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## How much palm oil do we need?

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### ABSTRACT

Palm oil is an important source of edible oil, and also a potential biofuel raw material. In the sometimes heated debate over the expansion of the oil palm industry, the distinction between these uses is rarely made. Future demand for edible oil can be estimated from population projections and per capita consumption. Demand will probably be around 240 Mt in 2050, nearly twice today's total. Most of the additional oil may be palm oil, which has the lowest production cost of the major oils, but soya bean oil production will probably also increase. An additional 12 Mha of palms could be required, if average yields continue to rise as in the past. This need not be at the expense of forest; oil palm planted on anthropogenic grassland could supply all the oil required for edible purposes in 2050. However, biofuel demand might greatly exceed that for edible use, and the interchangeability of the major oils, for edible and biofuel uses, means that this demand will drive oil palm expansion, whether or not palm oil is actually used for biodiesel. The importance of subsidies for biodiesel, the Roundtable on Sustainable Palm Oil and the roles of banks and NGOs are briefly discussed.

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## 1. Introduction

Uncontrolled oil palm expansion is a serious threat to biodiversity in S.E. Asia (Fitzherbert et al., 2008; Koh and Wilcove, 2008), and with recent campaigns against the crop (e.g. Friends of the Earth, 2005; Greenpeace, 2007), it is easy to forget that oil palm (*Elaeis guineensis* Jacq.) provides nearly 30% of the world's edible vegetable oil (Carter et al., 2007), and has been a major force for poverty alleviation and rural development in the tropics (Sargeant, 2001; Basiron, 2007). In part, recent expansion may have been driven by demand for biofuel raw material, and it can be argued that there are less damaging alternative raw materials (Scharlemann and Laurance, 2008), and indeed alternatives to biofuel altogether. If palm oil is an essential food but inessential for biofuel, then it would be useful to have an estimate of the volumes required for edible uses in future, to help to simplify the debate over how much expansion is acceptable. I have attempted to estimate future demand for palm oil for edible purposes using projections of

world population and estimates of future per capita vegetable oil consumption.

It is important to recognise that the main vegetable oils are readily interchangeable for most purposes. Thus, for example, if rapeseed oil is used for biodiesel production, the resulting gap in edible supply may quite possibly be filled by palm oil or soya bean oil. For many edible uses, food producers will use whichever oil is currently the cheapest, with product formulations changing accordingly. Schmidt and Weidema (2008) consider that palm oil is now the 'marginal' oil, the oil most responsive to changes in demand for vegetable oils. Thus the oil palm industry cannot be considered in isolation from the total vegetable oil market.

## 2. Current world vegetable oil consumption

According to the USDA (2007), total world vegetable oil consumption in 2006/2007 was 121 Mt, including 37 Mt palm

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oil, 35.5 Mt soya bean oil, 18 Mt rapeseed oil and 10.3 Mt sunflower oil. In the USDA database, consumption is subdivided among 15 countries, which account for 82% of consumption, plus ‘others’. From these figures, and populations taken from the UN Population Division (UNPD, 2006), current per capita consumption can be calculated. I have used 2006/2007 consumption, and 2005 population; the discrepancy in years is not important, as current consumption is not critical for my estimates. Per capita consumption averaged 17.9 kg, and ranged from 9.4 kg in Bangladesh and 10.6 kg in India to 17.7 kg in China, and up to 39.3 kg in the USA. Malaysia had an implausible figure of 183 kg/head, but I assumed that the very large ‘domestic consumption’ probably represents local downstream processing prior to export.

For the EU 27 (one ‘country’ in the USDA data), consumption was 45.8 kg/head. However, according to *Oil World* (2007) 4.54 Mt went for fuel use in the EU in 2006/2007. As my aim is to estimate edible consumption, I subtracted this from the EU consumption of 20.94 Mt (and also from the total world consumption). After this adjustment, EU consumption is 35.9 kg/head, just below the figure for USA. I assumed that biofuel use of vegetable oil is still too small outside the EU for any adjustment to be significant.

A proportion of vegetable oil has always been used for non-edible purposes (detergents and cosmetics), from well before the biofuel demand started to develop; for simplicity, I have included this ‘traditional’ non-edible use as part of the edible demand. According to USDA (2005), 83% of palm oil was used for edible purposes in 2000/2001. Since then, the proportion has declined, as fuel use has expanded, but I have assumed that 83% edible use represents the situation in the absence of biodiesel demand.

### 3. Future vegetable oil consumption

#### 3.1. Per capita consumption

To estimate future total consumption, one needs estimates of population and of per capita consumption. For population, I have used the ‘medium variant’ for 2050 from UNPD (2006). For consumption, there are two opposing trends: first, as living standards rise in the developing world, per capita consumption is increasing. Consumption calculated from the USDA and UNPD figures showed an increase from 15.8 kg/head in 2003 to 18.4 kg in 2007. Some countries are still well below this figure: the consumption of ‘others’ was 12.4 kg in 2007. Conversely, though, ‘western’ consumption of fats is said to be unhealthily high (e.g. HHS/USDA, 2005) and nutritionists recommend reduced consumption, so it may be wrong simply to assume that the rest of the world will eventually reach the EU/USA consumption level.

Rather than trying to reconcile these opposing trends, I have looked at dietary recommendations. Ideally, fats should make up at least 15% of daily energy intake (20% for women of reproductive age), and not more than 35% (30% for individuals with a sedentary life-style) (FAO, 1994; HHS/USDA, 2005). I have assumed that a reasonable target figure is 25%. Daily energy intake ranged from 2680 to 3380 kcal/head in different

regions of the world in 1999 (Kennedy, 2001), and I have assumed a figure of 3000 kcal/head (but this is higher than the recommendations in HHS/USDA, 2005). Therefore, energy from fats should be around 750 kcal; with an energy content of 9 kcal/g, daily fat intake should therefore be 83 g, or 30.4 kg/year.

A significant proportion of daily fat intake is of animal origin (butter, fat in meat, etc.). Kennedy (2001) gave estimates of the proportion of daily intake from animal and vegetable sources in 1999, based on FAO data. For developing countries 59% was of vegetable origin, whereas in industrialised and ‘transition’ countries it was 46%. Overall, 55% of dietary fat was of vegetable origin, and I have assumed that figure for future consumption.

I therefore arrived at a long-term estimate of ‘desirable’ vegetable oil consumption of 55% of 30.4 kg, or 16.7 kg/head. Assuming that the 17% traditional non-edible use (see above) applies to all the main edible oils, the annual per capita consumption of 16.7 g should be increased to 20.1 kg.

#### 3.2. Total world consumption

According to the UNPD (2006), the world’s population in 2050 will be approximately 9.2 billion (medium variant). To allow for differing rates of vegetable oil consumption in different countries, I have used the forecast population figures for the 15 individual countries in the USDA database (USDA, 2007), with ‘others’ arrived at by difference from the total. For per capita consumption of individual countries:

- (a) Where consumption is currently less than 25 kg/head, I have assumed that by 2050 it will have increased to 25 kg/head. This allows for some luxury consumption, above the desirable dietary intake of 20 kg/head.
- (b) Where consumption already exceeds 25 kg/head (USA, EU), I have assumed that it will continue at the present rate. This may be an overestimate, if dietary recommendations are widely followed in future.

This is the ‘medium’ estimate. Possible alternatives are:

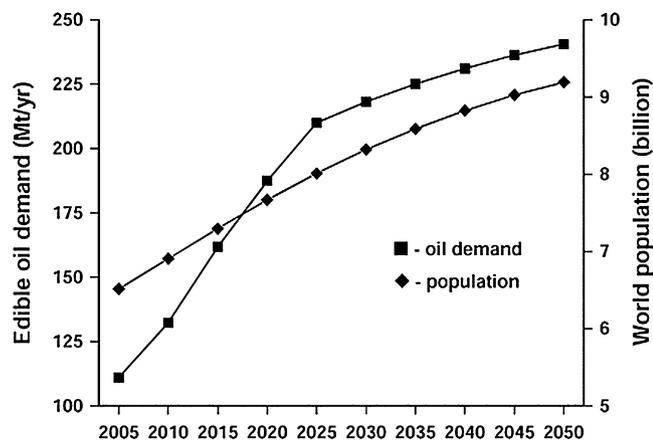
- Low: Consumption increases to a ceiling of 20 kg/head rather than 25 kg.
- High: Consumption increases to the present ‘western’ level of 37 kg/head.

To estimate the trend in requirements between now and 2050, I have assumed that per capita consumption in individual countries will increase by 0.8 kg/year; this is approximately the rate at which consumption in India and China has increased in recent years. I have applied this rate of increase until a country reaches the ceiling (25 kg/head in the medium estimate). Table 1 shows that the medium estimate of edible requirement in 2050 is 240 Mt, roughly twice current production. The trend in total requirements for the medium estimate is compared with population forecasts from UNPD (2006) in Fig. 1. Initially consumption increases faster than population growth, but by 2025 all countries have reached the ceiling of 25 kg/head, and thereafter consumption follows the population trend.

**Table 1 – Additional demand for vegetable oil in 2050.**

Estimate	Assumed rate of consumption	Demand in 2050 (millions of tons)					
		Total	Other oils	Soya constant		Soya increasing	
				Soya	Palm	Soya	Palm
Low	At least 20 kg/head	201	48	36	117	60	93
Medium	At least 25 kg/head	240	48	36	156	72	120
High	37 kg/head	340	48	36	256	102	190

Low, medium and high consumption estimates described in text. 'Soya increasing' assumes that soya continues to make up 30% of total production. 'Soya constant' assumes that soya remains constant at the current production level of 35.5 Mt. In each case, palm oil increases to meet the remaining demand.



**Fig. 1 – Expected trends in world population and edible use of vegetable oil. Population from UNPD (2006). Demand estimated from population and per capita consumption, as described in text.**

#### 4. Future contribution from palm oil

The two main oils are palm and soya bean; demand for the latter is driven primarily by demand for meal, rather than for vegetable oil. In the past, the rate of growth in demand for soya bean meal has been approximately the same as the rate of growth in demand for vegetable oil, so that soya bean oil has retained a more or less constant share of the vegetable oil market (J. Fry, pers. comm., 2008). Thus my base assumption is that soya bean oil will continue to make up 30% of total production. Other oils remain constant at today's production levels, with palm oil making up the difference.

Palm oil is the oil with the lowest production costs (Carter et al., 2007), and Schmidt and Weidema (2008) consider that palm oil is now the 'marginal' oil. The move away from trans-fatty acids also favours palm oil, as it can be used without hydrogenation as the solid fat component in many formulations (Berger and Idris, 2005). An alternative scenario therefore has palm oil meeting the entire additional requirement, with the other oils all remaining constant at today's levels, including soya.

Table 1 shows future vegetable oil requirements, based on the above estimates. The demand for palm oil will be at least 93 Mt, and more likely between 120 and 156 Mt (medium estimate).

#### 5. Land area required to meet demand

The area needed depends on the yield per hectare. I have used two alternative figures for palm oil yield per unit area:

1. I assumed that the 2007 average yield for Malaysia and Indonesia of 4 t palm oil/ha (Oil World, 2007) will be maintained ('current yield' in Table 2).
2. Alternatively, I assumed that the trend over the last 30 years for yield to increase by 0.027 t/ha year (Carter et al., 2007) will continue. This would give an average yield of 5.2 t/ha by 2050 ('improved yield' in Table 2). I also assumed that this average yield will apply both to areas already planted and to future plantings.

The present planted area in the main producing countries, including immature areas, is approximately 11 Mha (Malaysia, Indonesia, Thailand, Colombia and Papua New Guinea). Based on these figures, I have estimated the additional area of oil palms required to meet future demand (Table 2).

**Table 2 – Additional area of oil palms required to meet demand for vegetable oil in 2050.**

Estimate	Assumed rate of consumption	Additional area of palms required (Mha)			
		Current yield		Improved yield	
		Soya inc.	Soya const.	Soya inc.	Soya const.
Low	At least 20 kg/head	12.1	18.3	6.8	11.5
Medium	At least 25 kg/head	19.1	28.1	12.0	18.9
High	37 kg/head	36.4	53.0	25.4	38.2

Low, medium and high consumption estimates described in text. 'Soya inc.' and 'soya const.' refer to the estimates in Table 1, with soya bean oil production either increasing to maintain 30% of total production, or remaining constant at 35.5 Mt. Current area of oil palms is 11 Mha. Current yield is 4 t/ha year; improved yield is 5.2 t/ha year.

## 6. Discussion

There are obviously many uncertainties in these estimates. For world population in 2050 the high and low variants are 10.8 and 7.8 billion (UNPD, 2006). The high figure is 17% above the medium variant used here. For the medium consumption estimate, this would increase total requirement to 281 Mt, total palm oil to 149 Mt (if soya bean production also increases), and the additional area of palms required to 18 or 26 Mha, depending on yield.

The medium estimate of per capita consumption allows for some 'luxury' consumption, above the optimal dietary intake, and seems to me the most probable scenario. It seems unlikely that most countries will adopt completely 'western' diets (with 40% of fats consumed in cakes, cookies, crackers, pies, etc.—HHS/USDA, 2005). Thus the high consumption estimate is probably an overestimate.

With rising living standards, consumption of animal fats may increase. At the same level of total fat intake, this would decrease the consumption of vegetable oil, but if meat consumption increases, demand for soya meal will increase. The accompanying soya oil will displace palm oil, and the 'soya increasing' estimates of palm oil demand are thus more likely to be correct.

Whether or not palm oil yields continue to improve in future is another important uncertainty. The gap between average and record yields is widening, with record yields currently over three times Malaysia's national average (Corley, 2005). This shows that there is plenty of scope for future yield improvement, but also suggests that plantation managers may be failing to take full advantage of the genetic yield potential of their planting material. It should be noted that expansion is often into poorer soils and unfavourable climates; in Indonesia, the best soils and climate are probably in North Sumatra, but most land there was planted many years ago. Leaving the question of yields undecided, the additional area of oil palms which I consider likely to be required to meet edible demand in 2050 is between 12 and 19 Mha (Table 2—medium estimate, soya increasing).

The USDA data base indicates that total edible oil demand is currently expanding by 5–6 Mt/year (if European biofuel use is excluded), and Fig. 1 suggests that this may continue until 2020 or 2025. If 30% of this is met by soya bean oil, then at current yields 0.88–1.05 Mha of oil palms would be needed to meet the remaining annual increase in demand, but the area of oil palms is expanding by only 0.65 Mha/year (Oil World, 2007). Edible demand is currently increasing faster than palm oil supply, therefore, so it might be argued that current expansion would be occurring even without biofuel demand (though that demand must have influenced recent vegetable oil prices). Seed supplies and management resources, rather than demand, may be limiting the rate of expansion of oil palm.

## 7. Implications for biodiversity

The first point to recognise is that among the oil crops oil palm is the 'land sparing' option, because it gives much higher yields than other crops. The additional oil must come from

somewhere; if that required under the medium consumption estimate were all to come from soya bean, a total area of that crop of about 189 Mha would be needed in 2050 (assuming that yields continue to rise by about 1.5% per year (J. Fry, pers. comm., 2008), giving an expected yield in 2050 of about 0.82 t oil/ha). This is roughly double the current area under soya beans. Much of the current expansion of soya beans is in the Brazilian Amazon region (Fearnside, 2001; Morton et al., 2006), so environmental damage is probably comparable to that from recent oil palm expansion at the expense of forest in Indonesia. Thus it would be preferable to meet the increasing demand for edible oil with an additional 19 Mha of oil palms (medium estimate, soya constant and improved yield) rather than an additional 95 Mha of soya beans (in practice, both crops are likely to increase, as noted above).

Assuming that palm oil yields continue to improve, and that soya bean production also increases, then 12 Mha of oil palms will be required, equivalent to 14% of Indonesia's remaining forest (FAO, 2006) (though it is unlikely that all future expansion will be in Indonesia). The Roundtable on Sustainable Palm Oil ([www.rspo.org](http://www.rspo.org)) insists that 'high conservation value forest' should not be cleared to plant palms, so to the extent that RSPO criteria are followed in future, primary forest should be safe. Indonesia has 36 Mha of secondary forest (FAO, 2006); such forest has biodiversity value (Barlow et al., 2007; Koh and Wilcove, 2008), and some may have 'high conservation value', but its loss would usually be more acceptable than loss of primary forest. However, the oil palm expansion might actually be accommodated without any forest clearing. There are said to be 8 Mha of *Imperata* grassland in Indonesia (Garrity et al., 1996); in Brazil there are 15.5 Mha of 'fallow' land in the Carajas region of Para state alone (da Costa, 2004). In Colombia most plantations have replaced pasture, and there are a further 49 Mha of permanent pasture (Pagiola et al., 2004). The FAO database (FAO, 2007) shows areas of permanent pasture in 2005 which are of the same order as these figures. Thus even the 53 Mha required under the high consumption estimate with current yield could probably be accommodated in these three countries alone without further deforestation.

This raises the question of how to direct development away from forest towards grassland.

Among several problems with planting in grassland (Tomich et al., 1997), an important one is financial. Clearing forest gives a useful cash-flow from timber sales at the start of the project, whereas a grassland planting gives no return until palm oil production starts, 2.5 years after field planting. Several of the banks which finance oil palm projects are members of the RSPO, and should be looking for sources or types of finance which overcome this disadvantage.

A second problem is that of land ownership: an area which once was forested but is now grassland must have been cleared by someone, who may have established a 'customary right' to the land, even if not formal legal ownership. The land may have been abandoned as unusable for various reasons (Tomich et al., 1997), but oil palm development is clearly preferable to leaving the land fallow. Social NGOs should be helping to resolve ownership disputes on such land, rather than exacerbating them as has sometimes been the case, to ensure that development of this degraded land can proceed. At

the same time, plantation companies must ensure that development provides clearly understood benefits to the original land owners, whether in the form of employment and improved infrastructure, or more complex schemes such as leases or shared ownership.

I have discussed edible demand as distinct from biofuel demand, but the interchangeability of the main vegetable oils means that demand cannot easily be subdivided according to use, and that prices of the main oils will remain correlated. Although actual biofuel use of vegetable oil is small at present, there is no doubt that it has influenced prices in two ways. First, in a free market even a small excess of demand over supply may lead to large price increases, which will affect all oils. Second, the vegetable oil price is now tending to follow the petroleum price, whereas up to 2006 there was little relation between the two (J. Fry, pers. comm., 2008). Recent very high petroleum prices have made it worthwhile for biodiesel producers to pay high prices for vegetable oil. However, such demand is likely to be very price-sensitive, whereas total edible demand is mainly driven by population growth, and in the long-term will be relatively insensitive to prices.

Koh (2007) considered that by 2050 world diesel consumption might have doubled to 1380 Mt/year, and that biodiesel might make up 20% of the total. Koh's figure of 277 Mt vegetable oil made no allowance for conversion costs or the lower energy density of biodiesel. Allowing for these, 330 Mt of vegetable oil would be required; if this were to come from palms, 63–82 Mha would be needed. This dwarfs the edible demand. At present some countries subsidise the production of biodiesel, but interchangeability means that the price of all vegetable oils is artificially inflated; a subsidy for biodiesel in Europe indirectly subsidises deforestation in Borneo, even if the use of palm oil as biodiesel raw material is not permitted. If subsidies are necessary to encourage development of renewable fuel they should be much more precisely directed at raw material production in new projects, clearly additional to edible demand, or involving non-edible oils.

Germer and Sauerborn (2007) have shown that palm biodiesel only reduces greenhouse gas emissions if the palms have replaced grassland. Much recent expansion has been at the expense of forest (Koh and Wilcove, 2008), and this has led to calls for an embargo on the use of palm oil for biodiesel, but such campaigns against palm oil may have little effect on the rate of expansion of the crop. Whether or not Europe uses palm oil, the steadily increasing edible demand is most likely to be met by palm oil. Anti-palm oil campaigns may even be counter-productive: exclusion of palm oil from Europe would destroy the market for certified 'sustainable' oil, but the RSPO represents the main hope for reducing the environmental damage caused by oil palm expansion. RSPO membership and certification are voluntary, and there needs to be a strong demand for RSPO-certified oil for it to be successful.

Exaggerated counter-claims for the environmental benefits of oil palms by the industry will also be counter-productive, allowing the anti-palm oil campaigners to discredit the industry still further. For example, a detailed review of the literature has shown that the biodiversity in an oil plantation is no greater than that in plantations of other crops, and less than in secondary forest (Fitzherbert et al., 2008). Thus claims extolling the biodiversity value of oil palm plantations are

hard to justify. Sticking to the facts, even if not particularly favourable to the industry, will be beneficial in the longer term.

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## 8. Conclusions

While oil palm expansion has undoubtedly been damaging to biodiversity in the past, it is clear that considerable further expansion would be possible, without further environmental damage, provided that the expansion is properly managed. The palm oil industry could supply sufficient vegetable oil to meet the increase in edible requirements for the world population in 2050, and there is sufficient land available for the necessary expansion to occur without further deforestation.

Consumer demand for sustainable palm oil has led to the formation of the RSPO, but to ensure that future development is directed away from forest land, governments, the palm oil industry and NGOs must all contribute:

- Biofuel subsidies from western governments ought to be better directed, to remove artificial incentives for oil palm expansion.
- Environmental NGOs in producer countries should develop maps identifying the most suitable land for oil palm expansion.
- Governments should then regulate development, but the industry must also collaborate directly with the NGOs, particularly where government is ineffective, to ensure that development is directed to suitable areas.
- Banks which finance oil palm projects should offer alternative types of finance for projects with no initial income from timber sales.
- Social NGOs can help to resolve land ownership disputes, but plantation companies should be open to new ideas regarding land ownership.

The RSPO can play an important role in encouraging the adoption of such policies. The oil palm industry will inevitably continue to expand, regardless of the biofuel debate, driven by the ever-increasing demand for edible vegetable oil. Provided that the expansion is in accordance with RSPO principles, the industry can meet the demand and also continue to be an important force for rural poverty alleviation, without serious damage to biodiversity. However, the extent to which these principles will be applied is uncertain; outside Europe there are large markets for edible oil where certification of sustainability may not be a requirement in the near future, while demand for biodiesel raw material could greatly exceed edible demand, particularly if it continues to be stimulated by subsidies. These two factors could mean that oil palm expansion may become very difficult to control.

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