The Boomerang—When Will the Global Forest Sector Reallocate from the South to the North?

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The Rights and Resources Initiative

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I. Background

The conventional wisdom is that the international forest sector will move the gravity from the North to the South during a foreseeable period of time. For example the Swedish Forest Commission (SOU, 2006) writes: "demand and production capacities of pulp and paper are moving more and more to the Southern Hemisphere due to low wood costs". McKinsey (2006) assess that in 15 years 40% of the world's paper consumption will take place in Asia and the production capacities will follow this development. Pulp has become a global commodity and the capacities are moving to low costs producing countries especially in Latin America with the very low fiber costs. Brazil can deliver pulp to European parts at a cost which is about half of the world market price. In the literature there are many subscribing to this described and future development. I will not repeat these in this connection. But the main message is that this development is driven by rapid *economic growth*, *increased consumption* and *cheap fiber from plantations* in the South. This has brought in new global players to the arena as illustrated by STCP (2007) in Table 1.

Table 1: Exports and share in the international trade of wood products of selected countries

Country	Exports (USD million)		Trade (%)	
	1990	2005	1990	2005
Emerging Players				
Brazil	1,604	8,151	1.3	3.2
Chile	1,010	3,528	0.8	1.4
China	1,848	18,455	1.5	7.2
India	72	688	0.1	0.3
Indonesia	3,530	8,174	2.9	3.2
Malaysia	3,386	6,097	2.8	2.4
Russia	1,715	7,633	1.3	3.0
Vietnam	144	1,612	0.1	0.6
Traditional Players				
Canada	18,375	35,408	15.2	13.8
Finland	9,724	12,912	8.1	5.0

Source: STCP (2007).

There is no precise information on existing forest plantations and even less information on how much of productive forest plantations really exist. ITTO (2006a, b) assess that there are 187 million hectares (ha) of forest plantations currently but only 93 million ha can be regarded as productive forest plantations from an industrial point of view. FRA 2005 (FAO, 2006a) and Del Lungo et al. (2006) assess that the area of productive forest plantations was about 110 million ha in 2005. FAO reports (FAO, 2006a) the countries with the largest areas of productive forest plantations during 1990–2005, see Table 2.

Table 2: Ten countries with largest area of productive forest plantations 1990-2005

Country/area	Area of productive forest plantations (1,000 ha)			Annual change (1,000 ha)	Annual change rate (%)
	1990	2000	2005	2000–2005	2000–2005
China	17,131	21,765	28,530	1,353	5.6
United States	10,305	16,274	17,061	157	0.9
Russian Federation	9,244	10,712	11,888	235	2.1
Brazil	5,070	5,279	5,384	21	0.4
Sudan	5,347	4,934	4,728	-41	-0.8
Indonesia	2,209	3,002	3,399	79	2.5
Chile	1,741	2,354	2,661	61	2.5
Thailand	1,979	1,996	1,997	n.s.	n.s.
France	1,842	1,936	1,968	6	0.3
Turkey	1,459	1,763	1,916	31	1.7

Source: FAO (2006).

Already this table indicates problems with the existing information on plantations. In Table 2, China is reporting 28.5 million ha of productive forest plantations but we know that only about 5 million ha are fast-growing plantations (Bull and Nilsson, 2004). The reported "plantations" for Russia are planting after normal forest operations or production plantations. These "plantations" can not be compared with the plantations in, e.g., Brazil, Southern USA, South East Asia, or Southern Europe.

According to FRA 2005 (FAO, 2006a) there are in total 140 million ha of plantations increasing with 2.8 million ha/year during 2000–2005. However, FRA 2000 reported 187 million ha of plantations. So this equation does not make much sense. In addition, all countries over-estimate their area of successful industrial plantation by 30–50% (Pandey, 1995). In reality there are probably only 30–40 million ha of successful industrial plantations globally (Persson, 2006).

The total forest areas designated primarily for production has a declined trend for the period 1990–2005 according to FRA 2005 (FAO, 2006a), see Table 3. The reasons for this decline are manifold but all can be identified from a changing society.

It should be pointed out that there are different trends within sub-areas of these major regions showing a positive trend. But the overall picture is clear: a *stable or slight increase in the North and declining trend in the South*.

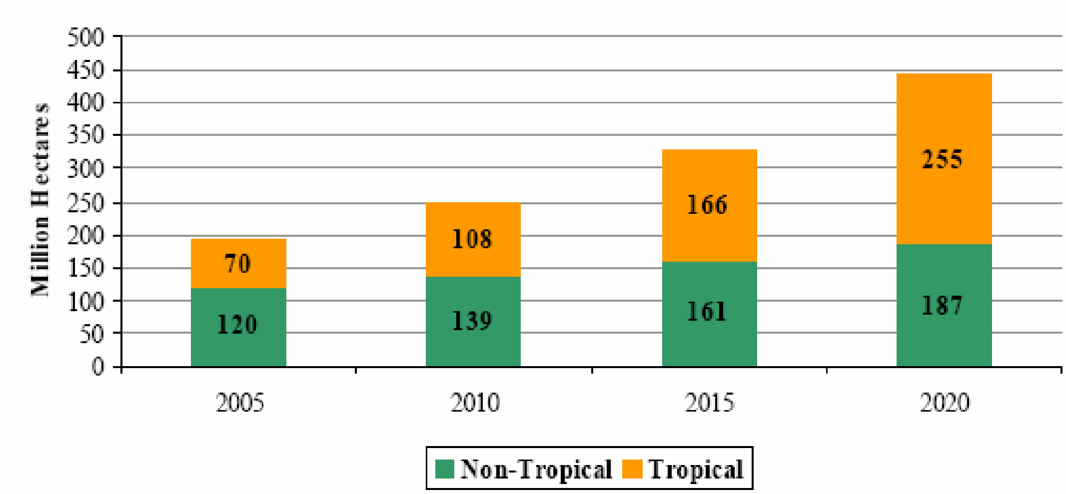
With this picture in place the conventional wisdom is that dramatic increase in plantations is expected in tropical countries and other countries of the Southern Hemisphere (e.g., ITTO, 2006a; STCP, 2007; FAO, 2007). STCP is assuming an increase of plantations as illustrated in Figure 1.

Table 3: Trends in area of forest designated primarily for production 1990-2005 (million ha)

	Area			Annual Change
	1990	2000	2005	2000–2005
Africa	148.3	139.9	134.7	-0.76
Asia	266.7	261.6	255.1	-0.50
Europe	770.5	722.1	721.4	-0.02
North America	37.9	40.4	40.5	+0.02
Central America	6.3	4.2	3.3	-4.65
Oceania	5.7	9.4	9.3	-0.24
South America	88.2	103.2	91.1	-2.47

Source: FAO (2006).

Figure 1: Projected forest plantation area



Source: STCP (2007) estimates.

If we assume that 50% of these plantations will be productive plantations it can be concluded that these plantations would cover all of the industrial demands on wood in 2020. But will this really happen? I doubt it.

II. Economic Growth

Demographic trends will be one of the forces for future change. In 2030 we will have around 8 billion inhabitants of the globe. It means an increase by some 60 million per year and some 97% of this growth will take place in developing countries. The World Bank (2007) states in its Economic Prospects Report that the global economy will rise from $35 trillion in 2005 to $72 trillion in 2030. The growth in the global economy will be faster than the earlier period but will increasingly be powered by developing countries. The growth rate is assessed to be, on average, 3.1% per year and capita up to 2030 in the developing world. It is highly probable that countries like China and Mexico will have the same living standards in 2030 as Spain has today.

Thus developing countries, once considered to be on the periphery of the global economy, will become the main drivers. Developing countries' share in global output will increase from about 20% of the global economy to nearly 35%. A growing share of global production of goods and services will be developed in these countries in transition to generate new economic opportunities. The World Bank (2007) states: "*agriculture now accounts for about 2% of the economic value added of most developed countries, that share will shrink to boutique niches*". Resource rich regions and countries in the developing countries will take over some 90% of the world's sugar production and more than half of the grain, beef and dairy products production according to the World Bank.

Energy

Energy is the lifeblood of the world economic system. A number of experts argue that high energy prices reduce the possibilities for economic growth substantially (e.g., OECD/IEA, 2006). However, Nilsson (2006) has analyzed existing studies on assessments of the empirical historical impacts of energy prices on economic growth over time. It can be concluded that:

- There seems to be a threshold value for sensitivity to energy prices and their impacts on economic growth.
- These thresholds vary with the robustness of different economies.
- The more robust economies are, the less negative impacts on economic growth.
- There seems to be a consensus that there may be short-term economic disruptions by high/increased energy prices but hardly any long-term negative impacts on economic growth.

However, it can also be concluded that the world's different economies can perform and survive with substantial energy price rises but can not survive supply and price shocks of energy.

The Financial Times (FT, 2006a) has later confirmed this conclusion by stating "if stable, high energy prices need not to be a disaster. For the most part high prices provide the right incentives for consumers and producers. It is the volatility of energy prices, not their level, that is most damaging to the world economy".

Thus, in discussing the energy issue, energy security and price volatilities are of major concerns. So what risks are we facing with respect to these entities?

The International Energy Agency (IEA) in its outlook study (OECD/IEA, 2006) assesses that the world demand on primary energy will increase from 11204 million toe in 2004 to 17095 million toe in 2030—an increase of over 50% in 25 years (see Table 4). During the same period, the dependence on fossil fuel will increase from 80 to 81%. But there are a number of constraints making it impossible to meet this demand especially with respect to fossil fuels. The constraints for reaching the demanded supply, according to Table 4, causing a lack of energy security and price volatilities are many and severe (especially with respect to fossil fuels):

- Limits to economically available resources.
- Lack of financial resources for investments.
- Lack of maintenance and efficiency of existing energy systems.
- Sabotage.
- Energy used as a political pressure tool.

Table 4: World primary energy demand in the reference scenario (million toe)

	1980	2004	2010	2015	2030	2004–2030*
Coal	1 785	2 773	3 354	3 666	4 441	1.8%
Oil	3 107	3 940	4 366	4 750	5 575	1.3%
Gas	1 237	2 302	2 686	3 017	3 869	2.0%
Nuclear	186	714	775	810	861	0.7%
Hydro	148	242	280	317	408	2.0%
Biomass and waste	765	1 176	1 283	1 375	1 645	1.3%
Other renewables	33	57	99	136	296	6.6%
Total	7 261	11 204	12 842	14 071	17 095	1.6%

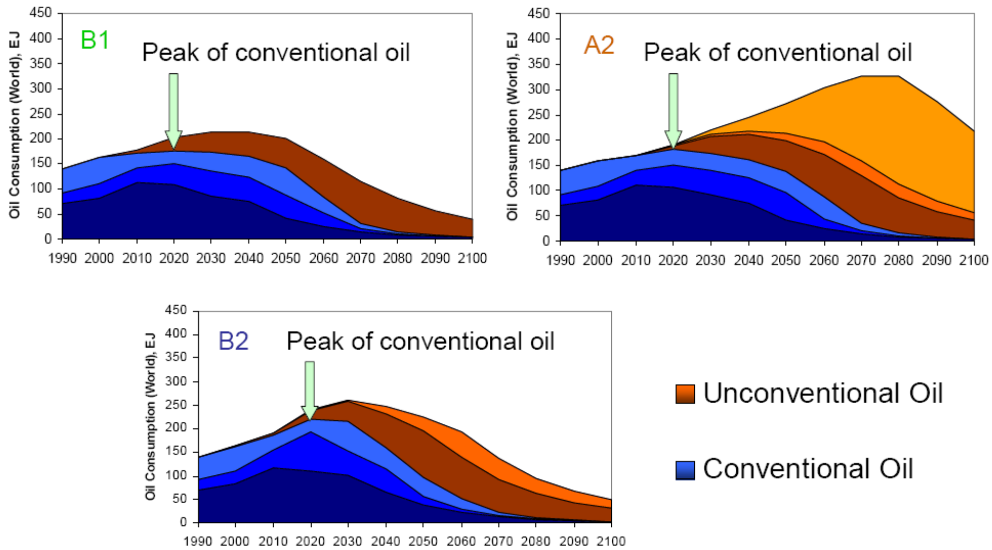
* Average annual growth rate.
Source: OECD/IEA (2006).

Economically Accessible Resources

There are especially concerns about the economic accessibility of fossil fuels in the future. One school is arguing that the conventional oil and gas production will peak any year now (e.g., ASPO). Another school is arguing that the conventional oil and gas resources will last for a substantial period of time (e.g., OECD/IEA, 2006). Nevertheless, there is consensus among the schools that at some point in time not too far away the production of conventional oil and gas will peak but unconventional and synthetic sources of oil could last for a long time to come — but at higher prices.

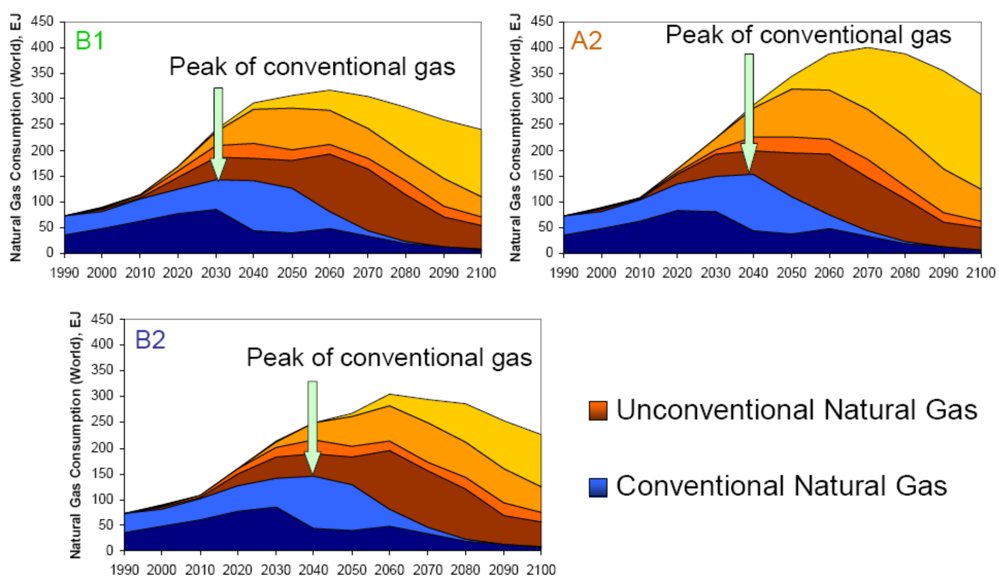
For many years at IIASA we have worked on global energy assessments and produced many scenarios. We also use the terms conventional and unconventional fossil fuels. Conventional resources are defined as fossil fuels that can be extracted with today's technology at competitive prices/economic viability (Rogner, 1997). In Figures 2 and 3 we illustrate some of our scenarios on global oil and gas consumption. Scenarios B1, B2 and A2 are based on different assumptions of economic and social developments and a different future environment. Scenario B1 reflects a peak in global population in mid century with rapid changes in economic structures toward a service and information economy and the implementation of resource-efficient technologies. Scenario A2 describes a very heterogeneous world with continuously increasing global population and slower economic growth and technological change than in Scenario B1. Scenario B2 describes a world with lower population growth than in A2, intermediate economic development and less technological change than in B1. This scenario emphasizes local solutions to the overall sustainability issue.

Figure 2: Global oil consumption (conventional and unconventional reserves and resources)



Source: Riahi and Keppo (2006).

Figure 3: Global natural gas consumption (conventional and unconventional reserves and resources)



Source: Riahi and Keppo (2006).

In all scenarios, the peak of conventional oil consumption is around 2020 and the conventional natural gas peaks around 2030–2040. If the oil consumption level at the peak in these scenarios is compared with the IEA demand scenario (Table 4) for 2030, it can be concluded that the assessed demand can not be supplied with conventional oil. The deficit is 15 to 25%. This means a very difficult supply situation and increased oil prices and high risks for *supply and price volatilities* with respect to oil. The gap or deficit of conventional natural gas at 2030 is not as difficult as for oil but there is a deficit in the magnitude of nearly 10%, which again indicates risks for *supply and price volatilities* of natural gas. Currently, global oil supply stands at 84 million barrels per day, with a spare capacity of only 1 to 1.5 million barrels per day—the lowest level during the last 30 years (Newell, 2006).

Lack of Investment Funds

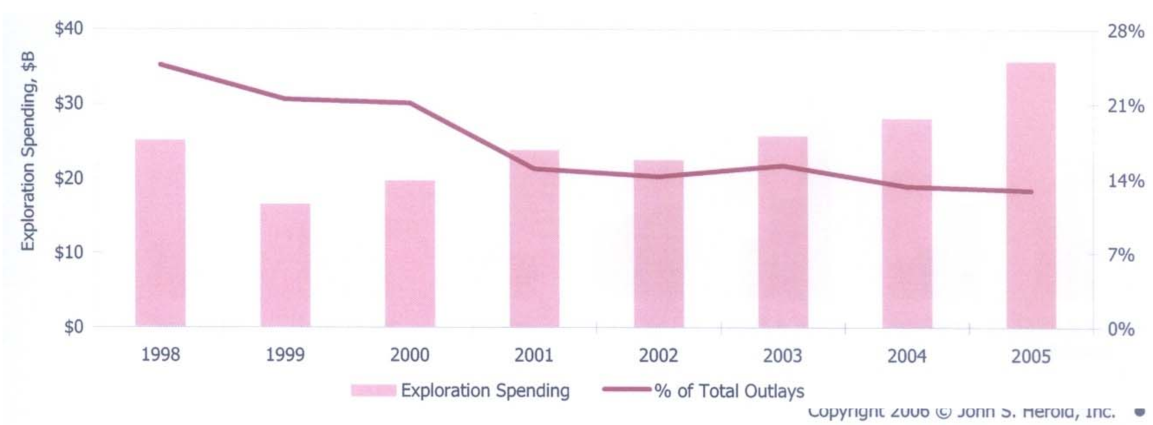
The IEA states that to reach the primary energy supply, which will meet the demand of 17095 million toe in 2030 (see Table 4), enormous investments in the energy infrastructure must be made (OECD/IEA, 2006). The accumulated amount needed to 2030 is over $20 trillion (2005 $). About half of the investments are needed in the electricity industry in the form of transmission and distribution networks and in power generation. The rest of the investments are roughly needed for the fossil fuel industry. Some $2.5 trillion of investments are needed in the European energy sector.

More than half of the investments will be allocated to just maintain the current level of supply. Much of the world's current production for oil, gas, coal, and electricity will need to be replaced. The IEA is quite frank that there is no guarantee at all that the needed investments will be forthcoming (OECD/IEA, 2006). The level of investments will in the end depend on government policies, geopolitical conditions, unexpected changes in costs and prices, new technologies, etc. It should be remembered that some 80% of the proven reserves of fossil fuels are concentrated in *volatile* regions (Newell, 2006). The IEA questions "whether investment in Russia's gas industry will be sufficient even to maintain current export to Europe and to start export to Asia" (OECD/IEA, 2006). Thus, also from a financial point of view there is a high risk that there will be *supply and price volatility* of the energy supply.

Maintenance and Efficiency

In spite of tremendous profits by the energy industry, the needed investments in maintaining the existing energy infrastructure have not materialized. Hautojärvi (2006) assesses that the productivity of the energy sector in the EU has improved by 15% during the last 45 years. At the same time, labor productivity grew by 350%. Herold and Lovegrove (2006) assess that the global petroleum industry needs to invest over $200 billion annually to maintain current reserves and current production rates but this has not happened during the last five years and in 2005 the upstream capital investment was $277 billion, whereby $128 billion was channeled back to shareholders through dividends and buybacks of shares. In fact, *buybacks* exceeded purchases of proven reserves by 20% and were nearly 80% higher than exploration outlays (see Figure 4).

Figure 4: More exploration is needed



Source: Herold and Lovegrove (2006).

As stated by the IEA, Russia has neglected maintenance investments in the infrastructure of gas, oil, and electricity (OECD/IEA, 2006). Several specialists have warned that there is the risk that Russia will have an oil and gas production crisis in the future due to the dearth of investments (e.g., Wood Mackenzie, 2004; Juurikkala and Ollus, 2006). Since the late 1980s, the Russian electricity sector has suffered from the lack of investments and the current generation capacity is deteriorating. Even a moderate growth in Russian electricity consumption will lead to serious supply shortages already in 2008 (e.g., Kurronen, 2006). Gheorghe *et al*. (2006) have made a detailed review of the European electric power system. From this review, it can be concluded that the European electric power systems are bound to fall short in the coming years due to aging generation and transmission equipment. There are doubts that current and planned generation plants will meet demand. Political decisions were taken for the establishment of an internal market in electricity but nothing was made to remove the physical constraints of power transmission. There has been substantially increased interconnection of electricity systems but no central control mechanism has been established. Therefore, the European electricity market is not optimal and lacks efficiency which pushes the prices upwards. In the case of Europe, there is an urgent need to upgrade and secure the electric power system.

The neglect of maintenance of the energy infrastructure is causing disturbances and volatility in supply and prices. Recent examples are the explosion in March 2005 in BP's Texas City Refinery and a string of disasters in BP's infrastructure in Alaska in 2002, 2005 and 2006. All are the result of cost cutting in safety and maintenance (FT, 2006b, c).

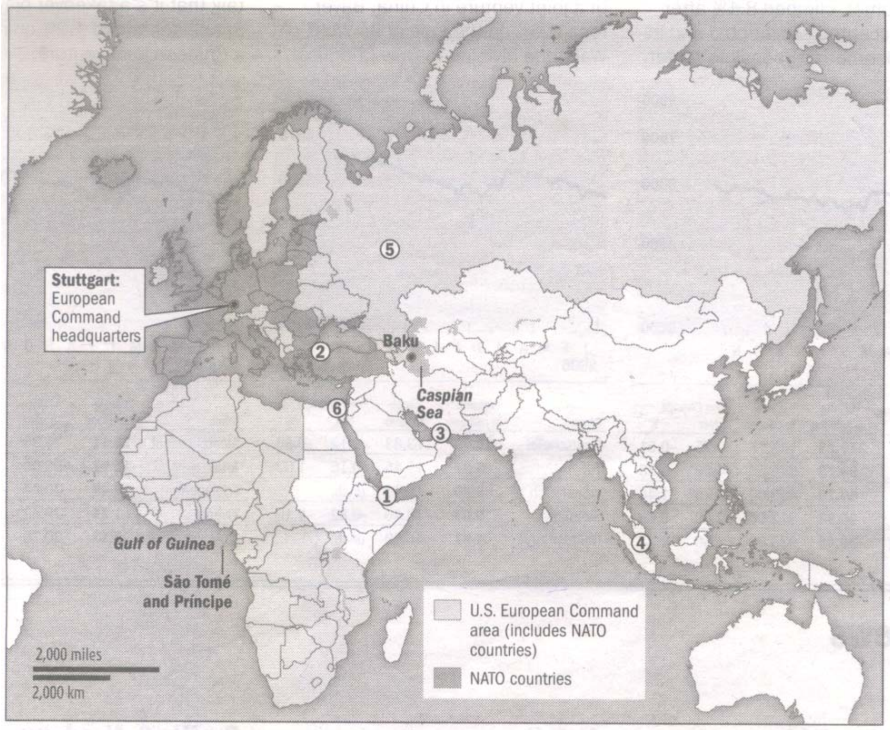
The explosion in Nigeria of a pipeline during Christmas 2006 was claimed to be caused by thieves vandalizing the pipeline but experts are questioning this. Corruption and mismanagement have forced much of Nigeria's energy infrastructure into decay and this was probably the major cause for the explosion.

The lack of sufficient security and maintenance of the energy infrastructure will cause volatility in supply and prices of primary energy in the future.

Sabotage

As stated earlier, some 80% of the proven fossil fuel reserves are located in volatile regions. This, coupled with increased intensity in globalized terrorism, increases the risks for sabotage of the existing energy infrastructure. The risks for sabotage are illustrated by Figures 5 and 6 with respect to oil and gas.

Figure 5: World oil transit choke points



World oil transit choke points

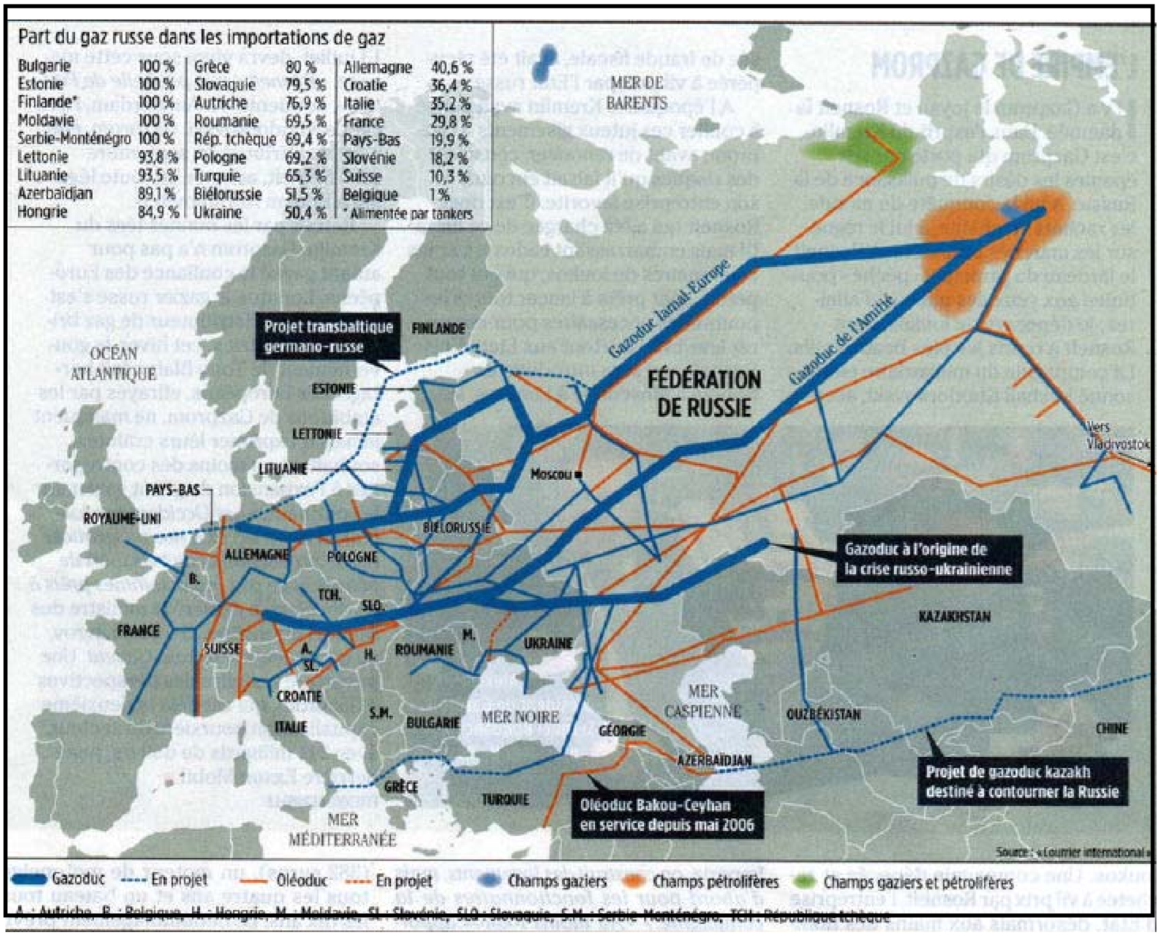
CHOKE POINT	OIL FLOWS, millions of barrels per day*	SECURITY CONCERNS
① Bab el-Mandab	3.0	Terrorists attacked an oil tanker in the area
② Bosporus and the Turkish Straits	3.1	Less than a kilometer wide at narrowest point and difficult to navigate
③ Strait of Hormuz	17	In the midst of volatile region
④ Strait of Malacca	11.7	Piracy is frequent
⑤ Russia	2.0 (Also natural gas)	Gas supplies controlled by Moscow
⑥ Suez Canal/ Sumed Pipeline	4.2	If closed, some tankers would have to go around Africa

*2004 estimate.

Source: Energy Information Administration.

Nearly half of the total world daily production of oil has to pass through the choke points in Figure 5.
The leader of Turkmenistan recently passed away, leaving a vacuum at the top of a dysfunctional institutional structure controlling the world's fifth biggest gas reserve. Political instability could threaten the gas supply to its main customer, Ukraine, with potential knock-on effects for the rest of Europe. Gazprom, due to lacking investments, relies increasingly on cheap central Asian supplies to meet domestic and international demands, including Europe.

Figure 6: Russian gas pipelines



Source: Vasara (2006).

The oil and gas infrastructure is too big to protect as a whole and the risks of sabotage must be counted for. The threats to oil supply multiply but the world is not ready to handle this development (Wall Street Journal, 2006).

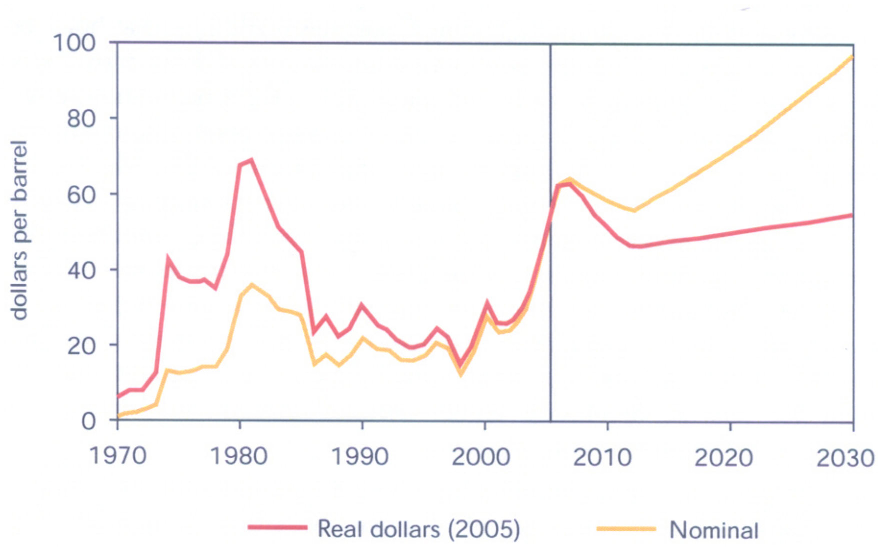
Energy as a Political Pressure Tool

A tight supply/demand situation, as described above, will open the possibilities for producers to use the energy supply as a political tool and the consumer countries may be forced to accept political and economic policies that are not really acceptable to the consumer countries.

Price Development

Under the conditions outlined above, the probability is high that the prices of primary energy will remain at a high level. But nobody knows what the price level will be in reality because the outlined development leaves room for a lot of speculation that could influence the price development strongly.
The IEA has been brave enough to present an assessment of future oil prices (OECD/IEA, 2006). It is pointing at a level of $50/barrel in real costs and $100/barrel in nominal costs in 2030 (see Figure 7).

Figure 7: Average IEA crude oil import price in the reference scenario



Source: OECD/IEA (2006).

Environment/Climate

Sir Nicholas Stern (2006) has made policy makers and the public aware that climate change presents serious global risks and requires urgent responses. The majority of the emissions of greenhouse gases (GHG) stems from the production and combustion of energy.

Some of the foreseen damages affecting the forest sector will be highlighted. Ecosystems will be vulnerable to the foreseen climate change. Increases in the extent and intensity of storms and hurricanes are foreseen. Increased and perhaps dramatic outbreaks of insects and pests with climate change will also cause increased damage of infrastructure.

There is also a chicken and egg problem between increased climate change damage of infrastructure and the production of primary energy carriers, which can be illustrated by the shutdowns of refineries and pipelines caused by hurricanes Katrina and Rita in 2006 resulting in price spikes.

Stern (2006) estimates that emissions following a business-as-usual path will cause an average loss of global GDP of 5–10%.

Stern (2006) argues that the concentration of GHGs in the atmosphere has to stabilize at 500–550 ppm in order to avoid the huge economic losses of 5–10% of the global GDP by climate change. In order to achieve this, the global emissions need to be 25% below current levels by 2050. In this context, it should be pointed out that in 2050 the global economy may be 3–4 times larger than today. This means huge reductions of emissions in a business-as-usual development. This can be illustrated with the increase of CO_2 emissions according to the OECD/IEA (2006) scenario (Table 4). This increase in primary energy demand will increase the CO_2 emissions by 14.3 billion tonnes (or 55%) during the period 2004 and 2030 and reach 40.4 billion tonnes. With the current pace of reductions in the EU, the reduction will be 1% in relation to the 1990 baseline instead of the EU commitment of a reduction of 8% in 2012 according to the Kyoto Protocol (EEA, 2006). Stern (2006) claims that the above stabilization can be reached through emission reductions at accumulated costs of around 1% of GDP by 2050 (although Stern has been criticized for this estimate and it is argued that it is an under-estimate).

But the overall conclusion of the Stern review is that the costs for emission reductions will be substantially lower than the costs of the foreseen climate change. However, actions have to be taken now.

Energy Policies

I hope I have made it clear that the current situation is severe and that the policy and strategy setting with respect to energy has to operate within the *triangle of economic growth, energy security (vulnerability to supply disruptions)* and *climate and environment*. This means there is a need to reduce the vulnerability and to diversify the energy supply. It is far from enough to just look at "high oil prices" in setting priorities.

This means that biomass for bioenergy will probably pay a crucial role in future energy strategies over the world.

Industrial Wood Consumption

The industrial wood consumption is currently around 1.6 billion m^3/year. The average growth in consumption during 1985–2005 has been 1.7% per year for pulp logs and 0.6% per year for saw logs. But in the most recent years the growth rates in consumption have been higher due to rapidly growing demand in emerging economies (especially China).

Given the most recent developments with respect to consumption of industrial wood a plausible development would be that in 2020 the industrial wood consumption would be around 1.85 billion m^3/year and over 2 billion m^3/year in 2030 (based on information from ITTO (2006b) and STCP (2007)). This means substantially increased demand on industrial wood during the next 15 years and increased demands on land.

Agricultural Development

In the Outlook Study "World Agriculture: Towards 2015/2030" (Bruinsma, 2003) FAO states:

- Demand for agricultural products will continue to grow more slowly.
- Agricultural trade deficits of developing countries will increase.
- Production will keep pace with demand but food insecurity will persist.
- There is enough land, soil and water and enough potential for further growths in yield.
- The agriculture, overall economy and food security will continue to depend on several crops for which the world market conditions are not only volatile but also, on balance, on a declining trend as regards real prices.
- Most future increases in crop production will be achieved through improved yields.

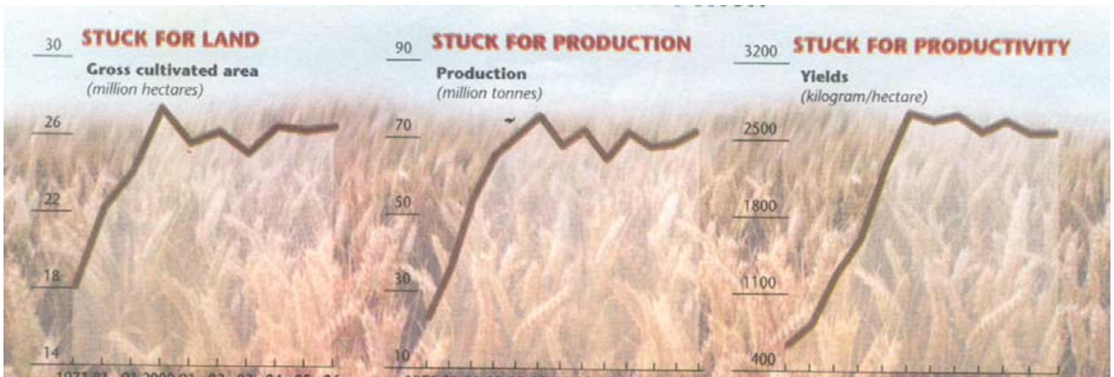
But things have changed since 2003. In 2007 FAO states (FAO, 2007):

- Food and agricultural systems in developing countries and economies in transition are undergoing profound changes. Agribusiness is responding to strong consumer demand for high-value commodities, processed products and pre-prepared foods.

So what has happened? The demand has increased substantially in the developing world due to increased economic growth (I will return to this issue later). But also productivity has changed. In a different study FAO (2004) states that in Latin America, sugar cane and soya production at large estates show a productivity increase, though only in some countries. For all other crops and management there is a flat or declining productivity development in agriculture in Latin America. The harvested area in Latin America grew from 105.6 million ha in 1993 to 129.4 million ha. The increase in harvested areas is concentrated to oilseeds, especially soya bean, and sugar cane. The annual harvested area is still shrinking in 16 countries of Latin America.

FAO (2004) reports a crop productivity increase of 2.5% in Latin America between 1993 and 2003 but all the increase took place in the crops mentioned above. The consumption of pesticides grew eight times during this period and fertilizer use by 5% per year. All of this is way above the rate of growth of production. India is reporting similar signs. Business India (2007) reports that the productivity in India of wheat production has gone flat or declined since 2000 (see Figure 8).

Figure 8: Crisis of wheat production



*Projected. Source: Economic Survey (2006–07)

Source: Business India (2007).

IFPRI (Rosegrant, 2007) states that Asian staple foods cannot continue their precious dependence on full water control due to competing urban and industrial water users and will result in declined agricultural production. He is also pointing out that growth in agricultural productivity of cereals is slowing and even being in decline, despite increased demand and limited scope for area expansion. Good agriculture trend is lost to urban and industrial expansion and agriculture is forced to less productive lands.

The share of cropland, free of soil fertility constraints, of agriculture lands ranges from 5 to 7% in South Asia and sub-Saharan Africa (in North America and Russia the corresponding number is about 25%).

Table 5: Share of extent of cultivated area for rice/wheat affected by major soil constraints for selected Asian countries

Country	Free of constraints	Saline soils	Poor drainage	Low moisture holding capacity	Acidity	High P-fixation	Low K-reserves
				Percent of total area			
Bangladesh	16.2	3.0	56.5	2.1	21.4	1.3	11.4
Bhutan	0.0	0.0	0.0	2.5	63.3	0.0	40.0
Cambodia	3.8	0.5	42.3	7.6	15.3	5.8	49.7
China	5.4	6.9	23.2	1.5	13.4	20.9	24.4
India	11.5	6.3	5.3	9.7	35.9	0.1	9.7
Indonesia	2.5	0.0	8.9	5.2	39.7	7.1	32.2
Laos	0.0	0.0	8.5	2.1	22.3	20.5	73.4
Malaysia	0.7	5.7	30.7	2.2	31.0	10.2	45.0
Mongolia	22.4	22.4	0.0	0.0	0.6	0.0	0.0
Myanmar	4.6	2.2	19.2	0.0	27.8	14.1	44.3
Nepal	4.5	0.0	8.2	1.2	51.8	0.0	15.6
Pakistan	23.2	35.7	1.5	3.3	3.4	0.0	0.0
Philippines	0.2	0.0	11.4	1.4	36.7	3.4	42.7
South Korea	0.4	0.0	8.6	0.0	26.7	9.0	22.2
Sri Lanka	3.6	1.4	20.7	2.9	46.2	0.0	19.5
Taiwan	15.4	4.1	40.7	0.0	13.0	12.3	19.5
Thailand	1.9	1.5	33.3	8.9	25.7	6.2	54.3
Vietnam	3.0	2.0	28.8	5.5	17.0	9.9	47.9
Overall average	**7.1**	**6.2**	**16.9**	**4.6**	**23.3**	**10.6**	**23.1**

Source: Rosegrant (2007).

Climate change will seriously cause stresses on agricultural production in the form of less irrigation water, droughts, heat-stress flooding, etc. The General Director Diouf of FAO (DN, 2007) expressed concerns recently that climate change may reduce the production in large parts of Africa with 50% in 2020 and in India with 20%. OECD/FAO (2007) points out that we have already had severe impacts of climate change on agriculture crops in Australia, USA, Canada, Russia, Ukraine, and to some extent in the EU.

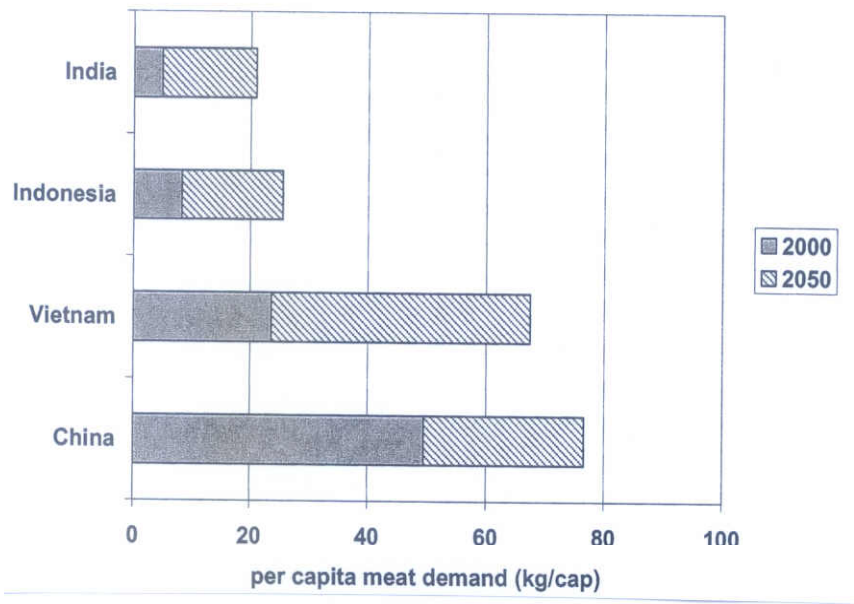
So what will happen?
OECD/FAO (2007) states that there will be a shift towards more area planted in cereals, in the form of reallocation of lands from other crops in the OECD, from land taken out of set aside land in the EU or from *cultivation of new land in many developing countries particularly in Latin America*. The rice production is set to expand and the major increase will come in India, Indonesia, Thailand and Vietnam. Oilseed production will expand especially in Brazil and Argentina where pasture will be directed to oilseed crops.

Oilseed meal consumption in the developing world will increase by 55% to 2020 with two-thirds of this increase coming in Brazil and China.

Developing countries will be increasingly dominant in meat production and there will be a growing importance of the developing countries in diary supply and demand.

As stated earlier, the economic growth is causing a change in the diet. This is illustrated for the Asian countries in Figure 9.

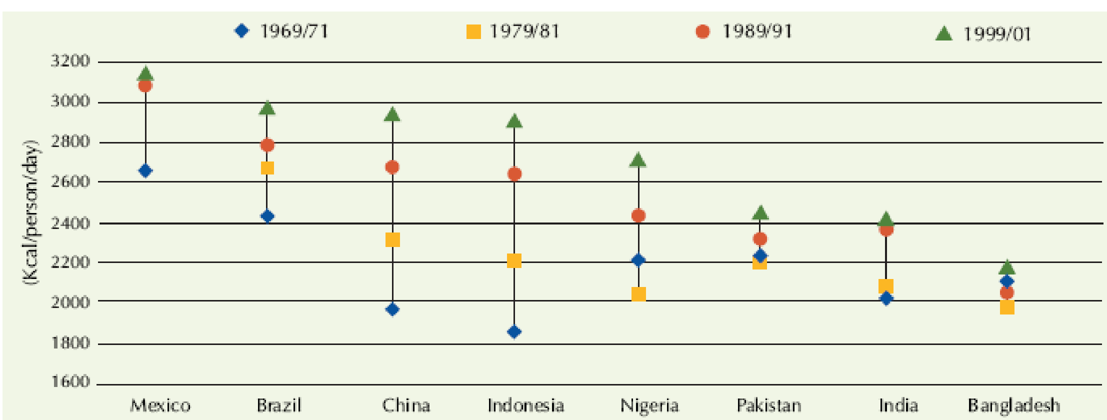
Figure 9: Per capita meat demand (kg/cap) for selected Asian countries



Source: Rosegrant (2007).

The improved economic conditions increase the calorie intake as illustrated in Figure 10, which is influencing the food demand.

Figure 10: Per capita food consumption, developing countries with over 100 million population in 2000



Source: FAO (2006b).

If we combine information on population development and changed calorie intake over time we get a picture as in Table 6.

Table 6: Development of population and calorie intake over time (modified from FAO, 2006b). Population in billion and kcal/person/day in brackets

Year / Region	2000	2030	2050
Developing World	4.76 (2654)	6.71 (2960	7.51 (3070)
Industrial	0.91 (3446)	1.00 (3520)	1.01 (3540)
Transition	0.41 (2900)	0.38 (3150)	0.34 (3270)

This means that the global intake of calories will increase substantially over time (Table 7) and the dominating increase will take place in the *developing world*.

Table 7: Relative global calorie intake

2000	2030	2050
100	145	165

With a substantial productivity increase these kinds of increase in demand may be handled. But the discussion above demonstrates that we can rather expect a productivity decline than a productivity increase due to different reasons. Thus a new Green Revolution would be needed or dramatic changes in animal production and diets in order to change the outlook.

If this increased demand would have to be covered by just increased land for agricultural production we would need a lot of land (Table 8). Table 8 is assuming no productivity increase.

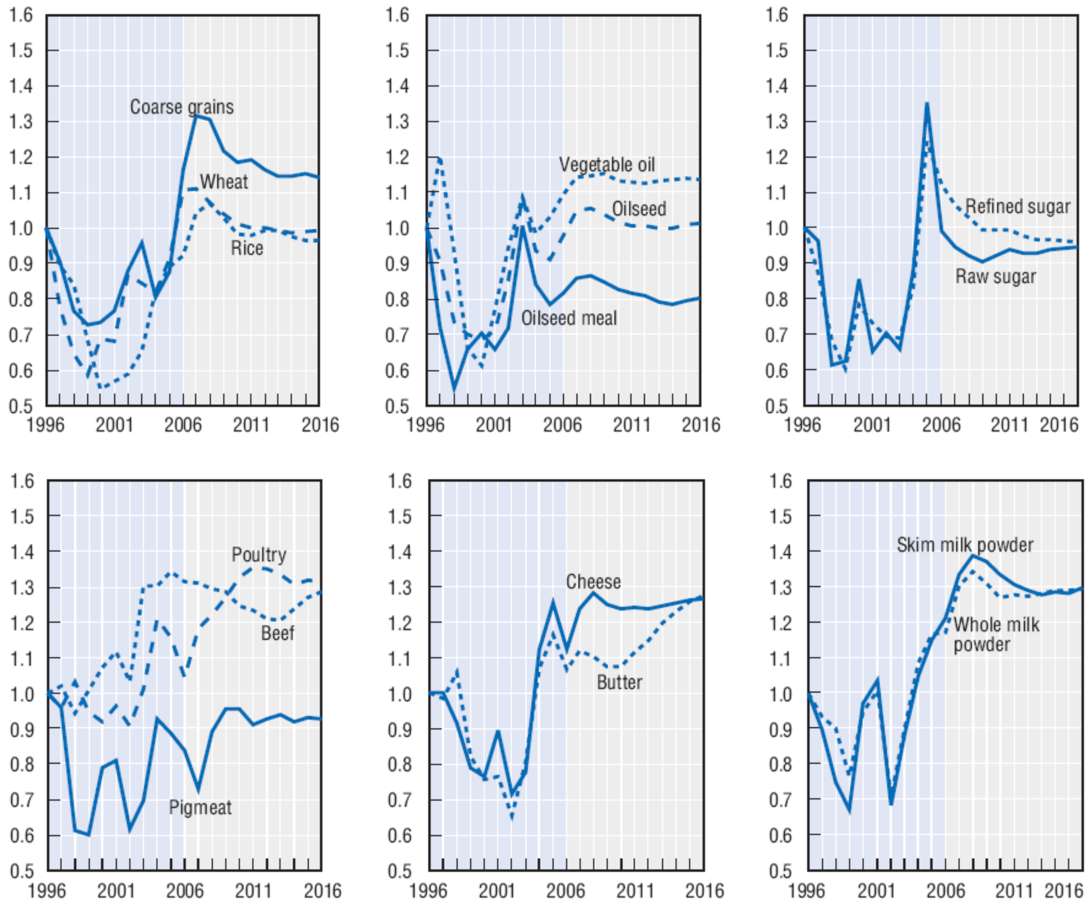
Table 8: Agriculture land required to meet increased demand of food (calories). In billion ha

2000	2030	2050
5.00	7.85	8.15

This means additional agricultural land of about 3 billion ha of which nearly all would be required *in developing countries*. This will in reality not happen. There will be different correction mechanisms but it illustrates the magnitude of the problem.

All of this will have a price impact. OECD/FAO (2007) states that world market prices in the medium term will stay above earlier prices as illustrated in Figure 11.

Figure 11: Outlook for world crop and livestock product prices to 2016 (index of nominal prices, 1996 = 1)



Source: OECD/FAO (2007).

Rosegrant (2007) states that prices of cereals will increase by some 25% to 2020 and by some 40% to 2050. He states that these changes are driven by the changed supply/demand situation—"*including much more rapid degradation of natural resources on the food production side, particularly as a result of growing water scarcity and growing heat and drought stress, combined with slowing yield growth that is unable to catch up with market dynamics*".

From a forest plantation point of view this means:

- Substantially increased competition for suitable land.
- Increased prices for land.

Bioenergy Development

Biomass is a primary source of energy for close to 2.4 billion people in the developing world (Karekezi and Kithyoma, 2006). Fuelwood and charcoal are the biggest forest products in the developing world and are of the most important source of energy. This situation will remain during the coming decades. The fuelwood consumption is assessed to increase in Africa, India and Latin America. Fuelwood will continue to be an important source of energy in China. The consumption of charcoal is increasing in most regions but is dominated by Africa and Latin America. I will not go into further detailed discussion on the specific fuelwood issue but would like to broaden the discussion with respect to the energy crossroad I have discussed earlier.

There seems to be a political hope that bioenergy will be the solution to many political concerns. Roberts (2007) has summarized these concerns as follows:

- Economic security (increasing real price of oil).
- National security (dependence on volatile regions).
- Environmental security (climate change).
- Political security (domestic rural development).

In order to look into how bioenergy and biomass can contribute to these issues the following criteria have to be looked into:

Resource Efficiency:	High productivity of biomass and high rate of re-utilization of rest products
Energy Efficiency:	Low energy input and high energy output. Thus, low losses in the energy chain
Environmental Efficiency:	Low emissions of GHGs and air pollutants Sustained local environment.
Cost Efficiency:	Low production costs

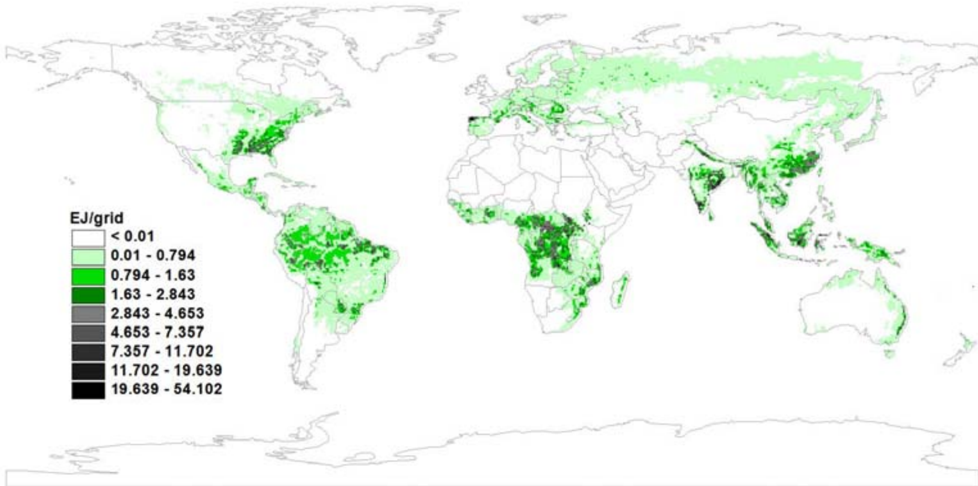
Resource Efficiency

The highest resource efficiency with respect to biomass for energy production is in the Southern hemisphere, South-East of the United States and Southern Europe. This is illustrated in Figure 12.
Thus, there we have the highest resource efficiency with respect to energy from biomass are at the same land resources as we will have a strong competition from agriculture in the future.

Energy Efficiency

The conversion losses in producing heat and electricity of biomass is in the range of 10–20%. The conversion losses can be kept especially low in co-production of heat and electricity. With biofuels the conversion losses are 30–65% depending on conversion technology and fuel. The energy yield per ha is 2–3 times higher for heat and electricity compared to biofuel production (Northern Europe). *Cellulose fibers* have much higher energy efficiency compared to conventional agricultural feed stocks.

Figure 12: Resource efficiency



Source: Obersteiner and Nilsson (2006).

Environmental Efficiency

The rate of reduction of GHG is closely linked to the energy efficiency. A high energy input is linked with high rate of emissions. Thus, *cellulose fibers* have a higher rate of reduction of CO_2 emissions than agricultural feedstocks in biofuel production. This difference is even greater if the N_2O emissions are taken into account. The conventional agriculture feedstocks employ a lot of N-fertilizers causing N_2O emissions. Crutzen et al. (2007) have recently demonstrated that N_2O emissions based on agri-biofuel production are 3–5 times higher than earlier assessed. This means that *cellulose fibers* are even more favorable than agri-biofuel production.

But again using wood/cellulose fibers for heat production are more efficient from a GHG reduction point of view than producing biofuels. One ton of wood used for heating reduces 1.3 ton CO_2. One ton of wood replacing coal-based electricity production reduces1.5 ton of CO_2. And one ton of wood used for biofuel production reduces 0.8 ton of CO_2.

Cost Efficiency

The current agriculture-based ethanol production would not be competitive without substantial subsidies. The Brazilian ethanol based on sugar cane and the palm oil biodiesel production is competitive with fossil fuels today. Biofuels based on cellulose fibers are not competitive today. But the second generation of biomass-to-liquid from forest biomass is assessed to be competitive around 2015.

Thus, from a cost point of view the biofuel investments will firstly be attracted by sugar cane and palm oil production.

Larson (2005) has made a review of existing life cycle analysis of liquid biofuel systems. He concludes that there are difficulties to generate general conclusions on the efficiencies of biofuels due to variation in production conditions but he states the following:

- Conventional agricultural feedstocks for biofuel production provide only modest levels of fuel displacements.
- Much more efficient are high yield lingo-cellulose crops.

- Of this follows that conventional agricultural feedstocks can only provide modest GHG mitigation benefits by any measure.
- Higher GHG savings with biofuels will be likely when biomass yields are high (Southern hemisphere).

Fulton (2005) has made an effort in summarizing the efficiencies of liquid biofuels. This typology is not complete with respect to all fuel alternatives and future technological development but I think it makes a good summary of the situation.

Table 9: A typology of liquid biofuels

Fuel	Feedstock	Regions where currently produced	GHG reduction v. petroleum	Production cost	Biofuels yield per hectare of land	Land types
Ethanol	Grains (wheat, maize)	US, Europe, China	Low-moderate	Moderate	Moderate	Croplands
Ethanol	Sugar cane	Brazil, India, Thailand	High	Low	High	Croplands
Ethanol	Biomass (cellulose)	None	High	High	High	Croplands, marginal lands
Biodiesel (FAME)	*Oil seeds (rape, soy)*	*US, Europe*	*Moderate*	*Moderate*	*Low*	*Croplands*
Biodiesel (FAME)	*Palm oil*	*South East Asia*	*Moderate*	*Low-moderate*	*Moderate-high*	*Coastal lands*
Biodiesel (BTL)	Biomass	None	High	High	High	Croplands, marginal lands

Source: Fulton (2005).

From a forestry point of view two overall conclusions can be made:

- Sugar cane and palm oil will attract investments in increased production in the South which will compete with possible forest plantations.
- Further down the road, cellulose fibers for biofuel production will be economically viable and efficient from energy and environmental points of view. This means increased competition for conventional forest plantations.
- Biofuel production will target croplands and marginal lands.

III. Demand on Bioenergy

Earlier I discussed that there will be continued demand at a substantial level on fuelwood and charcoal in certain regions of the world (e.g., Africa, India, China, Latin America). Plantations for just production of fuelwood have not been that successful over time (Persson, 2006). People in the developing countries prefer to collect the fuelwood in the existing forests. Therefore there does not seem to be that high competition on land between fuelwood plantations and industrial plantations.
As discussed above cellulose fibers for production of heat and electricity is superior to biofuels with respect to energy efficiency and environmental impacts. The future demand for heat and electricity production will depend on future energy prices. With higher prices the demand on cellulose fibers for heat and electricity will increase and an increased competition on land between energy plantations and industrial plantations will be the result. With respect to biofuels we can get a feeling for the future demand by looking at the development of road vehicles. WBCSD (2004) made a study on future mobility. From this study the following can be excerpted. The fuel use and potential biofuel demand is assessed to be a lower bound if compared with other energy scenarios.

Table 10: Road vehicles and energy consumption

	Vehicles (in million)	Energy consumption (in billion TOE)
2005	800	1.5
2030	1400	2.2
2050	2200	3.0

To get a rough assessment of the land needed for biomass production in this situation we have used a rule of thumb that 1 ha can supply 5 future cars (Deutsche Energy-Agentur, 2006). To fuel the vehicle fleet in 2030 with biofuel would require 280 million additional ha of biofuel plantations in addition to the increased demand on agriculture land discussed earlier.

According to OECD/FAO (2007) Brazil plans to increase its sugar cane ethanol production from its current 16 billion to 44 billion liters by 2016. Based on Girard et al. (2006) technology assessment, this corresponds to an increase of about 4.5 million ha of high productive land. China is planning to increase its corn-based ethanol production from 1.5 billion liters to 3.8 billion liters during the same time period. This corresponds to an additional high quality land demand of 75,000 ha.

OECD/IEA (2006) assesses future biofuel consumption as illustrated in Table 11. This means some 100 million Toe of biofuels (in the case with subsidies). This corresponds to, in a very conservative estimate, some additional 35 million ha of land.

But the second important message from Table 11 is that it is assumed that substantial subsidies will go into the production of biofuels. That the subsidies are substantial can be illustrated by a table presented by Doornbosch and Steenblik (2007).

Table 11: Projected world biofuels consumption (million tonnes of oil equivalent)

	2010	2015	2030
With No New Government Measures On Climate Change			
Europe	14.8	18.0	26.6
US	14.9	19.8	22.8
Brazil	8.3	10.4	20.3
China	0.7	1.5	7.9
India	0.1	0.2	2.4
Total	***41.5***	***54.4***	***92.4***
With Government Measures			
Europe	16.4	21.5	35.6
US	16.4	27.5	42.9
Brazil	8.6	11.0	23.0
China	1.2	2.7	13.0
India	0.1	0.3	4.5
Total	***48.8***	***73.0***	***146.7***

Source: OECD/IEA (2006).

Table 12: Subsidies to ethanol and biodiesel per liter net fossil fuel displaced and per metric ton of CO_2-equivalent avoided

	Units	Ethanol		Biodiesel	
		Low	High	Low	High
Support per liter equivalent of fossil fuels displaced					
United States	$/liter equivalent	1.03	1.40	0.66	0.90
European Union	$/liter equivalent	1.64	4.98	0.77	1.53
Switzerland	$/liter equivalent	0.66	1.33	0.71	1.54
Australia	$/liter equivalent	0.69	1.77	0.38	0.76
Support per tonne of CO_2-equivalent avoided					
United States	$/tonne of CO_2 equivalent	NA	545	NQ	NQ
European Union	$/tonne of CO_2 equivalent	590	4520	340	1300
Switzerland	$/tonne of CO_2 equivalent	340	394	253	768
Australia	$/tonne of CO_2 equivalent	244	1679	165	639

Source: Doornbosch and Steenblik (2007).

Note: The ranges of values reflect corresponding ranges in the estimates of total subsidies, variation in the types of feedstocks, and in the estimates of life-cycle emissions of biofuels in the different countries.

These kinds of subsidies can not be expected for conventional forest industrial production from plantations. It should also be added that he oil companies are sitting on enormous financial resources compared to the forest industry. The oil industries' investments would rather go to biofuel plantations than to forest industrial plantations.

The oil palm production in tropical regions has nearly doubled in less than 10 years (see Table 13).

Table 13: Oil palm production in tropical regions (after World Rainforest Movement, 2006)

	Area	Tons of Palm Oil
1997	6.5 million ha	19.6 tons
2005	12.0 million ha	30 million tons

IV. Land Availability

How much land is available for increased agriculture, energy and industrial wood production? In the literature there are huge areas identified as suitable for biomass production—from 345–760 million ha (Persson, 2006). But land reported available is generally over-estimated and the land reported unused is under-estimated in these reports (Doornbosch and Steenblik, 2007). Persson (2006) is stating that this is "happy" over-estimates. He claims that in the developing world all land—independently of how degraded it is—is used in one way or the other. Therefore the basic question is how large is the accessibility of land, which will not cause conflicts and not be expensive. The German Advisory Council on Global Change (WBGU, 2003) has tried to come up with a "guarded estimate" on the land availability and assess it to be 390 million ha globally.

Table 14: Global potentials for energy crops by continent

Region	Potential land		WBGU "guard rail"		
	(mio. ha)	(%)	(mio. ha)	(%)	(EJ/a)
Europe	22	4.5	22	4.5	2.5
Asia + Australia	37	0.7	26	0.5	3
Africa	111	3.8	111	3.8	12.7
Latin America	323	16	165	8	18.8
North America	101	5.9	67	3.6	7.7
World	**595**	**4.6**	**391**	**3**	**44.7**

Source: WBGU (2003).

Let us assume that there is 390 million ha of additional suitable land available out there. Is this enough for covering increased food, energy, and industrial wood demands? The answer is probably not and the land will be most expensive and all biomass production will come with much higher prices. And this is valid for agricultural products, biomass for energy and wood fiber for the forest industry.

V. Development of Industrial Wood Production

Nilsson (2007a) has made an outlook on the global industrial wood supply. There is no room for the detailed presentation of the background analysis in this connection but the results are summarized in Table 15.

Table 15: Globalization of fiber markets; future scenario on wood fibers

Region	Accessibility of wood fiber	Demand forest industry products	Wood fuel	Balance supply/demand wood fibers
Nordic	slight increase	slight increase	strong increase	reduced
EU15	slight decrease	slight increase	strong increase	reduced
Former East Europe and CIS	slight decrease	increase	strong increase	reduced
Russia	slight increase	strong increase	strong increase	unchanged
Africa	unchanged/increase	slight increase	increase	reduced
China	slight increase	strong increase	increase	strongly reduced
India	strong decrease	strong increase	increase	strongly reduced
SE Asia	strong decrease	strong increase	increase	strongly reduced
Oceania	increase	slight increase	slight increase	improved
USA	slight decrease	unchanged	slight increase	reduced
Canada	strong decrease	slight increase	strong increase	strongly reduced
Latin America	increase	strong increase	increase	reduced

Source: Nilsson (2007a).

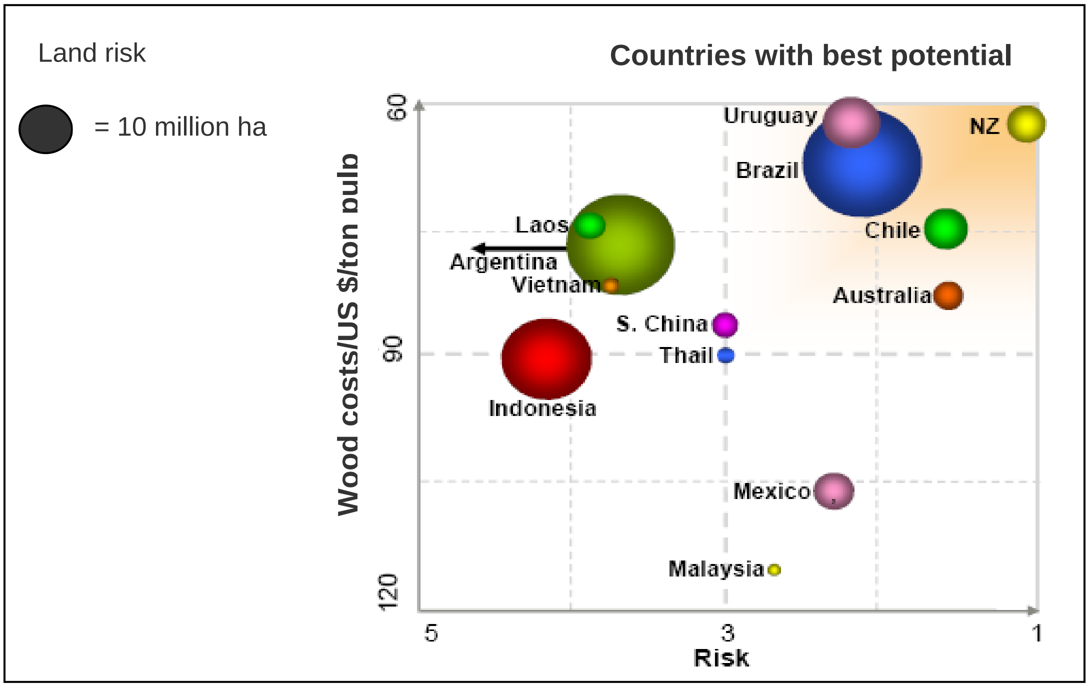
This shows that the future industrial supply/demand situation will be tight with increased costs as a result.

This situation could of course be eased with a rapid development of plantations in the South as many suggests (e.g., FAO, SCTP, etc.). However, there is a lot of criticism against the plantations in the South. For example, it is argued that the plantations are causing environmental degradation (loss of biodiversity, reduction and contamination of water, negative soil impacts, etc.). In reality these problems are over-estimated with respect to fast growing plantations if they are correctly managed (Persson, 2006). The problems with the plantations are in the framework of the economic and social context of plantations. This means the issues of land-use, property rights, income, jobs, etc. These problems are escalating and are causing escalating costs of the plantations in combination with increased demand on wood.
The forest industry is continuously on the road looking for possibility in investments in new plantations.

In Figure 13 I present a recent assessment made by StoraEnso and presented by Tosterud (2007) and the risks are based on the possibilities to handle the social and economic risks.
But these assumptions are not taking into account the development we are seeing happening now with the development of demand on food, energy and industrial wood. This can be illustrated by the land price development in Uruguay (see Figure 14). Within less than three years the land prices have increased three times.

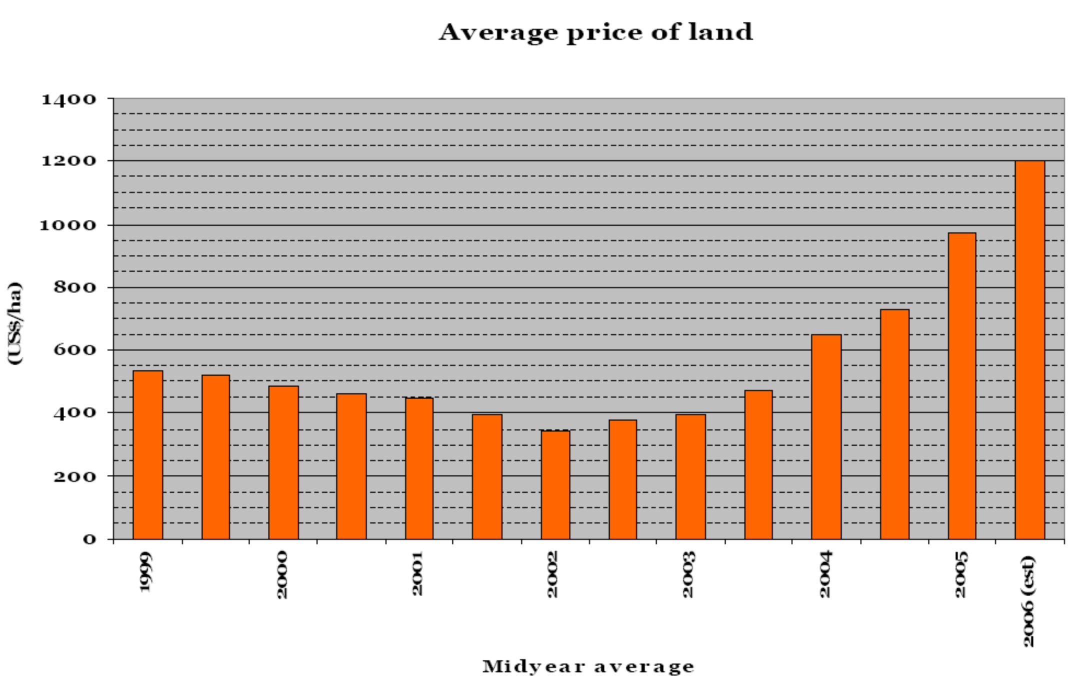
We see similar developments in other tropical countries and in China.

Figure 13: Accessibility of land suitable for forest industrial plantations



Source: Tosterud (2007)

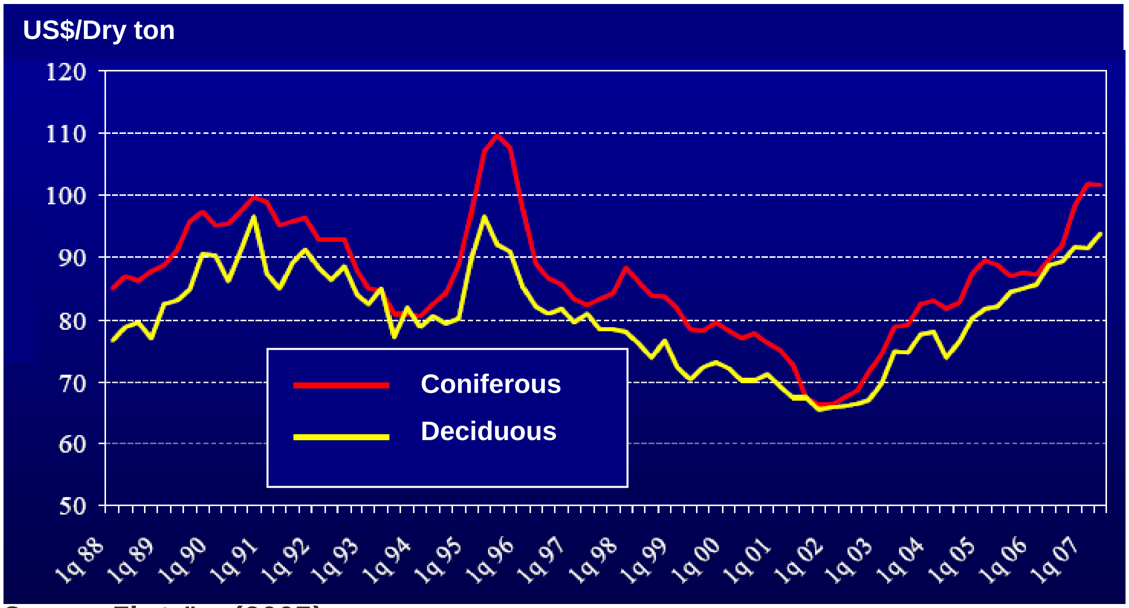
Figure 14: Price evolution: Uruguay land price $/HA



Source: Scanfiber (2007).

In addition, due to the tight wood supply conditions described in Table 13 the wood prices are increasing. This is illustrated in Figure 15.

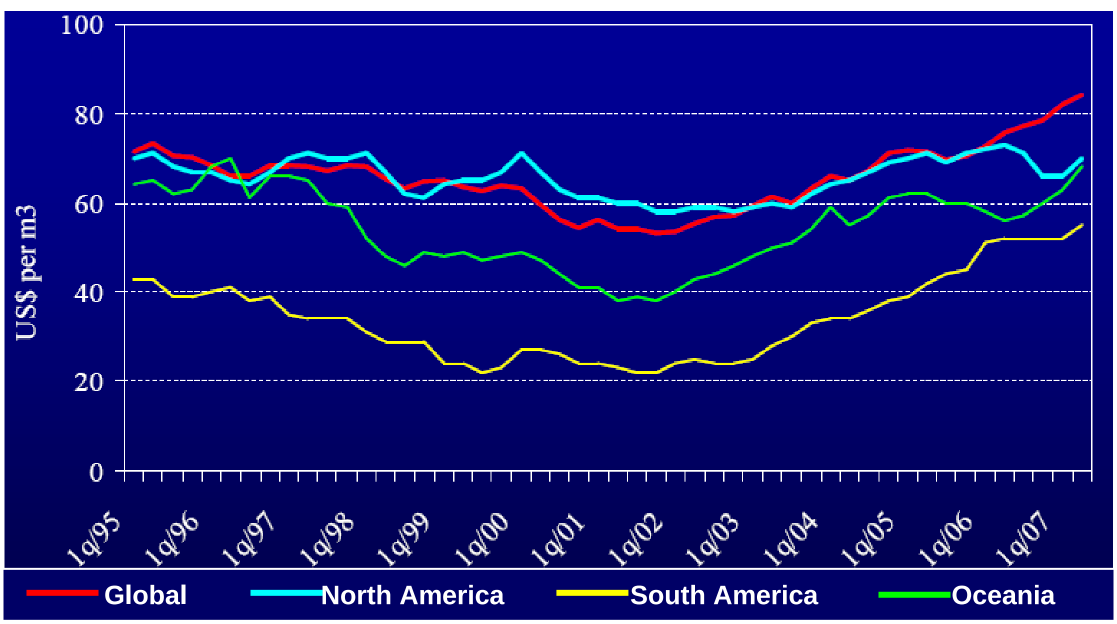
Figure 15: Global average wood price for wood fiber 1988-2007



Source: Ekström (2007).

In addition, the prices of wood are in a merging development which is illustrated in Figure 16.

Figure 16: Prices of coniferous sawlogs 1995-2007



Source: Ekström (2007).

It can be concluded that:

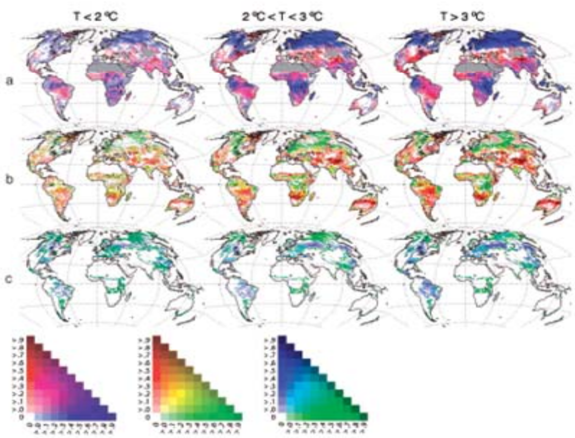
- The costs for pulp and saw logs have increased faster during the last five years in tropical plantation countries compared to North America and Northern Europe.
- We will in a foreseeable time see the same level of wood costs in all major wood producing regions of the world.

VI. Climate Change and Forestry

One aspect, which is not usually taken into account in the debate of future wood supply, is climate change impact. Scholze et al. (2006) have used existing models and knowledge assess the future impacts of climate change.

Figure 17: Climate change and forest ecosystems

Probability of exceeding critical levels of change between 1961–1990 and 2071–2100 for three levels of global warming. For quantitative variables (freshwater runoff and wildfire frequency), critical change is defined where the change in the mean of 2071–2100 exceeds ±1σ of the observed (1961–1990) interannual variability. (a) Freshwater runoff (blue for increase, red for decrease; mixed colors show cases where different runs produce changes in opposite directions, i.e., there are runs of both exceeding the critical level by +1σ as well as by −1σ). Gray areas denote grid cells with ≤10 mm•yr-1 mean runoff for 1961–1990. (b) Wildfire frequency (red, increase; green, decrease). (c) Biome change from forest to nonforest (blue or vice versa (green). For wildfire frequency and biome change, colors are shown only for grid cells with <75% cultivated and managed areas.



Source: Scholze *et al*. (2006); PNAS 103(35): 13116-13120.

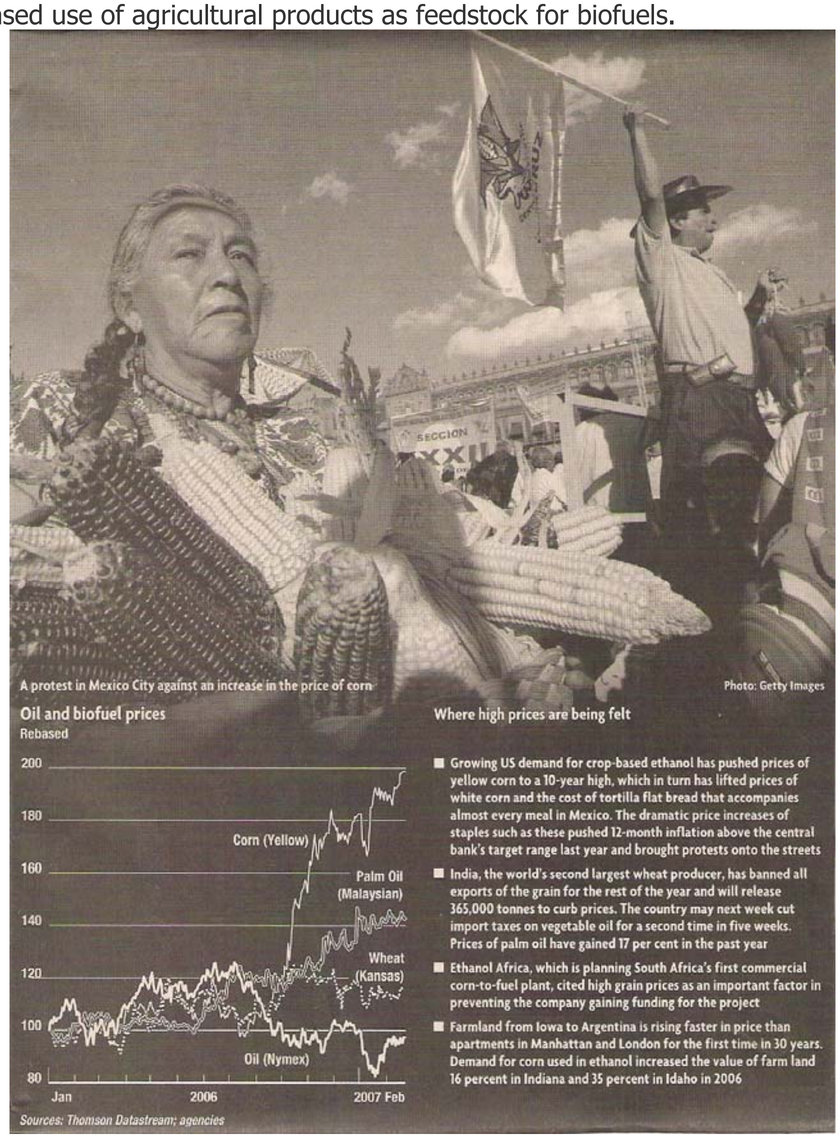
There is common picture through the models with substantially increased wild fire frequencies foreseen in South America, Southern Africa, Australia, Central Asia and China. This year we have seen some 100,000 ha plantations burn in South Africa. A consistent picture of changes of forest biomes to non-forest biomes will take place in South America, a southern bold in Africa, China and Southern Europe. These are important aspects to take into account in the discussion on future plantation possibilities.

VII. Conclusions

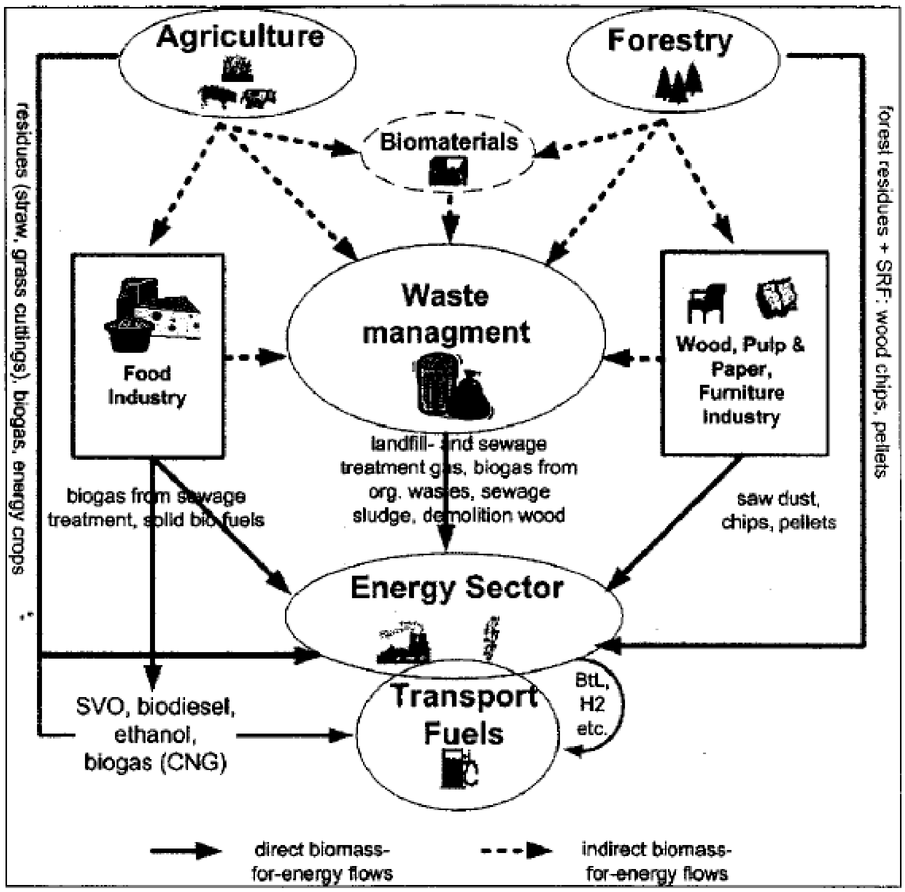
The common sense view in the global forest sector is that plantation forestry in the South will in the future dominate the global forest sector. But if we are taking a broader picture than just the forest sector this view can be strongly challenged.

We are foreseeing an increased demand on food, fiber for energy and fiber for the forest industry.

- The economic global growth is assessed to continue to grow and with the transition and developing economies as the engines.
- The economic growth will increase the demand for food and with the rising living standards is also the calorie intake increasing. The calorie intake will increase by 45% in 2030 and by 65% in 2050.
- This will require a substantial increase in agriculture productivity or additional land of some 3 billion ha (if there is no productivity increase). This is about the size of the land of Russia.
- What we currently see is a flattening out or declining production and productivity in the agriculture sector in the developing world.
- At the same time there are difficulties to identify high productive new land to be used for agriculture production unless forest deforestation is increased.
- This situation has already caused increased prices of agricultural products. Often this is blamed on increased use of agricultural products as feedstock for biofuels.



- But for most agriculture products the price increase is caused by a structural change in demand and supply caused by increased consumption in the developing world, declining productivity and climate impacts.
- We are confronted with a Herculean task from an economic and environmental point of view to find new energy sources instead of fossil fuels in a situation with strongly increasing energy demands.
- Biomass can make a contribution to this transfer in the intermediate period. Therefore demand on biomass for fuel will increase substantially.
- Biomass can produce heat, electricity and liquid fuels. Biomass is more efficient from energy and environmental points of view for production of heat and electricity than for production of biofuels.
- Non-food feedstocks (trees, woody plants, grasses) out-perform most food-based feedstocks for biofuels on energetic, environmental and economic criteria.
- Nilsson (2007b) concludes that once markets have stabilized, biofuels will be dominated by lingo-cellulosics.
- We can also expect that a lot of subsidies and investments by oil industry will flow into the biomass for energy production.
- The demand on industrial wood fiber will continue to increase and there is already now tight demand/supply conditions for industrial wood.
- The latter is already today causing an increase in wood costs and increase in land prices in potential plantation countries.
- Over time we will see wood costs become rather equal between the major wood producing regions of the world.
- The ongoing climate change process is affecting the South negatively and North probably positively.
- All of this means that all three sectors—agriculture, energy and forestry—are looking for cropland and marginal land for expansion especially in the South. The conclusion is very obvious; there is not enough cropland and marginal land available.
- There will be a stiff competition between the three sectors and it is doubtful if the forest sector will be competitive with food and energy in the South.
- We have to stop to speak about Agriculture, Forest and Energy Sectors. We have to work with the complete and integrated biomass sector in the future. See flowchart of the biomass sector (GEF, 2006):



- When we do that kind of analysis we will find that there will be only marginal areas available for forest industry fiber production in the South.

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