-wide for investments in commercial agriculture.[357] These are very large areas indeed, and the estimates are arrived at in the customary way, by using proxies for actual land use – foremost population density – and adding satellite images of land, thereby conflating land cover, which is identifiable via GIS, with actual land use, which is not, a mistake "as people often have intentions behind land use that cannot be deciphered remotely." For instance, 50 million pastoralists, sometimes estimated at 200 million

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[355] Alan García, Peruvian daily *El Comercio*, October 28 and November 25, 2007, quoted in Benavides 2010:7-8.

[356] Daniel 2011:7.

[357] World Bank 2011:xxxiv.

agro-pastoralists, live on African dry lands which frequently are described as underused.[358]

The geographic concentration of the areas identified as available by the World Bank is high, with only seven countries accounting for half the land area: Sudan, Brazil, Australia, Russia, Mozambique and the Democratic Republic Congo (in this order).[359]

The World Bank is not an innocent bystander here, and we are confronted by a terminology whitewashing the dispossessing of farmers, for instance when it talks of Africa as a "sleeping giant" which supposedly should be awakened in the name of increased efficiency and increasing yields, hiding eviction and violation behind euphemisms and myths of abandoned, underutilized or sub-optimally used lands.[360] In this way, the World Bank can "identify" vast areas where the "yield gaps" may be closed if only commercial agriculture was introduced in order to produce the missing food, feed, fibres, and fuels to satisfy the land hunger of the global socio-ecological metabolic regime.

At times, the World Bank leaves the realm of fantasies and speaks openly about what financialization of land and land-based resources is all about: transferring land use, and exchanging one category of land users for another. In a somewhat muffled language, the World Bank flagship publication *World Development Report 2008* made markets – not corporations, or governments, or finance capital – the actors realizing this transfer:

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[358] Nalepa & Bauer 2012:410. The tradition of disregarding the land use by supposedly inferior peoples go a long way back, of course, and has not always relied on GIS; also Friedrich Engels in 1844 ridiculed the Malthusian idea of population pressure on limited land as "absurd" as there was enough "waste land" available in the Mississippi valley to allow the "transplantation" of the whole population of Europe, and he went on to stress that "no more than one-third of the earth can be considered cultivated" and that "the production of this third itself can be raised sixfold and more by the application of improvements already known." Engels 1844:19-20. I detect here a similar outlook which 128 years later coloured Emmanuel's complaint that the earth was seriously under-utilized (see chapter 4).

[359] World Bank 2011:79.

[360] "Awakening the Sleeping Giant" is the title of a World Bank publication advocating commercial farming in West Africa. See World Bank 2009.

> Secure and unambiguous property rights also allow markets to transfer land to more productive uses and users.[361]

Again, "secure property rights" are not secure for the peasants and other small-scale landholders, but rather constitute the vehicle for transferring land to new users. The World Bank knows what it is suggesting, the usurpation of the rights of the peasants who today use these lands, and it acknowledges that

> very little, if any of this [globally available land] will be free of existing claims that will have to be recognized by any potential investment.[362]

Put clearly, the World Bank is advocating the transfer of land which it knows is currently being used, and which thus most likely will lead to conflicts when it comes to both its uses and users.

Return to the land

We are entering a new era where land matters are coming to the fore once again, an era which may bear a resemblance to the conflicts which accompanied the undoing of the laws valid for all times which Malthus thought he established in 1798. As the limits to growth then were overcome by a combination of appropriation of land areas (colonialism) and the substitution of land-based energy for fossil fuels (coal and later oil), the limits today may become undone through environmental load displacement and the various shapes of ecologically unequal exchange of land-based resources which I have documented in this study.

This, then, is the return to the land as a key scarce resource needed for capital accumulation, economic growth and development. Although Malthus was wrong for two hundred years, he is now right, at least if my two underlying assumptions – no fossil fuels, no deforestation – are respected.

Such thoughts were behind my initial argument in favour of re-introducing a Malthusian perspective, and for not rejecting the label "neo-

[361] World Bank 2007:138.

[362] World Bank 2011:78-79.

Malthusian", at the outset of this study. Here, I am once again in the company of Georg Borgström. Although he in the 1950s tried to dissociate himself from Malthus – he then considered "Malthusian" an insult and was afraid that he would be dismissed in the public debate should he be perceived as a follower of the old priest[363] - a decade later Borgström had changed his opinion and now celebrated Malthus as a

> mathematician and economist, not at all 'a poor priest led astray', who in simple and clear words and with mathematical exactness had formulated the unquestionable limit to the size of humanity established by the availability of food.[364]

Apparently, Borgström had become more self-assured in the intervening years, and now supported his own ideas by admiringly referring to Malthus's "clear-sightedness" in establishing a "final limit to the extension of mankind".[365]

I am not sure whether Borgström refers to the "young" Malthus – who 32 years old published his *Essay on the Principle of Population* in 1798 – or to the "mature" Malthus, who five years later in a revised edition made a clear statement against expropriating lands and ousting indigenous people overseas to make room for the surplus population of Europe. Possibly writing in reply to Benjamin Franklin, who in 1755 had contemplated replacing "all Blacks and Tawneys" by whites, Malthus said:

> There are many parts of the globe, indeed, hitherto uncultivated, and almost unoccupied; but the right to exterminating, or driving into a corner where they must starve, even the inhabitants of these thinly-peopled regions, will be questioned in a moral view. […] To exterminate the inhabitants of the greatest part of Asia and Africa, is a thought that could not be admitted for a moment.[366]

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[363] See Linnér 1998:114 and 206.

[364] Borgström 1964:258.

[365] Borgström 1964:260. In a footnote, Borgström adds that Malthus was professor of economics at Cambridge, "seemingly the first of its kind in the world", but although Malthus was a fellow of Cambridge's Jesus College, he held his professorship in History and political economy at the East India Company College in Hertfordshire. See Matlhus (2004/1798): xxix.

[366] Quoted in Bashford 2012:105. Bashford comments that if Malthus had renamed his later versions instead of keeping the original title, more scholars would be familiar with how his

Malthus argued against the colonial "solution" to the problem of too many people and not enough land, but his words – driving people into a corner – sound eerily relevant for the contemporary practice of land grabbing.

In my view, the appropriation of ecological space, the various forms and shapes of environmental load displacement which I have documented here, should be seen, to paraphrase Clausewitz, as a continuation of the colonial route of escape from the restrictions imposed by limited land areas and land-based resources by other means.

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thinking on this subject evolved. As it is, most readers, including myself, and most contemporary publishers, feel satisfied with the first, short edition.

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