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Thematic Focus: Resource Efficiency

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

Tom Marshall, K2D2vaca-Flickr

Why is this issue 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 2 000 litres per year in oil equivalents are required to supply food for each American, which accounts for about 19 per cent of the total energy used in the United States (Pimentel and others 2008).

Truck being loaded to transport agricultural produce. Photo: Bengal Foam/Flickr

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 (Wood and others 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) (Figure 1).

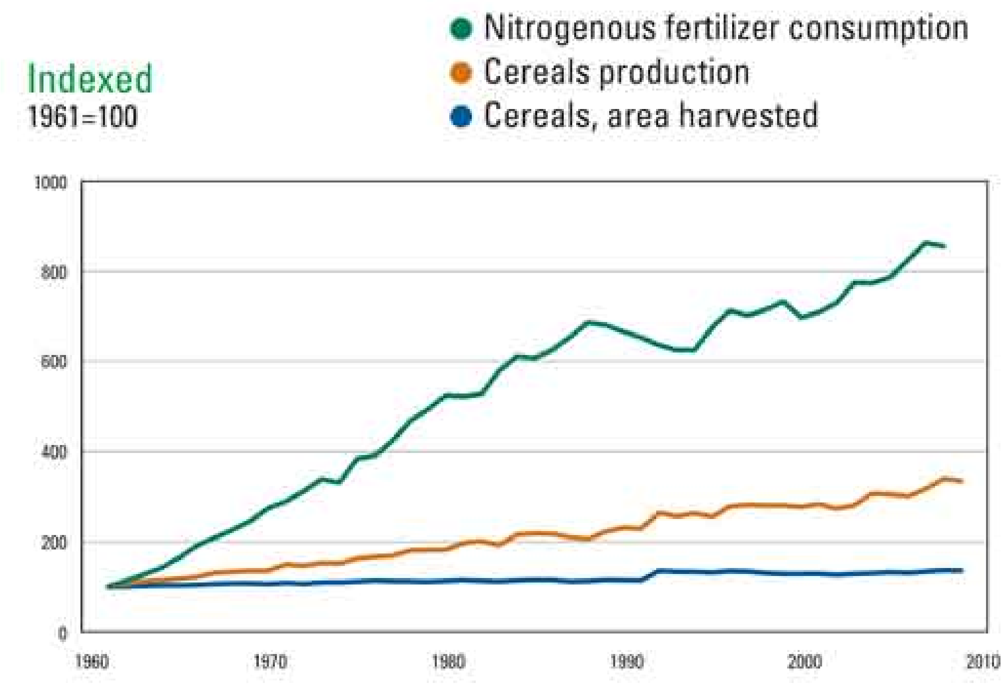

Figure 1: The global growth of fertilizer use and cereal production, 1960-2010. Source: UNEP 2011

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

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

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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) (Figure 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 per cent 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 water demands and so compete with food production (Amigun and others 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).

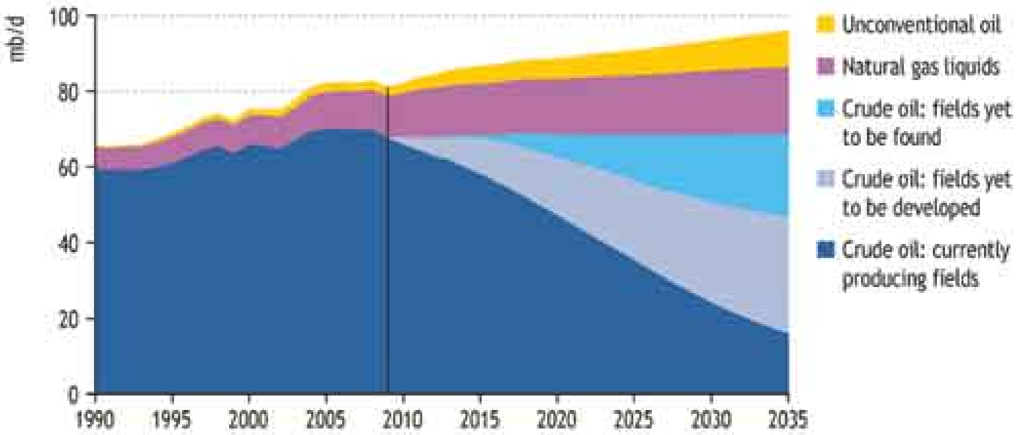

Figure 3: Conventional oil production reached a plateau in 2006. Source: IEA 2010

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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 per cent 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).

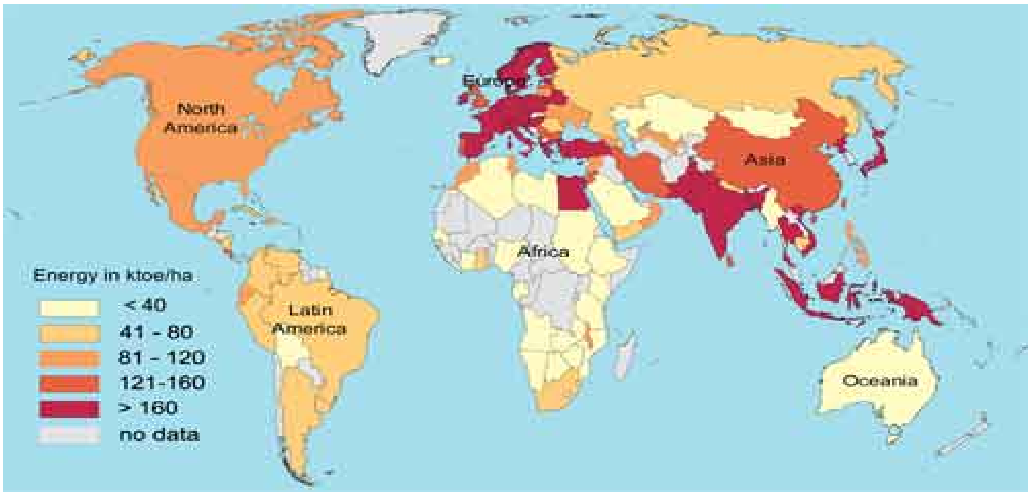

Figure 4: Energy used for agricultural production in kilo tonnes of oil equivalent per hectare (ktoe/ha). Source: FAOSTAT 2011. Visualisation by UNEP GRID-Geneva

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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 (Figure 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 and others 2011). The prices of basic food commodities (cereals, oils and fats, meat, sugar and dairy products) have been rising in the last few years.

Tractors and trucks bringing water melons to the consumers. Photo: Adam Cohn/Flickr

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 (Figure 5) (OECD FAO 2010).

Food price on the rise. Photo: Walmart Stores/Flickr

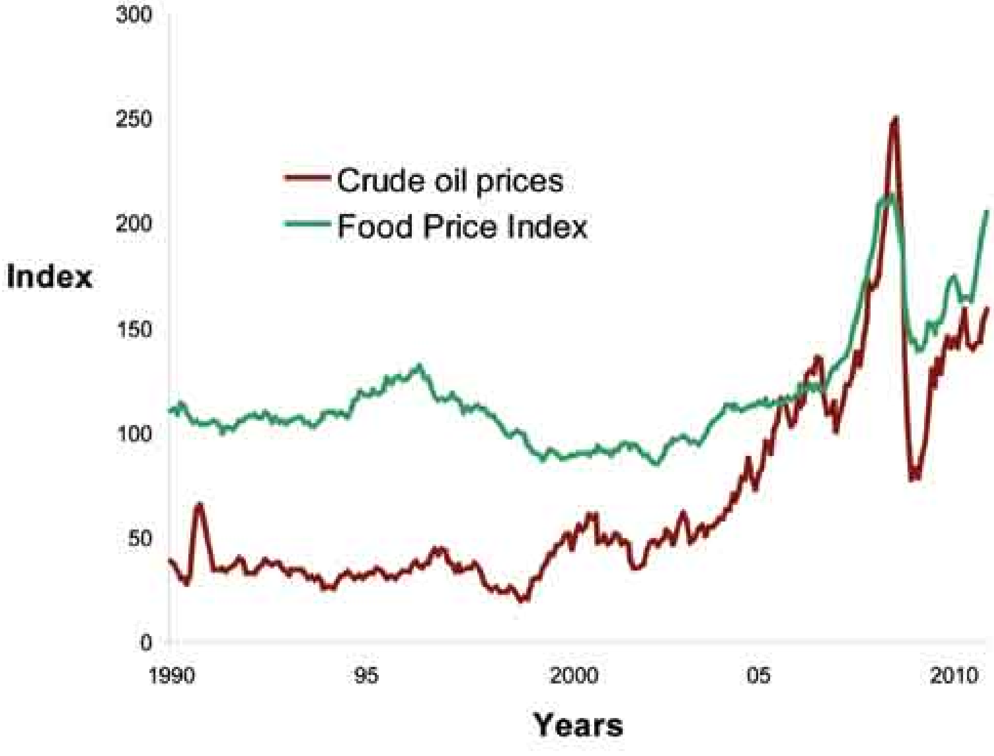

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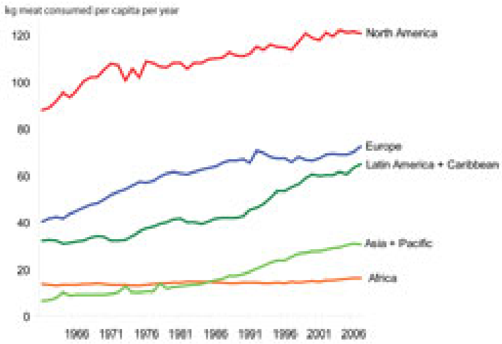
Figure 5: The price of food is highly dependent on the price of oil. Source: FAO 2011; and Mundi Index 2011

Factors that influence fossil fuel use in agriculture

Agricultural methods: In general, the industrialisation 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.

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 hectares 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 and others 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 (Figure 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, industrialised 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 (Figure 6). Global meat production and consumption is increasing and is expected to rise by 70 per cent between 2000 and 2030 and by 120 per cent in the period between 2000 and 2050. This growth is a major cause of rising fertilizer use (IAASTD 2009).



Trend in meat consumption per capita in different regions of the world. Source: UNEP Environmental Data Explorer n.d.

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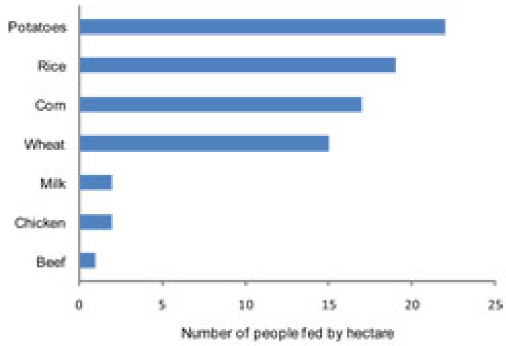

Number of people fed in a year per hectare, by different foods. Source: Horne and McDermott 2001

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Figure 6: Meat consumption per capita and number of people fed per year on different foods, by hectare

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 and others 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.

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 globalised, food products are increasingly imported and exported and distances between producers and consumers have increased. By one estimate, food travels an average of 2,400 km in the United States before being consumed (Pimentel and others 2008). Thus, agriculture's dependence on fossil fuels has strengthened (Garnett 2003).

Transformation and packaging: In developed countries, 40 per cent 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 and others 2010).

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).

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 (eg,. smaller tractors, less and lighter farm equipment, reduced use of machinery, less irrigation)
- Apply sustainable tillage practices that minimise 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 labour 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).

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 States (Viglizzo and others 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
Photo: graibeard/Flickr

Acknowledgment

Written by: Ruth Harding[a], Pascal Peduzzi[b]

Production and Outreach Team: Arshia Chander[c], Bruce Pengra[c], Erick Litswa[d], Kim Giese[c], Michelle Anthony[c], Reza Hussain[c], Theuri Mwangi[d]

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([a] Consultant, [b] UNEP GRID Geneva, [c] UNEP GRID Sioux Falls, [d] UNEP Nairobi, [e] UNEP ROLAC)

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