The end to cheap oil: a threat to food security and an incentive to reduce fossil fuels in agriculture

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The end to cheap oil: A threat to food security and an incentive to reduce fossil fuels in agriculture Article reproduced from United Nations Environment Programme (UNEP) Global Environmental Alert Service (GEAS)

1. Why is this important?

Fossil fuels are essential for modern, mechanized agricultural production systems. Petroleum products are used directly to power tractors, machinery and irrigation, and to transport, transform and package agricultural products. They are also used indirectly to manufacture fertilizers and pesticides and prepare seeds. Thus, food production is energy intensive. For example, approximately 2000 l per year in oil equivalents are required to supply food for each American, which accounts for about 19 percent of the total energy used in the United States (Pimentel et al., 2008).

The industrialization of agriculture, known as the Green Revolution, occurred during the middle of the 20th century, as farming became increasingly dependent on direct and indirect fossil fuel inputs (Woods et al., 2010). Between 1945 and 1994, agricultural energy inputs worldwide increased four-fold while crop yields increased three-fold. Since the early 1960s, the global growth in cereals depended almost entirely on agricultural intensification, with little expansion in the area harvested (UNEP, 2011) (Fig. 1).

As machines replaced farm workers, the energy output-to-input ratio declined (Fig. 2) (Pfeiffer, 2003). In industrialized countries today, one food calorie requires expending an average of between seven and ten calories of fossil energy (Dahlberg, 2000).

While food production—not to mention transportation and many other modern systems—has become ever more dependent on oil, world oil reserves have been dwindling. The amount of oil that can be recovered cost effectively and the date at which oil production will begin to decrease is known as "peak oil". Estimates of peak oil vary widely. In 2010, the International Energy Agency (IEA) reported that conventional oil production reached a plateau in 2006 and started declining in 2009 (IEA, 2010) (Fig. 3).

Many experts believe that biofuel production is a solution; the rate of production is growing steeply worldwide and it is already partly replacing fossil-fuel use. The production of biofuels instead of food crops in areas of Europe and in the United States is partly to blame for the 12.7 percent decline in world cereal stocks between 2009 and 2011 (de Schutter, 2011). The balance between food and biofuel production is fragile, and in some regions, biofuel production could have detrimental impacts on the environment and human well-being. For example, energy crops potentially have high

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Fig. 1. Global growth of fertilizer use and cereal production, 1960–2010.
Source: UNEP, 2011.

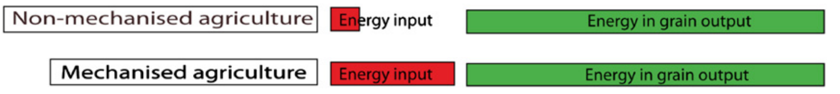

Fig. 2. Difference in energy input-to-output with the change in agricultural systems.
Source: based on data from Pimentel, 2009.

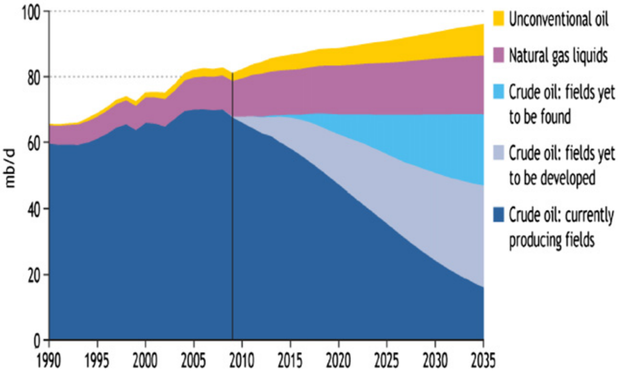

Fig. 3. Conventional oil production reached a plateau in 2006.
Source IEA, 2010.

water demands and so compete with food production (Amigun et al., 2011). The production of unconventional oil, such as oil sands and shale gas, to mitigate the decline in conventional oil production could have many environmental consequences, including climate change impacts, since their production requires higher water volumes and emits more greenhouse gases than conventional oils (UNEP, 2011b).

2. What are the findings and implications?

The consequences of a potential increase in the price of oil as conventional oil production decreases would be manifold and likely serious. In addition to agriculture, many other aspects of modern life are also highly dependent on inexpensive oil. Major price increases for transportation would occur, as 99 percent of this sector depends on fossil fuels (ITPOES, 2008). Health impacts can also be expected, as oil is a primary raw material for many drugs and health services depend on cheap oil (Raffle, 2010). National security also depends heavily on oil, in terms of all types of military aircraft, land vehicles and ships requiring fuel (Gokay, 2011).

One of the impacts of peak oil on the agriculture section would be a rise in fertilizer prices at a time when its use is increasing. By 2030, the FAO expects global fertilizer use to grow by 188 million tonnes (IAASTD, 2009).

Peak oil could imply a reduction in the current heavy use of fossil energy inputs to agriculture (Fig. 4), with many serious consequences. Already, the world is facing a food crisis. In the next several decades, population growth, lifestyle modifications (including an increase in meat consumption), biofuel production, climate change and water pollution and scarcity are all factors that will increase pressures on agricultural production (Arizpe et al., 2011). The prices of basic food commodities (cereals, oils and fats, meat, sugar and dairy products) have been rising in the last few years.

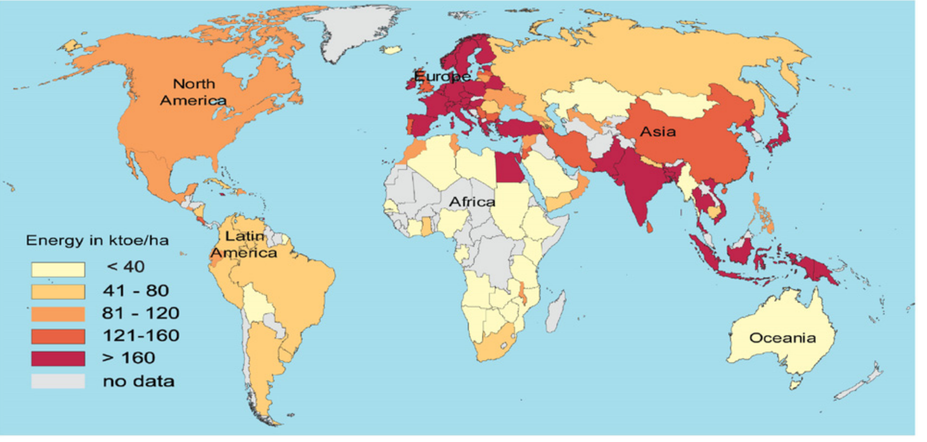

Fig. 4. Energy used for agricultural production in kilo tonnes of oil equivalent per hectare (ktoe/ha).
Source: FAOSTAT, 2011, Visualization by UNEP GRID-Geneva.

Fig. 5. The price of food is highly dependent on the price of oil.
Source: FAO, 2011; Mundi Index, 2011.

Food prices increased since 2004 to an all-time high in February 2011 and since then have decreased slightly, but remain higher than ever before. This has contributed to the increase in the number of undernourished people and to social unrest in several countries. Notably, the recent "Arab Spring" has been linked in part to increased food prices (Johnstone and Mazo, 2011). Rising oil costs is not the only factor influencing food prices, but since food production depends on oil, food prices are strongly linked to the price of oil (Fig. 5) (OECD/FAO, 2010).

2.1. *Factors that influence fossil fuel use in agriculture*

2.1.1. *Agricultural methods*

In general, the industrialization of agriculture increased both fossil-fuel use and agricultural yields considerably; however there are many different types of agricultural practices that require more or less fossil fuel, including organic farming, sustainable agriculture and intensive farming methods. Usually, the more technically advanced and mechanically oriented an agricultural system, the more external energy is required.

2.1.2. *Land availability*

In areas with limited land, more fossil fuel is necessary to produce agricultural outputs using industrial agricultural techniques, which are more input-intensive. In the world's globalized economy and increasing international interdependence, no country is isolated from the loss of arable land to other uses (for example, urbanization) and its consequences. Worldwide, there is currently 0.72 ha per person of agricultural land. Based on the United Nation's projected rise in population (UNPD 2011), this amount will drop to below 0.7 ha within the next five years, without taking into account the degradation and loss of current agricultural land. If the high level of fossil fuel inputs used since the Green Revolution were to decrease, land area would have to increase to maintain current yields (Goklany, 2001). The amount of land available for agriculture is unlikely to increase, however, due to climate change (and associated sea-level rise and other impacts), urbanization, land set aside to protect biodiversity, and unsustainable land management (Godfray et al., 2010). Cutting trees to increase arable land area would increase carbon emissions and lead to habitat and biodiversity loss and greater soil erosion (CGIAR, 2011).

Different foods require different levels of energy inputs (Fig. 5). Meat production needs particularly high energy inputs compared to cereals. Two and a half to ten times more energy is required to produce the same amount of caloric energy and protein from livestock than can be gained directly from grains (Naylor, 1996). The amount of energy to produce meat depends on the production system. For example, industrialized systems that use feed produced from grain or soya, often imported from tropical countries, use more energy than systems where cattle are grass-fed. Meat consumption per capita is unevenly distributed, but is much higher in developed countries (Fig. 6). Global meat production and consumption is increasing and is expected to rise by 70 percent between 2000 and 2030 and by 120 percent in the period between 2000 and 2050. This growth is a major cause of rising fertilizer use (IAASTD, 2009).

2.1.3. *Soil degradation*

Soil degradation occurs worldwide and is increasing (FAO, 2008). The more degraded the soil, the greater the need for fertilizer. The use of inorganic fertilisers (made from fossil fuels) hides decreases in soil fertility due to intensive agriculture practices (Mulvaney et al., 2009). Energy is required to manufacture, package, transport and apply inorganic fertilisers; thus, an increase in fossil fuel prices has an impact on fertilizers prices.

2.1.4. *Transportation*

Moving food from the producer to the consumer uses fossil energy. The extent and intensity of transportation has increased as agriculture has become more specialised and globalized, food products are increasingly imported and exported and distances between producers and consumers

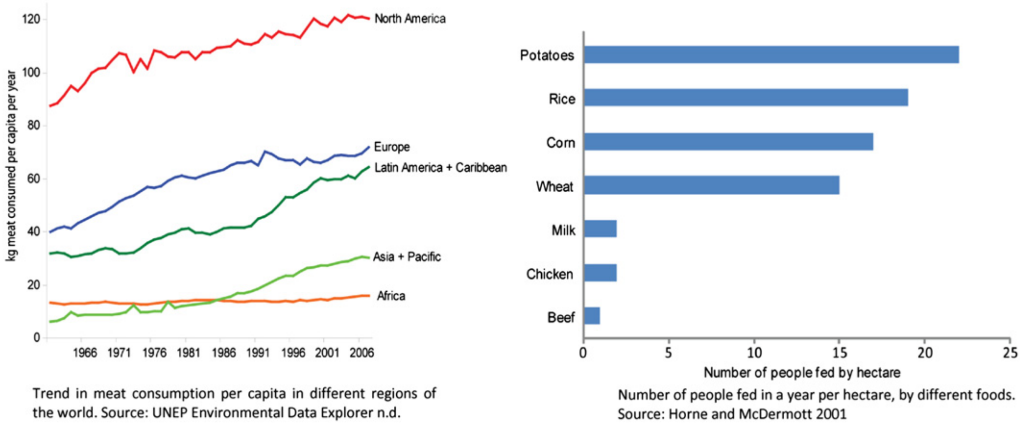

Fig. 6. Meat consumption per capita and number of people fed per year on different foods, by hectare. *Source:* UNEP, 2012.

have increased. By one estimate, food travels an average of 2400 km in the United States before being consumed (Pimentel et al., 2008). Thus, agriculture's dependence on fossil fuels has strengthened (Garnett, 2003).

2.1.5. Transformation and packaging

In developed countries, 40 percent of the fossil energy that supplies food is used to process, package, distribute and prepare the food (Pimentel, 2009). Packaging is necessary to ensure food security and protection and prevent waste. The type of packaging material can affect the amount of energy used (Ziesemer, 2007), while recycling packaging and other management approaches to waste packaging also involves energy, which needs to be considered (Canning et al., 2010).

2.2. Options for the future

If the peak oil energy situation evolves, the agricultural production systems developed during the Green Revolution will have to be modified. There are several approaches to reducing the food system's dependence on fossil fuels and they all require changes in agricultural practices, lifestyles and urban and rural development. A number of those suggested most often are listed in Box 1. Agronomic practices like no-till, minimum tillage, crop diversification, crop rotation and integrated pest management, in combination with the strategic application of fertilizers and irrigation water, the use of low-impact pesticides and the expansion of precision-farming procedures, are recommended as well-proved schemes that are more sustainable than those of intensive, high-input conventional farming both in terms of energy use and other direct environmental impacts (Viglizzo, 2012).

3. Conclusions

Current levels of agricultural production depend on cheap oil, but this dependence needs to decline to avoid food shortages and higher prices in the future. Supplying adequate food and water are global priorities. Sustainable food production requires sustainable energy resources. There are already examples of efforts to reduce the environmental impacts of farming that have successfully reduced fossil fuel use. For example, over the last 50 years, Argentina has adopted low-input/low-impact schemes in its farming sector, which resulted in lower energy consumption (as well as soil erosion and other impacts) than some European countries, China, Japan, New Zealand and the United

Box 1–Approaches for reducing fossil fuel use in agriculture.

- Increase the efficiency of fossil fuel use in agriculture, by reducing the requirement of farm power per unit of land area, for example (e.g., smaller tractors, less and lighter farm equipment, reduced use of machinery, less irrigation)
- Apply sustainable tillage practices that minimize soil erosion and compaction and also reduce the use of machinery and associated energy inputs.
- Adopt fertiliser and pesticide management schemes that reduce agrochemical use and the amount of indirect energy used, such as the methods employed by precision farming.
- Halt the degradation of arable land to conserve more land for agriculture, by stemming deforestation and overgrazing that erodes soils, for example.
- Increase the number of people working in agriculture and reduce farm sizes. It has been shown that for the same yields, smaller farms use less fuel than big ones. This is often linked to the increased size of the labor force on small farms. A policy-making matrix integrating agricultural and conservation elements can be used to encourage small-scale agroecological approaches, especially when they function within the payment-for-ecosystem-service framework (Perfecto and Vandermeer, 2010). Another suggestion is to support a global fund for micro-financing that would promote the development of diversified and resilient ecoagriculture and intercropping systems (UNEP-GRID, 2009).
- Adopt environmental and social full-cost pricing of energy inputs to agriculture to discourage unsustainable production patterns.
- Reduce the transportation of agricultural products from farms to consumers by integrating agricultural production into human settlements and promoting locally grown and in-season products. Also, diminish the amount of refrigeration by encouraging consumers to buy smaller quantities of in-season fresh produce more frequently. Community Supported Agriculture (CSA), a partnership between a local organic farmer and his clients involving a subscription to weekly baskets of produce, achieves these aims (Van En, 1995), as do garden allotments and local produce markets in cities.
- Increase the production of animal feed on the farm or in its vicinity.
- Develop sustainable energy systems to replace fossil energy sources. For example, irrigation and some farm machinery could use solar or wind power instead of fossil fuels.
- Reduce the amount of meat consumed worldwide, since vegetarian options require far less energy to produce than meat.
- Introduce sustainable practices for large-scale commercial livestock production. An example is by increasing the growth rate in beef cattle, resulting in significant declines in land, water, fossil fuels and feed consumption, as well as less waste outputs (manure and GHG).
- Develop biofuel production from waste, by-products or feedstock instead of using food crops for biofuels (UNEP-GRID, 2009).
- Implement a certification scheme for sustainable production and good practices to reduce energy use.
- Introduce a combination of regulatory instruments, incentives and public–private initiatives that would help to reduce fossil fuel inputs in agriculture (Alemany and Lanzilotta, 2011).

States (Viglizzo et al., 2011). In another example, various Brazilian organizations unified criteria and efforts to develop the Integrated Crop–Livestock-Zero-Tillage System (ICLZT). Integrating crop rotation, livestock production and zero-tillage in the Brazilian Cerrado resulted in sustainable grain and meat production on the same lands using less fertilizer and herbicides and without requiring further deforestation (in addition to less soil erosion, improved soil biological activity and nutrient recycling and lower greenhouse gas emissions) (Landers, 2007). It is urgent to replicate actions such as these, since it will take time to develop and implement energy savings in the farming sector on a scale that will have a global impact.

Injecting liquid fertilizer into a drip irrigation mainline

Acknowledgment

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