

**Discussion Paper**

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**Agriculture and Trade after the Peak Oil**

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**About the EcoFair Trade Dialogue:**

The EcoFair Trade Dialogue is a project carried out by the Heinrich Boell Foundation, MISEREOR and the Prague Global Policy Institute (Glopolis). It aims at promoting a framework to organize international agricultural trade in a socially and ecologically sustainable way.

The main outcome of a two years first phase of the project was the report “Slow Trade – Sound Farming. A Multilateral Framework for Sustainable Markets in Agriculture” (2007), which emerged from an extensive consultation and exchange process that took place across all continents. This discussion paper is one out of several “implementation papers” that are based on the perspectives and proposals contained in the “Slow Trade – Sound Farming” report.

[www.ecofair-trade.org](http://www.ecofair-trade.org)

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## List of abbreviations

COMESA	The Common Market for Eastern and Southern Africa
FAO	Food and Agriculture Organization
FDI	Foreign Direct Investment
GHG	Greenhouse gas
k cal	kilo calorie
MERCUSOR	Trade pact between Argentina, Brazil, Paraguay, Uruguay, Venezuela, Ecuador, Chile, Bolivia, Peru, and Columbia
NAFTA	North American Free Trade Agreement
OECD	Organization for Economic Co-operation and Development
RTA	Regional Trade Agreement
UNEP	United Nations Environment Programme

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## Executive Summary

Peak oil – a peak in global oil production when a significant proportion of recoverable resources has been produced – will induce several changes in the way we produce and distribute agricultural commodities, especially food. How will the current excessive and wasteful dependence of agriculture on fossil fuels be affected once oil becomes expensive and supplies decline?

The purpose of the EcoFair Trade Dialogue is to promote a framework for agricultural trade that is ecologically and socially just and sustainable. The objective of this discussion paper is to offer decision-makers and citizens a synthesis of existing information on likely changes in the agri-food systems once oil becomes expensive and scarce. The paper highlights the fossil-fuel dependence in existing agricultural production and distribution systems as part of a larger and highly unsustainable structural problem in the global economy.

Peak oil portends a world that will aggressively increase current levels of fossil-fuel consumption, unemployment, hunger, and environmental degradation – all in the name of producing more food to feed hungry populations in developing countries. This dependence is part of a larger structural problem, of a comparative advantage in access and use of cheap energy (oil). In agriculture, this structural problem manifests itself in the increasing homogenization of agriculture as well as in the industrial substitution and appropriation of the sector, most specifically its chemical- and mechanical-energy components. A classification of agriculture by extent and nature of conversion of the three components of energy in agri-food systems – i.e., the biological, mechanical, and chemical components – presents three types: low, medium, and high energy-consuming agri-food systems. Energy-efficiency decreases, the number of energy transformations (and wastage), and the industrial ownership of energy and agricultural operations increase as we move from Type 1 (farms that use no oil and produce 4–10 kilo calories (k cal) of energy in food for every k cal energy used), to Type 2 (the state-subsidized and controlled green revolution), and Type 3 (large industrial agriculture that derives 90 percent or more of energy from oil and uses 10–20 k cal of energy to produce 1 k cal of food). It is the latter that contributes the most to energy-intensive livestock production and trade, increasing export subsidies and the share of processed foods in global agricultural trade. Among the key actors in the food-fuel complex, the most important ones making decisions about energy supply and use are

governments and industry. The environmental integrity and democratic sovereignty of nation-states that are dependent on energy-intensive and increasingly expensive food imports are being undermined by a few food exporting countries and a few transnational corporations that channel this trade.

Peak oil price-impacts will be most severe in Type 3: fossil-fuel-dependent industrial agriculture. Yet, the impacts on Type 2 (green revolution) systems and Type 3 (corporate-controlled industrial agriculture) will be softened by aggressive state support. Little is available within nation-states or globally to promote the strengths of Type 1 (energy-efficient, small peasant) agri-food systems. The latter, part of the rural poor whose access to food will be affected severely by peak-oil-induced changes in distribution, will suffer economic and ecological disruption. Many studies show that as freight becomes expensive, access to food will reduce – particularly for the poorest in developing countries – along with worsening impacts on regional trade, increasing investments in transport and storage facilities. This will lead to an increase in intra-and inter-regional inequalities. Overall, agricultural production and trade will enter an economic, social, and ecological downward spiral with developing and developed countries and corporate sector investing in industrial agriculture.

Though many alternatives – biofuels, organic agriculture, renewable energy, and other technological alternatives – are available, they will be economically and ecologically sustainable only when accompanied by other changes like support for local food systems, reduction of barriers to regional trade, and similar policy-induced systemic changes. In conclusion, the paper asks if politically and ecologically agri-food systems and energy use are possible. The twin crises of persistent poverty and climate change make it imperative that the role of energy and the macroeconomic logic of agricultural production and distribution be analyzed with due attention to the relationships between agriculture, industry, and the environment.

The increase in economic distress and environmental degradation post-peak oil will force decision-makers to confront fossil-fuel-dependent agriculture as the outcome of a grossly unjust and imbalanced political economy where agriculture has become a net energy user, though it is the primary source of all energy (including fossil fuels, utilized by plants via the sun for millions of years) on earth. Alternatives in agricultural production and distribution that draw upon other sources of energy and can feed people and provide for agro-industries can become sustainable only if two crucial structural issues are confronted

and addressed. These are the industrial appropriation and substitution of agriculture and the reductionist monetary valuation of energy and the environment.

Theoretically, institutional and evolutionary economics as well as political geography offer the tools to address these structural issues. Governments and civil society organizations with rooted, locally accountable capital, must take up alternatives like organic agriculture in local or community food systems. Also, experiments such as a tax on every additional energy transformation in each food item, increasing and enhancing the value of agricultural labor (mechanical energy) in farming – especially female workforce participation in agriculture – and increasing information and data on government and industry functions in agriculture must be attempted, with outcomes measured not just as yield per hectare but as multiple gains from agriculture, ranging from employment to better nutrition and healthy ecosystems. If there is a willingness to change, peak oil and climate change might turn out to be blessings by encouraging pluralism in the ideology and practice of agricultural production and distribution, acknowledging and fostering the multifunctionality of agriculture. This consciousness can start a de-homogenization of agri-food systems, and build local capacities for food-security decision-making. All these suggestions echo the EcoFair recommendations for democratizing the food chain, investing in multifunctionality, setting local and sustainable standards, and redressing asymmetries in global and national agri-food systems.

# **Agriculture and Trade after the Peak Oil**

## **1. The iron-grip of oil**

These are critical times, times when decision-makers and ordinary citizens confront the collective economic, environmental, and social burdens that past development choices have imposed on us. This EcoFair Trade Discussion Paper focuses on the possible impacts of peak oil on agricultural production and trade. Peak oil – a peak in global production when a significant proportion of recoverable resources has been produced – was first mooted by M. King Hubbert in 1956. Logistics curve estimates of peak oil by various researchers suggest the peak occurring in 1996, 2000, 2020, 2025; despite these differences in dates, the reality of peak oil must be confronted.

The heavy dependence of agriculture on oil and other fossil fuels like natural gas and coal has resulted in higher production and productivity. But today, over a billion people on earth are hungry and over 3 billion malnourished, especially in developing and least-developed countries, which derive about 20 to 80 percent of their national incomes from agriculture and yet have to buy or beg for food on the international market. Moreover, innumerable cases of agriculture-induced ecosystem degradation, some of it irreversible, are being reported every day. Agriculture contributes about 10 to 14 percent of global anthropogenic greenhouse gas (GHG) emissions and is an icon of the unequal access to energy. Every year, the agri-food sector in the United States uses more energy than all of France does!

The purpose of the EcoFair Trade Dialogue is to promote a framework for agricultural trade that is ecologically and socially just and sustainable. This discussion paper stems from the acknowledgment that agriculture will change drastically once oil and natural gas supplies start to decline. The objective is to offer decision-makers and citizens an opportunity to reflect on the significance of energy (fossil fuels) in agricultural production and distribution. We need to acknowledge that trade – including the current emissions-trade fetish – is a solution to global economic, social, and environmental problems if, and only if, it is accompanied by some fundamental structural changes in agri-food systems and in the relationship between agriculture, industry, and the environment.

Agriculture is a biological process that utilizes solar energy and makes it available for other production processes. Though food is not to be reduced to its energy equivalent, agriculture produces the energy required for the application of human labor to its own and other production processes. Historically, human evolution from hunter-gatherer to cultivator

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marks a major shift in global energy use, where the biological process of utilizing solar energy is supported by physical or mechanical energy supplied by human beings. Later, other sources of energy like fossil fuels that human beings extracted are added to enhance agricultural production and to further its distribution. Availability and access to fossil fuels now allows for repeated transformation of food to feed and animal protein and also for long-distance transportation, processing, storage, and marketing of food and other commodities. Despite oil becoming more expensive and being counted as a major polluter, agriculture now uses more of it to collapse millions of years of nature's work into one crop season to produce biofuels. From being the world's largest energy producer, agriculture is now a net energy consumer, whether it is to produce food and other bio-materials or to produce more biofuels. This is a fundamental energy and economic imbalance – wasteful, polluting, unsustainable, and unfair.

This discussion paper begins with a brief introduction to fossil-fuel dependence in agriculture. This dependence is part of a larger structural problem, of a comparative advantage in access and use of cheap energy (oil), selective perception of environmental costs, and deceptive accounting of energy flows. Section 2 presents the key actors in the food-fuel complex and a classification of agriculture by extent and nature of energy use. The three components of energy in agri-food systems – i.e., the biological, mechanical, and chemical components and the efficiency of these energy inputs are used to classify existing agricultural production and distribution systems into three types: low, medium, and high energy-consuming agri-food systems (Types 1, 2, and 3). Section 3 presents the peak oil price-impacts on agricultural production and distribution, which will be most severe in Type 3: the energy-intensive industrial agriculture. While the impacts on Type 2 (green revolution) systems and Type 3 (industrial agriculture) will be softened by aggressive state support, little is available within nation-states or globally to promote the strengths of Type 1 (energy-efficient, small peasant) agri-food systems. The latter – part of the rural poor whose access to food will be affected severely by peak-oil-induced changes in distribution – will suffer though their production systems are the most energy-efficient. Section 4 explores alternatives – especially to Type 2 and Type 3 energy-guzzling, highly subsidized production systems and trade. Biofuels, organic agriculture, and other technological alternatives, as well as new policy mechanisms to promote regional trade, will be sustainable in the peak oil scenario if accompanied by macro policy goals to reduce consumption and promote local, sustainable food-energy systems. Prometheus I, marked by the wood age, ended some time ago in many parts of the world; Prometheus II of coal, oil,

and other fossil fuels is now at a peak. Will there be a Prometheus III? (Georgescu-Roegen 1986). Will that be biofuels, hydrogen cells, or a new planet to inhabit? Or will human beings learn the basics of entropy, and energy use and availability through agriculture? Will there be a new political order that respects fundamental energy flows, people's right to food, and ecological values?

In conclusion, section 5 asks if a political reconsideration of energy creation and use in agri-food systems is possible. Fossil-fuel dependence is a structural problem where industrial agriculture and trade is legitimized in the name of millions of hungry mouths to be fed, where the macroeconomic logic of global trade demands that unemployment (waste of human energy), poverty, and hunger in certain pockets of the world have to be maintained in order to subsidize the wasteful energy use and economic growth of the developed countries and select regions in developing countries. Concerted thinking and socially and ecologically responsible action to seek alternative frameworks for agricultural production, distribution, and consumption is the need of the hour, given the crises of climate change impacts and persistent global poverty, hunger, and environmental degradation.

#### 1.a. Oil in agriculture and food

This brief introductory section lays out the relationships between agriculture and fossil fuels, evident in the production and distribution of agricultural commodities – especially food, feed, and energy.

Many would argue that the jury is still out on the very phenomenon called “peak oil.”<sup>1</sup> The fact that there are several potential peaks (oil, gas, coal, and uranium in energy; and phosphorus in agricultural inputs) to confront in the immediate and slightly distant future makes peak oil an even greater reality (Heinberg 2007; PCI 2009). Yet, the sense of urgency to confront the issues, to learn more, to take action, and to increase peak oil awareness among people – evident among political leaders in 2008 (when oil prices shot up) – seems to have plummeted in 2009 (when oil prices fell). But market behavior, when faced with material scarcity, warns us that price volatility is an important signal of an existing or approaching peak.

Fossil fuels account for 86 percent of global power consumption, and the consumption of fossil fuels as well as other primary energy sources has grown by 40 percent globally from 1980 to 2000 (IEA 2009). Globally, the 13 petagrams (billion metric tons) of biomass harvested per annum as biomass (food, feed, energy, other bio-materials) equals about 240

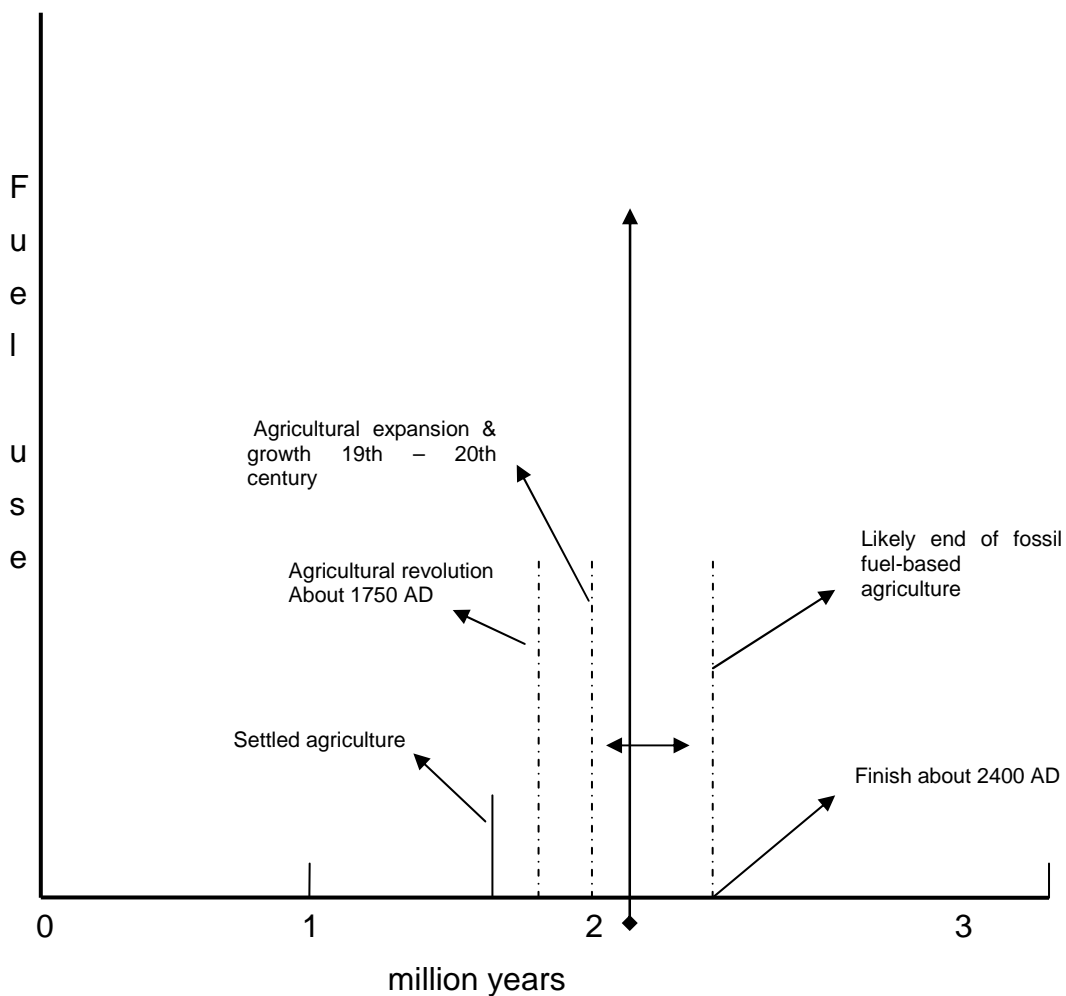
exajoules, or 5.7 billion metric tons oil equivalents, which is close to the amount of fossil fuels used per annum (about 390 exajoules) in energy terms (Wirsenius 2007). Fewer than 2 billion people in the developed countries use 70 percent of global fossil energy annually, while over 4 billion in the developing countries live on less than 30 percent (Pimentel 2009).

Among the global uses of fossil fuels (coal, oil, natural gas, etc.), agriculture accounts for very little, but its dependence on fossil fuels today is higher than it ever has been before (Pimentel and Pimentel 1979, 2008; Giampietro 2009; Roberts 2008; Sachs and Santarius 2007). Ranging from the production of agricultural inputs to almost all farm operations and on to long-distance transport of food across continents, fossil fuels have become an integral component of agri-food systems. The “total energy per person used in the food system in the United States is 500 gallons of oil equivalents,” second only to the amount of fuel used per person in automobiles in the country (Pimentel and Pimentel 2008); in the food system in the United Kingdom, each individual uses 19.8 barrels of oil per annum (Lucas et al. 2007).

Whether located in developing or developed countries, industrial agriculture has become part of a global urban culture: a demand for convenience foods that cook fast and are ready to serve. This increasing service-sector and manufacturing-sector involvement in the food value chain does not add anything in terms of nutrition but does add to energy consumption, urbanized lifestyles, and profits. Urban food systems demand long hauls, processing, storage, refrigeration, etc. – conveniences demanded by urban consumers and delivered by the agri-food industry using anywhere between 10 and 20 calories of energy for 1 calorie of food (Giampietro 2009; Murray 2005; Tomczak 2005; Pirog et al. 2001; USDA 2005). Food production and supply in the United Kingdom accounts for 21 percent of its total energy use (Lucas et al. 2007). The spatial dimension of food systems becomes evident in the share of this chemical-energy equivalent for producing the food and processing it (34%) and transporting it to the consumers (18.5%). It is estimated that 20 percent of the fossil fuels used in the United States goes into its agri-food system, of which only 20 percent goes into production. The rest goes into packaging, processing, and refrigerating food (23%) and transportation of outputs and inputs (all using fossil fuels). In the United States, long-distance food transportation is a luxury, using up immense quantities of oil, that provides “fresh” produce and seafood from exotic places at any time of year (Gever et al. 1991; Pimentel et al. 2009).

Fossil-fuel dependence is not uniform globally. Marked by the least biodiversity and highest fossil-fuel consumption, from industrial food grain production (concentrated mainly in the developed countries and pockets of capital-intensive production systems in developing countries) – with over 183 countries importing food from five major food exporters (FAO 2008a) – survives because of international trade. The European Union and the North American Free Trade Agreement (NAFTA) together account for over 55 percent of global agricultural trade (agricultural exports from this region account for \$397 billion out of a total of \$687 billion globally, as of 2005), and almost 50 percent of this is traded among members of this region (Korinek and Melatos 2009), with an increasing share of processed and intermediary goods. Together, the region also accounts for over 80 percent of global export subsidies.

Figure 1: The epoch of fossil-fuel-based agriculture in the history of man on earth



Source: Adapted from Fig 2.1 Pimentel and Pimentel (1979, p. 17). For illustration, the scale from settled agriculture to end of oil has been exaggerated.

Export subsidies account for colossal wastage of energy in the name of enhancing international trade. The dairy industry (milk and milk products), which accounts for almost half of global export subsidies (USDA 2006b; Pimentel and Pimentel 2008), is among the worst in energy conversion and efficiency. High export subsidies result in bizarre trade regimes such as in the United Kingdom, where 4,400 tons of ice cream is exported to Italy and 4,200 tons imported from there annually; or 22,000 tons of potatoes imported from Egypt and 27,000 tons exported! (as quoted in Nef 2009). Given current fuel prices, it is meaningless to ask at which point the fuel costs for these exports and imports will make this trade economically unviable – it already is.

### 1.b. Peak oil and agrarian structure

Oil is a primary energy source (considering that secondary sources like electricity are generated from oil, which has stored energy from the sun, primarily captured by plants). Besides being the most convenient and multi-purpose of all fossil fuels and a part of almost all production investments, technologies, and policies, oil has the largest infrastructure built the world over. Being “thicker than blood and water,” marked by “graft, autocratic thuggery, and the most grotesque exercise of imperial power” (Watts 2003, Ghosh, 1992), and the chief resource that runs the global food production and distribution regime (McMichael 2009), it has now a strangulating grip on agriculture – the most basic of all production processes on earth. It is perplexing for national governments and the oil industry to consider a world without oil – especially agriculture without oil. They must confront the legacy of economics and political thought that has gone into planning for, extracting, investing, and using oil. The latter is all the more striking because the current forms of fossil-fuel-guzzling agricultural production and distribution systems are pretty recent in the history of humankind and of agriculture (see Figure 1 above).

Starting in the 1950s (the immediate post-war era) when the Marshall Plan successfully de-peasantized, modernized the agricultural production system, and provided surplus labor and capital for industrial growth in Europe, there was a concerted attempt to “transform traditional agriculture” using modern inputs, technologies, and market knowledge. Population rhetoric, along with the marriage of mega-technology with huge farms (economies of scale), was a major legitimization for macroeconomic policies, food production strategies, and choice of policy instruments globally, particularly in the developing countries. Policy goals oriented to production increase and instruments such as subsidies or R&D organizations (public and private) that cater to energy-intensive production soon became irreplaceable features of modern agriculture. Most crucially, this

was accompanied by the demand for increased trade, mainly in the form of food (as aid and for commercial sale) and manufactured goods imported by developing and least-developed countries. These were all exported by (heavily subsidized) production systems of developed countries, which had built a comparative advantage in access to and use of cheap energy (oil) for agricultural production and distribution by the 1950s. The international exchange of agricultural products in terms that were increasingly unfavorable to developing countries and to their agricultural exports was thus a necessary condition to maintain manufacturing-sector growth (surplus accumulated and labor made available).<sup>2</sup>

There is indeed a direct and significant relationship between energy use and crop productivity (Pimentel and Pimentel 2008), measured as grain yield per unit of land. Fossil-fuel use in industrial agriculture, which has increased by over 40 percent (1980–2005), did lead to increased crop production by over 250 percent. But, going by the increasing number of hungry and malnourished people in the world (FAO 2006), increased production does not have much impact on access to food. The 323 million tons of food grains used as livestock (feed that can feed 1 billion people) (Pimentel and Pimentel 2008), the role of surplus labor and surplus agricultural output in enhancing industrialization, and the concentration of corporate power in agriculture and industry must be discussed as issues directly related to livelihoods, poverty, and hunger (Davis 2006; Patel 2007; McMichael 2009). The role of knowledge and policies designed to cater to trade, production successes and accompanying social and ecological consequences, was acknowledged and assessed by the International Assessment of Agricultural Knowledge Science and Technology for Development (see IAASTD, 2009), supported by the Food and Agriculture Organization (FAO), the United Nations Environment Programme (UNEP), the World Bank, several governments, civil society organizations and socially responsible industry. Yet, the population rhetoric (of millions of hungry people to feed) of the 1960s and 1970s still holds sway<sup>3</sup> (Pimentel and Pimentel 2008; FAO 2005) despite the evidence about wasteful energy and input use in agriculture.

The paradigm of industrial agriculture goes against the empirical evidence about the productivity and high energy-efficiency of small farms (Pretty 1995; IAASTD 2009; Ong'wen and Wright 2007). Increasing fossil-fuel use has made agriculture – the fundamental source of energy for human beings – one of the worst polluters of the atmosphere (CO<sub>2</sub>, CH<sub>4</sub>, and NO<sub>x</sub> emissions), soil, and water systems (nitrates, phosphorus, and several toxic chemicals). Value addition – by processing, storing, marketing, and transporting food across the globe – is sustainable only because energy and labor that feed

into agribusiness and other industries are cheap to maintain (Pimentel and Pimentel 2008; IATP 2008).

The continuing diversion of scarce land, water, nutrients (like phosphorous, an impending peak), and heavy subsidies to biofuel production and worsening the current food crisis (FAO 2008a; Practical Action Consulting 2008; Vaccari 2009; Pimentel et al. 2009) reflects the prevailing worldview that agriculture, peasants, and rural labor are all mere facilitators (as inputs and preconditions) for industrial and service sector growth. Food for hungry populations, energy efficient production systems and sustainable environments are not central concerns.

Given the ways in which modern agri-food systems use fossil fuels, it is apparent that both agricultural production and distribution are part of a larger food-fuel complex, controlled by certain actors and the political-economic legitimizations they present. Even the biological component of agricultural energy use (the crop varieties or genetic material), is now designed to fit into industrial chemical-energy components (weedicides or pesticides)<sup>4</sup>. Given that energy-intensive monocultures (like palm oil and sugar) and industrial meat production are eligible for C credits, it is obvious that decision-makers are fighting shy of the energy equations and control regimes that underpin current emissions and pollution from agriculture. This trade in pollution defies all definitions and cognizance of energy flows and environmental issues!

## **2. Energy use in agri-food systems – actors and types**

This section presents the main actors involved in energy decisions in agriculture, and a classification of agri-food systems by the extent of energy use and output, with corresponding changes in the biological-, physical-, and chemical-energy components of each system. Given the amount of energy transformation involved, modern agri-food systems can no longer be categorized into one or another type by a simple measure of units of energy use, by sources of energy (fossil fuel, biofuels, renewable energy systems, etc.), or by the nature (direct or indirect) of energy use.<sup>5</sup>

Farmers, national governments (and their policies), industry, international monetary and development agencies, and consumers have different stakes in fossil-fuel-intensive industrial agriculture. Though farmers are the ultimate decision-makers about energy use on each farm, farmers themselves are no longer the chief actors in today's agri-food systems. Our current food-fuel complex is rigged with various parallel and intersecting relationships among a dwindling number of actors.<sup>6</sup> Decisions, especially about the

chemical- and mechanical-energy components in agriculture, are increasingly made by national governments. Despite contrary reportage, high-energy industrial agriculture is like the green revolution production systems, which are highly subsidized and supported by governments (Patel 2007; Pimentel and Pimentel 2008; McMichael 2009; Sachs and Santarius 2007; Lucas et al. 2007). Recent G-20 deliberations reveal the commitment to increasing export subsidies in developed countries – perhaps the expected knee-jerk reaction to emerging oil supply and price scenarios. There is little evidence of the ability of governments to control or regulate food-price increases, increases in the share of agricultural commodities traded in commodity futures, or any of the highly speculative market practices that resulted in the 2008 food crises and riots (IATP 2008).

Industry gains significantly from subsidies whether for production (fertilizers) or export (dairy). Increasingly, global food production and distribution is concentrated among a few key corporate sector actors.<sup>7</sup> This concentration – also depicted as the narrow bottleneck between the producers and consumers of food in the agri-food industry – is an indicator of market power as well as of energy intensity per unit of food produced and distributed, without adding anything to the calorific or nutritional value of food (Hendrickson and Heffernan 2007; Pirog and Benjamin 2005; Pimentel and Pimentel 2008, Lucas et al. 2007; Sachs and Santarius 2007).

The role of international actors depends on the political economy of oil-importing and oil-exporting states as well as food-importing and exporting states. Multinational agribusiness actors, international legal and monetary agencies, and now (in increasing numbers and strength) investment bankers and commodity markets promoting food as a high-returns, low-risk investment, are important players in agriculture, wielding considerable influence on market behavior as well as on policy decisions made by governments (WCSDG, 2004; Tansey and Rajotte, 2008; IAASTD 2009).

Consumers with increasing per capita incomes have changed trade in agriculture and agri-food systems. In the 2000s, the share of bulk commodities have been reduced (down to less than 30 percent of global agricultural trade) with a corresponding increase in processed food and intermediary products (Gehlhar and Coyle 2001; IATP 2008). Globally, industrial agriculture legitimizes its energy use in the name of the 1 billion poor hungry people, but caters to the preferences and convenience of increasingly affluent and environmentally indifferent consumers. The spatial or physical distance between producers and consumers, and the increasing post-harvest cost of food (more than 80 percent of food prices)

characteristic of industrial societies, is now being imitated in some metropolitan centers in developing countries, subsidized heavily by national governments (Giampietro 2009).

Consumers have also been at the forefront of community food systems, designing and organizing low-energy-use food production and distribution systems for their localities; they demand food sovereignty as the right of peoples and sovereign states to democratically determine their own agricultural and food policies (Ho et al. 2008; IAASTD 2009). But their voices are ignored in the international food-fuel complex, transcending conventional developed- and developing-country distinctions, that has its strongholds within global (rule-making) organizations and systems, national governments, corporate actors, and at least two or three generations of farmers who, having depended excessively on state/corporate controls, have become deskilled and alienated from their land, water, and local labor systems.

**Table 1: Agri-food systems classified by energy components**

<b>Energy components/ Range of energy use</b>	<b>Biological</b>	<b>Mechanical</b>	<b>Chemical</b>
<p><b>Type 1</b></p> <p>1 calorie produces 4–10 calories of food.</p> <p>Agriculture accounts for 60–80% of all energy use in society.</p> <p>80–90% of energy use in agriculture is deployed for production.</p>	<p>Farm-based or local planting material, bio-control agents. Subsistence or local market commodities.</p> <p>At least 35% of energy inputs in production.</p>	<p>Family or local labor + some draught power.</p> <p>Transportation minimal. Minimal infrastructure.</p> <p>40–60% of energy inputs in production.</p>	<p>Farm-sourced compost, crop rotation, vermi-compost, local rhizobial cultures, traditional pest management practices, location and culture-specific preservation and storage.</p> <p>No fossil fuel.</p> <p>At most 20% of total energy inputs in production.</p>
<p><b>Type 2</b></p> <p>1 calorie produces 2–5 calories or less.</p> <p>Agriculture accounts for 30–50% of energy use in society.</p> <p>60–80% of energy use in agriculture is used for production.</p> <p>20–40% of energy use in agriculture is used for processing, transport, storage, and distribution.</p>	<p>Informal, unregulated planting material exchange and seed market.</p> <p>Public and private sector firms supply improved, hybrid, and genetically engineered varieties that respond to chemicals.</p> <p>About 20% of energy inputs in production.</p>	<p>Mixture of machine, animal, and human power.</p> <p>Input &amp; produce transport from and to distant markets.</p> <p>Agro-processing.</p> <p>Energy to access water and chemical inputs.</p> <p>Between 20–50% of energy inputs in production.</p>	<p>Energy inputs in chemical fertilizers, pesticides, weedicides, application equipment, processing and storage, and transportation.</p> <p>Fossil fuels account for over 60% of energy in agriculture.</p> <p>About 40% of agricultural production energy used for production of fertilizers &amp; pesticides.</p>

<p><b>Type 3</b></p> <p>1 calorie produces 1/10th –1/20th of a calorie.</p> <p>35 k cal to produce 1 k cal of animal protein (beef).</p> <p>Agriculture accounts for 10–30% of total energy use in society.</p> <p>Production accounts for 20 % of total energy use in agriculture.</p> <p>Transport, processing, packaging, storing, retailing accounts for 80 % of total energy use in agri-food systems.</p>	<p>Private sector/ industry-bred or designed, produced, marketed, and protected planting material or genetic stock.</p> <p>Chemical-specific crop choices (Round-up Ready varieties) and modified crops for producing biofuels (more chemical energy).</p> <p>5–10% of energy inputs in production.</p>	<p>Vertically integrated mechanical operations with minimal human energy and no draught power.</p> <p>Completely mechanized industrial operations.</p> <p>Specific infrastructure and energy systems for transport, storage, processing, packaging, and marketing.</p> <p>At most 20–25% of energy use in agricultural production, and about 40% of energy use in processing, packaging, retailing.</p>	<p>Energy inputs in fertilizers and other chemical inputs – pesticides, weedicides, growth regulators, hormones, therapeutics, product homogenizers, preservatives (especially in perishable produce).</p> <p>Fuel for mechanical operations, and long-distance transportation of inputs and outputs.</p> <p>Fossil fuels account for over 85% of energy in agricultural production and distribution.</p>
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*Source: Compiled and synthesized from Pimentel and Pimentel 2008; Giampietro and Pimentel 1994; Pfeiffer 2004; Wirseniuss 2007*

Some transnational networks – in several small farmer or peasant movements (say, Via Campesina), environmental movements or coalitions (Pesticide Action Network, Third World Network, etc.), the right to food campaign, and the Slow Food movement – transcend ideological differences, ground themselves in environmental and social values, and account for wasteful energy applications. These networks and alliances seek healthy and sustainable human livelihoods, ecosystems, and societies. Conscientious consumers in affluent societies are now demanding and willing to pay for fair trade and eco-friendly products.

### 2.a. A typology of energy use in agriculture

A typology of production systems by energy-intensity and fossil-fuel dependence is presented here to distinguish between systems that “do not use a drop of oil” to ones whose biological-, chemical-, and physical-energy components are completely oil-dependent and undergo two or three energy transformations without adding any additional energy or value to the final product, but consuming anywhere between 50 to 75 percent of the fossil-fuel

use in that product. This typology (Table 1) is useful for identifying the different energy components, the major stakeholders, and thereby the likely impacts that they will face after peak oil.

Type 1 systems refer to the small peasant farming systems, wherein every k cal of energy used results in the production of 4–10 k cal of energy in the form of food, feed, fibre, or bio-materials consumed locally. Type 2 systems refer to the energy-intensive cereal crop production (green revolution) and are supported by the policies and institutional arrangements put in place by nation-states, whereby every k cal of energy used results in 2–5 k cal of energy output in grain. Type 3 systems refer to the industrial agri-food systems, whereby 10–20 k cal of energy is used to produce 1 k cal of energy as agricultural output; it is the least energy-efficient of the systems but is considered the most productive of all three types of agriculture in terms of grain yield per unit area cultivated. In Type 3 systems, a mere fifth of the total energy used is for production; the rest is for processing, packaging, and transporting food.<sup>8</sup>

Type 1 agriculture, where human labor is the major mechanical-energy input, is the most energy-efficient. If fossil-fuel use includes use of implements in the production process (say, hoe and axe used by labor in corn production in Mexico, yielding 10.7 k cal of corn per k cal of energy expended), then the output of corn per k cal of fossil-fuel energy used is 422 k cal (Pimentel and Pimentel 2008). In Type 2 grain production systems, the ratio of energy output per unit of energy input is 2:1 for wheat and rice, and 5:1 for oats in the United States (*ibid*). Though the grain yield per hectare is much higher than in the developing countries producing the same crop, US agriculture has a much lower output-to-input ratio because much of the human labor used is replaced with fossil fuels. When compared with sorghum production in Sudan, where human labor is the main energy input, producing a calorie output-input ratio of 14.43:1, the fossil-fuel-dependent grain production systems in the United States become worrisome, though grain productivity would be much higher (*ibid*).

Green revolution agriculture (Type 2), using fossil-fuel-based fertilizers, chemicals, and irrigation water withdrawal, uses on average 50–60 times the energy used by traditional agriculture (Pfieffer 2004; Giampietro and Pimentel 1994). In Type 2 systems, inputs directly dependent on fossil fuels are fertilizers and chemicals (their production and supply costs), water (fuel costs for extraction), and mechanization (fuel costs). Globally, fuel accounts for 90 percent of the monetary costs of fertilizer production (Schnepf 2004; Tomczak 2005). Though fertilizer use increased by a factor of 10 from the 1950s up to

1989, the trend since the 1990s has been noteworthy, with India (at 14 million tons of N fertilizer per annum) and China (at 30 million tons) accounting for the highest consumption.<sup>9</sup> While rising natural gas prices led to the shutdown of ammonia plants and reduction in production (two-thirds of the pre-2000 level) in the United States (IEA 2006; Schnepf 2004), India and China recorded increases in production and made renewed commitments to investments in fertilizer production and subsidies, even in the 2008–2009 period, when oil prices went on a rollercoaster ride. Similarly, in several African countries like Malawi (which had previously withdrawn state support for agriculture based on World Bank advice), reintroduction of subsidies has encouraged farmers to use more fertilizer and produce more food.

Given the striking inverse relationship between percentage of population engaged in agriculture and the energy use per person in a country (Pimentel 2001), the type of agricultural production, investment, and other policy decisions are conscious development choices that governments make.<sup>10</sup> Irrespective of the ideological orientation of national governments or transnational agencies and negotiations, the state has ensured investment in and availability and access to fossil fuel or fossil-fuel-based inputs for Type 2 green revolution systems. It is only recently (since the mid-2000s) that governments of developing countries, wary of stagnating productivity growth rates and eager to gain from global trade, have started supporting Type 3 corporate industrial agri-food systems. This is now evident as the global transition to sustainable intensification, the second green revolution being unleashed in Africa, and the call for increasing Foreign Direct Investment (FDI) in agriculture.

In Type 3 production systems, on-farm energy use accounts for a small share (about 18–20% in the UK, US, and other industrial agriculture systems) of total energy use in the product that finally reaches the consumer, and is a part of global decisions made by the corporate suppliers or traders (Pimentel and Pimentel 2008; Smil 2002; Pfieffer 2004; Murray 2005; Church 2005). The increase in fossil-fuel energy use is an approximate indicator of the increase in industrial control over the biological-, mechanical-, and chemical-energy components in the agri-food system.

The nature of ownership of energy components and the number of energy transformations involved distinguish Type 1 from Type 3 production systems. Type 1 agri-food systems are different from Type 2 and Type 3 in that industry has substituted capital inputs for land, labor, and local knowledge – the latter supplied as specific technologies or practices generated in laboratories by scientific personnel, irrespective of the variations in the

environmental and social conditions of the farmer, crop, or livestock involved. Of the solar energy used by crops, 25 percent is used for respiration, 35 percent for structure building, and 35 percent for reproduction or grain production (Pimentel and Pimentel 2008). When this grain becomes animal feed in livestock farms (Type 3, industrial agriculture), 43 percent is used for respiration, 46 percent becomes manure, and 6 percent methane; only 5 percent of the feed energy is retained as animal tissue, of which 1 percent is lost as slaughterhouse byproducts (Wirsenius 2007). The loss is further aggravated by the organization of the livestock industry, where crop residue and byproducts are not used as feed, and animal manure is mere waste, not recycled as farmyard manure.

About 40 percent of the global food grain produce and nearly half of that in the United States is used as livestock feed (Pimentel and Pimentel 2008). If the United States were to export all the food grain currently used as feed, and if the 323 million tons of global grain production annually fed to livestock were used to feed human beings, then the United States would still have more animal protein than the per capita recommended daily allowance and over a billion people now hungry could be fed (ibid; FAO 2008a).

Whether it adds to production or productivity, mechanization is significantly high in the developed countries. Europe and the United States have the highest number of tractors per unit of arable land. While their share of arable land is almost a fifth of the global total, they own almost half the world's tractors (FAO 2005). Argentina, Brazil, and India appear more mechanized than China; but Russia, sub-Saharan Africa, Central America, and the Caribbean are less mechanized. Compared to mechanization, it is the chemical-energy component that is predominant in the Southern countries (Sachs and Santarius 2007; FAO 2005). Type 3 agri-food systems are marked by the capitalization of agricultural inputs, farming methods, and practices, as well as product markets, processing industry, and sale.

The differences in the ownership, access, and use of the biological-, mechanical-, and chemical-energy components in the three types of agri-food systems point to the following:

- (i) an increase in the share of chemical- and mechanical-energy components as agriculture moves from Type 1 to 3;
- (ii) fossil-fuel-based chemical-energy controls over the biological energy components (seed) and mechanical energy (human labor, tools, and machines);
- (iii) energy inefficiency, wastage, and the number of energy transformations increase in Type 2 and Type 3 production and distribution systems;

(iv) industrial ownership and concentration of energy components are absent in Type 1 and highest in Type 3;

(v) national public policy is geared to increasing fossil-fuel supply to agriculture, thereby pushing Type 1 systems into Type 2 or 3.

Though Type 3 systems exist predominantly in developed countries, all three types are found in developed and developing countries. Industry and national governments are the major stakeholders and decision-makers promoting energy-intensive Type 2 and Type 3 agri-food systems. Moreover, government policies and support mechanisms are increasingly shaped by the norms of international trade (Sachs and Santarius 2008). These have largely negative impacts on the survival and sustainability of Type 1 systems and encourage subsidies for energy-guzzling Type 2 and 3 systems. Worse yet, is the current transition from Type 2 to Type 3 systems, with increasing commitments from governments and investors to enable more Type 3 systems.

### **3. Inevitable peak oil – production and distribution impacts**

*“Decoupling the food system from the oil industry is key to improving food security.”*  
(Murray 2005)

The iron grip of oil – an excessive and rather slippery dependence of agriculture on fossil fuels – is alarming. Here, we explore how different agri-food systems will adapt and change after peak oil. Which of the three major energy components (biological, chemical, or mechanical) in agriculture will succumb to the decline in fossil-fuel supply? Which will have the capacity to respond to oil stress and pave the way for economically and environmentally sustainable agri-food systems? This section analyses the price-impacts of peak oil on agricultural production and distribution.

#### **3.a. Price-impacts on production**

Within nation-states, the decision to transmit prices downwards to farms and industrial production or service systems in agriculture is highly dependent on the nature of state investment in agriculture and the political clout of the farm and agribusiness lobby. In industrial societies, given certain expected income levels, even a doubling of energy prices will not lead to a significant reduction in energy use in agriculture (Dvoskin 1976, quoted in Buttel and Youngberg 1982). At best there would be a 5-percent reduction in energy use. But peak oil is likely to have a significant impact when supplies start to decline. Increasing

oil prices driven by an increasing demand for oil is very different from a scarcity-driven (by increasing costs of exploration, extraction, or refining or transportation of oil) price increase (see Desai 1990; Hagman and Tekin 2007). Even a 10-percent decline in the supply of fossil fuels will lead to a drastic change in agricultural production systems – leading to a fall in yields and higher prices for commodities (Dvoskin 1976, quoted in Buttel and Youngberg 1982).

**Type 1 production systems** (as in Table 1), which has the least dependence on fossil fuels or external sources of energy, will experience the lowest impact of oil price increases. For these subsistence agricultural production units or the more advanced ecological agriculture systems or organic agriculture systems, the increase in fossil-fuel prices or a decline in supplies makes no change in the amount of compost, farmyard manure, or other forms of green manure and integrated pest management or non-pesticide management practices (Pimentel and Pimentel 2008; Heinberg 2007; Kimbrell 2002).

Many small farmers will shift their crop choices to low-risk traditional food crops, as they are doing now in India (Chand et al 2007), and in doing so they may move further away from existing input markets. They will bring in many traditional practices, especially pest management practices, which can be scientifically agro-ecologically analyzed and validated to enable low fossil-fuel agri-food systems. As peasant farming or traditional farming is a highly location-specific, diverse (with millions of practitioners), and small-scale operation, it is likely that new forms of organizing knowledge and enabling learning will emerge. Since crop and animal traits that are important to these small farmers (often indigenous farmers in niche ecosystems like mountains, coastal ecosystems, drylands, etc.) are under-researched in formal science and technology systems, very little funding or support will be available for outreach of know-how in these energy-efficient, multifunctional farming systems that are the least fossil-fuel-dependent.<sup>11</sup> But without state support and adequate funding, monitoring, and decentralized agri-food governance systems, the fate of low fossil-fuel farming systems looks bleak. Worsening food security and feminization of rural poverty will become a severe reality in many agrarian systems the world over, minimizing the few achievements in poverty reduction and other Millennium Development Goals (UNDP 2007, 2008; IAASTD 2009).

**Type 2 production systems** will witness increasing state support following peak oil. In developing countries wherein Type 2 state-supported commercial food grain and other cash crop (sugarcane, cotton, soya bean, etc.) production systems prevail, it is likely that states will invest further in the same chemical- and mechanical-energy-intensive production

inputs to ensure that agricultural production and food security are assured. The increasing support to medium and large farms in irrigated food grain tracts will further reduce the scope for and availability of resources to help support (through appropriate infrastructure and services) sustainable Type 1 production by peasants, especially in low chemical-energy, high labor-input (mechanical energy) farming systems in the drylands and mountain ecosystems.

Despite the evidence that an increase in the application of nitrogen and phosphorous cannot be as effective in increasing yields because of diminishing returns ( Roy et al. 2009), or the fact that increasing input use – especially those subsidized by governments – causes severe degradation of land and water systems (IAASTD, 2009; UNEP, 2009), governments will continue to expand the same approach to other areas. Given the oil supply crunch, many governments will consider an expansion of input-intensive production into the drylands and other cropping systems ignored by the green revolution and euphemistically call it a “second green revolution” (Swaminathan 2005; IAASTD 2009). India’s new fertilizer policy shifts from product subsidy to nutrient-based subsidy and from oil-based to natural gas-based ammonia production (Parikh et al. 2009). This may marginally reduce the emissions from fertilizer production, but will increase the consumption of fertilizer, depending on access to water/irrigation, which in turn will be drastically reduced (especially groundwater use) once the energy cost of pumping water increases.

The chemical-energy (fertilizer) component in agri-food systems in the West (the Organization for Economic Co-operation and Development– OECD) goes through several transformations compared to that in the major (Type 2) production systems in developing countries (see 2.a. above). Fertilizer (N) – the basic chemical energy that gets transformed into biological energy (feedstock – corn or soya) and then again into biological (N or protein) energy in the form of meat or milk products in the developed West – will become more expensive and make industrial livestock production systems more expensive as well (Smil 2002). In Southern developing countries, which account for more than half the global fertilizer consumption, N fertilizers will be applied aggressively legitimized by the national food-security concern, as energy required to produce food grains for human consumption.

After the peak, it is likely that mechanization of the kind we know now – diesel-guzzling heavy machinery – will give way to small power tillers, manually operated threshers or planters, rotary hand-operated weeders, etc. Energy-intensive dairy farms in much of South Asia will find water withdrawal too expensive, and there will be a shift toward small ruminants and foraging (wherever common lands or pastures are available). Already, about

60 percent of irrigation in South Asia comes from groundwater, egged on by subsidies – free to low-tariff electricity, diesel price cuts, etc. (IWMI 2007). It is likely that the High Yielding Varieties package for irrigation, fertilizer and machines that characterized the green revolution will be broken when fuel costs prohibit pumping water at current rates (where annual withdrawal is 130–160 percent of recharge). However, this dismembering of the ‘green revolution’ package may help governments view alternatives (especially resource-conserving technologies and energy-efficient small farm systems with high productivity) more favorably, and provide supportive investments for them.

A related and major impact on Type 2 production will be that of supply and access to capital – especially for farmers (investments in land, agro-machinery, water extraction machines: diesel and electric) and the processing industry. Once fuel supply declines and fuel-based technologies become hard to access and use, the credit currently available to farmers from domestic and international banks, co-operatives, and private lenders will become more expensive, commanding higher interest rates. With declining national savings rates (with increasing current account deficits as a consequence of other development investments using expensive fossil fuels) and the recent global financial debacle, the volume of credit available for agriculture will shrink. In response, individual governments will increase the subsidies available to farmers to permit increasing (resource-degrading) input use, and the further deterioration of environmental and food security. In the medium- to long- term, as a major fallout of peak oil, governments will be forced to rethink the nature of subsidies and the role of the state in agriculture as well as the issues of food and environmental security.

**Type 3 production systems** will suffer the most after peak oil, given their significant dependence on oil. Contrary to the narrative of Type 1 (farmers and their production decisions), and Type 2 (the state and the decisions it makes for farmers), Type 3 production systems use markets to convince states (mainly governments of developed countries) to support and subsidize their production and distribution systems. The most recent evidence is the reintroduction of export subsidies to dairy industry in two G-20 countries (OECD, WTO, UNCTAD 2009).

Though Type 3 industrial agriculture belts have marginally increased the efficiency of energy use per unit of land and output (Brown 2008; Schnepf 2004), the pressure to increase energy efficiency will increase post-peak oil (USDA 2006a; Tilman et al. 2002). In terms of on-farm costs, these large energy-intensive farms may show only a marginal response to increasing energy prices by reducing input use or increasing production costs

(Kingwell 2003; FAPRI-MU 2009).<sup>12</sup> Their dependence on non-farm energy sources and industrial ownership of these sources will increase because non-farm (including transport) costs constitute over 80 percent of energy inputs in industrial agriculture.

Many of the price-impacts on agriculture and food are expected to be due to the increase in freight costs. Farmers who will have to pay more for fertilizers, feedstock, and other inputs that are transported to their farms and on (often refrigerated) road and rail transport that takes their produce to markets will bear the brunt of this increase in freight costs. As livestock (especially beef) and dairy products are the most freight-intensive products – involving three to four energy transformations (from chemical (fertilizers) to biological to further biological and mechanical energy) – it is these production units in Type 3 systems that will take the brunt of increasing fuel prices. In the livestock industry, several adjustments will have to be made to reduce the number of energy transformations and also to shift the N-animal protein out of energy-guzzling beef and dairy production to small ruminants – poultry and pork – which are far more energy-efficient proteins to produce in the meat farms (Smil 2002; Sorensen et al. 2006).<sup>13</sup>

Technology and investments that promote the right technological choices will emerge as *the* answer to keep the input-intensive industrial agriculture going (ibid.; Tilman et al. 2002; World Bank 2008; Shattuck and Holt-Giminez 2009). In Type 3 agri-food systems, the knowledge and investment inputs into production will converge to enable greater control and uniformity in production. There will be increased tailoring of biological energy (genetically engineered) components to fit into the chemical- and mechanical-energy inputs that industry has already put in place and can control in the future. International aid will continue to support many such wasteful energy-conversion technologies, all in the name of agricultural productivity and development investments (GM Freeze 2009; Lotter 2008). In the near future – perhaps by 2015, as food prices in the post-peak oil period increase globally – many private players in seed, fertilizer and pesticide manufacturing, and agromachinery industries will become subsidiaries or affiliates of transnational corporations.

As the downward spiral of industrial control, state impotence, international collusion, and environmental degradation continues, and human rights as well as food rights are violated, it is likely that many developing and least-developed countries – with heavy oil-import bills and large numbers of rural on-farm livelihoods to account for – will find alternatives. Government and industry responses to increasing inequality may drive many of these alternatives to Type 3 agri-food systems. But with actors in the civic space and local-rooted capital, many will seek ways that can feed their local populations without input-intensive

industrial production. In addition, climate change-induced vulnerability will make food sovereignty a prime concern in many developing countries; shared perspectives and international agreements and action plans on the right to food and sustainable environments will be accepted under the auspices of the UN.

### **3.b. Impacts on different regions**

With the “rapid but unstable homogenization” of global agriculture (Friedmann 1992), especially of Types 2 and 3 (in Table 1), it is likely that current patterns of resource use and state support for this homogenized production system will continue. In this section we explore how regional dimensions of energy use and agri-food systems are likely to become more piquant in the post-peak oil era and demand an exigency not witnessed thus far.

What is most likely is the rapid escalation of poverty, hunger, and environmental degradation in developing countries, as the developed nations and transnational corporations make a beeline to acquire more land in developing countries to produce the grains (for feed and biofuels) they need to account for the declining availability of fossil fuels and carbon emissions from the same. Globally, higher energy prices are likely to affect input costs, thereby increasing costs of production and commodity prices, with Asia, Africa, and South America being rather severely affected because of the nature of their economies and their heavy dependence on agriculture (Jha et al 2009; IMF 2008). In the Asian green revolution tracts, these input price-increases alter the ways in which inputs are produced, accessed, and used (Wen Jiajun et al 2009; Leng 2008). Type 2 production systems will be shielded from an immediate price increase in fertilizer and fuel costs (for water extraction, farm machinery, etc.) by subsidies or other protection measures. Also, fiscal and trade responses – like taxes on fertilizers and an embargo on grain exports (FAO 2008a) – are likely, as was seen in India, China, Ukraine, and Argentina in 2007–2008. Though expertise seems to ignore and grossly underestimate peak oil impacts and energy demands in Asia (Nel and Cooper 2008), the current economic recovery is testimony to the fact that only Asian countries may have sufficient savings to buy up or invest for their energy security.<sup>14</sup> A re-regionalization is likely to result from these shared domestic concerns about food and energy security in the developing world.

In addition, there are some intraregional changes that may have global impacts. In many parts of South Asia, North Africa, Latin America, and the Caribbean, oil price increases are likely to have major intraregional impacts by pushing small farmers and tenant farmers out of agriculture. This could mean a distressed population ranging from 40 to 65 percent of

the total population in these areas. An increasing consumer price index and a likely hike in rents along with increasing input costs will make sharecropping or other forms of tenancy unviable. In addition to the recent land-grabbing by richer nations to cultivate and ship biofuels (to keep their own oil supplies steady), a peak oil-induced loss of tenant cultivators will encourage governments to invite corporate (transnational) investors to buy or lease more land in developing countries.<sup>15</sup> The loss will also be in the form of knowledge and expertise vested with these small farmers who are also in many countries tenant farmers leasing land from larger and richer landowners. This in turn will have a tremendous impact on governments, research and development organizations, and donor agencies, all of whom will progressively reaffirm their faith in the efficiency of large-scale industrial production systems, the need to support agriculture as an “industry,” and to ensure that the agricultural production process delivers the expected quantities of food and raw materials for the growth of the manufacturing and service sectors. In India the poorer eastern regions will have to pay much more for their groundwater after peak oil. This is because of India’s “energy divide.”<sup>16</sup> All the diesel-pump-operated areas (the Nepal Tarai, Eastern India, and Bangladesh), which are the poorest areas in South Asia, will face a massive decline in production – especially irrigated *rabi* crop – once oil becomes expensive. Increased inequality and social unrest within regions is an expected impact (see Box 1).

In the developing countries, the demand for a “second green revolution” will make a strong comeback (Tilman et al. 2002), with global investors wooing capital with the promise of high returns. Governments and international agencies are already designing ways of ensuring “fair land-grabbing” in developing countries (Japan, Ministry of Foreign Affairs 2009; UNCTAD 2009), and scouting land using religious affinities (Anjaiah 2009). Irrespective of the social and ecological consequences, these encroachments on land in developing countries will grow once fuel becomes expensive or price volatility increases. There will be no room left for discussing peasants’ rights, gender and common property, land reform and productivity, or the land-care ethics of small farmers. In many countries, the politics of and analysis of the multiple functions and roles of agriculture will face a dead end. The end of oil may well be the end of food (Mark 2006). Peak oil will increase intraregional inequality and political tensions in the developing world and create resistance to new agri-colonialism.

### **3.c. Price-impacts on distribution**

The year 2007/08 revealed more than just violent clashes for basic food in many countries. Though the year brought home to many food-importing developing countries – the

message that the global agricultural trade regime was not a reliable one that could feed their people, global leaders pledged at the recently concluded G-20 meeting that global trade will flourish and that capital to support trade will be made available to sustain economic growth (OECD, WTO, UNCTAD 2009).<sup>17</sup> The global economic and political leadership can afford to sustain this now because fossil fuels are available for shipping produce (more processed foods and intermediary goods than bulk commodities) and inputs over long distances. This section explores how fuel-price changes will affect agricultural trade, transport, and access to food.

### *Agricultural trade*

How will trade respond to rising oil prices and declining supplies? Global trade in agriculture has grown rapidly since the 1990s, but with an increasing share of developed countries in the global market (Sachs and Santarius 2007). This trend will continue into the near future. Peak oil will affect global trade through changes in duties and tariffs on imported goods, which as a rule are low for raw material imports (cotton, cocoa, etc.) and very high for finished products. With increasing oil prices and, correspondingly, more expensive transport costs, the balance should ideally tilt in favor of developing countries by increasing intra- and interregional trade (lower transport costs), increasing investments in local processing facilities, reducing expensive imports of processed foods and food grains from the developed countries, and correspondingly increasing food availability for intraregional distribution and consumption. Developing countries might also revert to increasing cultivation of low-energy-consuming traditional food crops (millets, tubers, bananas, and pulses), and replace their recently acquired wheat or corn-based diets with traditional diets. But this is unlikely to be the case. Market access itself is influenced by increased export subsidies available to developed-country industrial agriculture and increased domestic support given to (mainly cereal crop) production systems in developing countries. Some international measures to protect farmers of developing countries from dumping and, consequently, reducing domestic prices and production capacities may emerge (Sachs and Santarius 2007; IAASTD 2009). Yet, the prescriptions for the future focus on increasing international trade and capital investment in agriculture (UNCTAD 2009; OECD, WTO, UNCTAD 2009). And to add to the disadvantage of oil and food-importing developing countries, both the United States and European Union have recently reaffirmed their export subsidies (dairy industry).

Once oil prices increase, governments of developing countries wedded to input-intensive methods of cultivation and industries that produce agricultural inputs – as well as

governments of developed countries concerned about competitive agricultural exports – will both steadily increase domestic support. Given that, ultimately, even complete removal of domestic support can only change a maximum of up to 20 percent of energy use in agri-food systems (even in the most energy-intensive countries like the US or UK), domestic support for production is unlikely to be reduced significantly due to fuel-price increases; much of the increase in support will be for export subsidies.

### *Access to food*

Let us recall that over the latter half of the 20th century, with worsening terms of trade, agricultural incomes have not been sufficient for subsistence.<sup>18</sup> How will peak oil affect agricultural incomes and access to food? Currently, roughly a third to half of the income of cultivator households in rural Asia, Africa, and South America comes from non-farm or periurban labor or services (Reardon and Vosti 1995; World Bank 2008). In the event of a post-peak oil food price-hike, these households will have little left for investment in agriculture (see Box 1) to access green manure or compost from local markets or to pay for labor.

### **Box 1: Cumulative price-impacts on the poor in developing agrarian countries**

When grain prices rose worldwide (2004–2006 first and then again from 2007–2008), producers of corn, soybeans, wheat, or cassava that had surpluses to sell did make gains. But for the nearly 1 billion of the world's poor, who are chronically food-insecure, there was little gain.

These are poor farmers in countries such as Bangladesh who can barely support a household on a subsistence basis, and who have little if any surplus production. They are also poor slum-dwellers in Lagos, Calcutta, Manila or Mexico City who produce no food at all. They are net-consumers of food, not producers, who spend as much as 90 percent of their meager household incomes just to eat (FAO 2008b, pp. 6–7).

Worsening the impact on the poor is the increasing share of cash purchases in their total food expenditures and fuel expenses (UNDP 2007). In the early 1990s, cash purchases accounted for only 45 percent of rural household food expenditures in China; by 2007 this figure had jumped to 70 percent (Shapouri et al. 2009, p. 36). This decline in the share of self-produced and processed foods not only implies greater vulnerability to food-price shocks (Ugarte and Murphy 2008) but also a loss of generations of wisdom about local food processing and preservation, which undoubtedly is far less energy-consuming and, by virtue of lower levels of chemical preservatives, more nutritious too. It is this organic link between agriculture and nutrition that gets disrupted due to peak oil price-impacts. The implications are worse for the poorest, who have little access to information or education to regain the lost knowledge, institutions, and systems.

Food security will worsen globally and domestically. The 183-odd countries importing food from five major exporters will face a range of peak oil price-impacts, higher food-import bills, a decline in domestic production and productivity of staples (especially in Type 2 production systems), an increasing share of household income spent on food, and increasing domestic support (subsidies) for natural resource-degrading production inputs, thus creating a vicious downward spiral of increasing dependence on economically and ecologically debilitating trade for global agriculture.

Many countries spend far more on food imports than they did in the early 1990s.<sup>19</sup> Global food-price increases will stretch both food-import bills and food-aid budgets beyond any preceding level the world has witnessed. Because India and China, the European Union,

and many developing countries are major food-importing countries rather than food exporters, the precariousness of global food security and its susceptibility to fuel food-price volatility is a major concern.

Local food systems – described as “a set of mutually dependent and interlinked activities that result in the production, exchange, and consumption of sufficient, safe, and nutritious food, by all people in the community or locality” – will emerge as the answer to this dire food-security crisis. The recent spurt of farmers markets and local food systems in the United States is testimony to a future food system that will increasingly be local, specialized, or non-homogenized, and spatially contiguous with and accountable to the natural resource and consumer ends of the food chain (Mark 2006; Heinberg 2007; Ho et al. 2008).

International agencies, especially ones that have a stake in the chemical-energy components (fossil-fuel economies) in agriculture, will continue (for a while) to ignore the peak oil scenario; both the OECD-FAO Outlook (2007) and the FAO (2008b) are premised on past oil-supply, -price, and -demand responses. A peak oil revision of estimates of fuel supply, prices, and food security by international agencies will go a long way in changing the way impressionist national governments make their estimates and plan to face an increasingly food-insecure world.

#### *Transport and storage*

Globally, many of the current transportation modes – like air transport for fresh fruits and vegetables from the developing countries to the OECD – will become unaffordable as fuel prices rise. A shift from energy-intensive air and road transport to rail and maritime transport will be the answer. This may also add to storage costs and perhaps to increasing chemical preservatives in food – to survive the long and slow haul to the market. But a restructuring of several processing and manufacturing activities, including agricultural production closer to utilization or market sites, is likely (Rodrigue and Comtois 2006). With an accompanying decline in domestic-production subsidies and export subsidies (which are mainly in the form of storage, processing, and transport costs taken up by the government), this could also lead to a change in the form of food transported – from current fully-processed and packed stuff ready for the supermarket shelf, to bulk foods that need local processing and value-addition as well as packing to reach the supermarket shelves. The impact of fuel costs will increase fertilizer prices globally, since fertilizer is

the single largest bulk commodity traded (second only to crude oil and gas) through sea routes.

Given that the fuel costs for shipping are much less (about 77 times less than comparable (kilotons) air freight, 7 times less than heavy trucks, and 3 times less than rail), maritime transport of food and agricultural produce will increase in the near future, especially from the developing countries, who are currently under pressure to reduce their currently minimum per capita carbon emissions (UNCTAD 2009).<sup>20</sup> However, in the freight sector almost all the growth in the past decade seems to be in truck freight, with railways having to compete with increasing support and subsidized oil prices for trucking in several countries (Fulton 2004). In order to ensure the sustainability of the current transport sector (if possible at current levels), the recommendation is a three-pronged approach: increasing the technical efficiency of existing and future vehicles; increasing the production and use of biofuels (especially advanced biofuels with low well to wheel GHG emissions); and aggressively adopting hydrogen- and fuel-cell vehicles (Fulton 2004; ESMAP 2005).

Given that, globally, automobiles account for the single largest end-use of fossil fuels and contribution to CO<sub>2</sub> emissions, food systems that rely on car- or SUV-based consumption – bulk purchases from supermarkets – will change once oil becomes expensive and less available. This has implications for global supermarket chains, which are expanding rapidly now in developing countries (USDA 2005; Stokke 2007) and rapidly replacing traditional processors as well as retail and transport networks.

Sustainable economical and ecological alternatives are emerging from community initiatives (GEF 2006), though there are few policies that address the agri-food and transport sector linkages. These involve a combination of locally adapted options of mass transit, non-motorized transportation, emissions-monitoring and reduction, and production and use of biodiesel (with a much higher energy-conversion ratio and higher emissions compared to corn ethanol). Biodiesel or biofuel production and local use (as in Mozambique, Ghana, India, Papua New Guinea, and Barbados) are far more sustainable and genuinely renewable alternatives to fossil fuel: biological- (organic agriculture, cultivation of biodiesel crops), mechanical- (where women's groups use the diesel to operate flour mills), and chemical- (extraction and use of biodiesel in local production activities) energy components are locally owned, operated, and used (GEF 2006).

To recap, the price-impacts of peak oil will negatively affect production in Type 2 and 3 agri-food systems, though the nation-states and international organizations – in finance, development aid, trade, agriculture, and agricultural research – will continue to support the

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energy-intensive, resource-degrading, and polluting Type 3 agri-food systems. Peak oil will bring an additional dimension of resource control that will worsen the current human rights and environmental integrity within nation-states through increased trade distortions and production investments that favor the industrialized regions. This will reinforce global capture of agricultural, environmental, and human resources in the guise of attempts to survive the fuel crisis, thereby creating major political and economic imbalances as well as unfair and unethical agri-food regimes. “Decoupling of the food system from the oil industry” will not happen in the near future; current trends portend peak oil driving industrial agriculture aggressively to a point of no return. It is the responsibility of nation-states – especially democratically elected governments with a commitment to welfare and conservation – to be forewarned and forearmed to confront these energy challenges that are no longer mere equations of joules of inputs and outputs.

#### **4. Alternatives and choices**

There is mounting evidence to suggest that the long-term decline in real prices of agricultural commodities has shifted to a new paradigm in which agricultural prices have a strong link to energy prices, not only via input costs, but determined by a competitive food versus fuel-price linkage. Much depends on the future of international energy markets, the role of bioenergy, and the policies of governments (FAO 2008b, p. 2).

Section 2 presented an overview of the main actors in agri-food systems and their stakes. In this section we explore how certain alternatives to fossil fuels and other forms of energy use are being considered and promoted by these actors. We discuss biofuels and policy regimes for fuel supply and regional collaborations that may come into effect in a post-peak oil world.

##### **4.a Biofuels, organic agriculture, and technological alternatives**

Industrial societies and financial systems assume that there will be continuous growth; it is impossible for actors in these societies to conceive of finite stocks of resources and make changes in their growth- and consumption patterns to enable a sustainable future (Hirsch et al. 2005; Georgescu-Roegen 1986). Right from R&D to market development, governments in developed and developing countries are investing in biofuels and renewable energy, subsidizing and institutionalizing fuel mandates and policies. Globally, as demonstrated by \$180 billion in fiscal stimulus, “the political will to invest in alternative energy sources has

never ever been greater” (UNEP, SEFI 2009, p. 10). Central banks lowering interest rates on renewable energy projects, international fiscal support packages, and national mandates all point to a commitment to find sustainable and renewable alternatives to fossil fuels and fossil-fuel-induced pollution and global warming. Biofuels, the unchallenged investment destination,<sup>21</sup> reveal the same slick alliance between governments and corporate actors that mark fossil-fuel-based industrial agriculture.

With a substantial subsidy for biofuel production, especially cellulosic ethanol, there are several environmental and social consequences and major risks and uncertainties (Robertson et al. 2008; IAASTD 2009; RFA 2008; FAO 2008a and 2008b). Industry (including R&D), farmers, blenders, transport services, and others will respond to these policy pushes – the environmental consequences and disproportionate increase in hunger and starvation notwithstanding.

When land-use changes are included in the analysis, greenhouse gas emissions for some biofuel feedstocks and production systems may be even higher than those for fossil fuels. FAO (2008a) quotes a study which estimates that the conversion of rainforests, peatlands, savannahs, or grasslands to produce ethanol and biodiesel in Brazil, Indonesia, Malaysia, or the United States of America releases at least 17 times as much carbon dioxide as those biofuels save annually by replacing fossil fuels. This “carbon debt” would take 48 years to repay if Conservation Reserve Program land is returned to corn ethanol production in the United States, over 300 years to repay if the Amazonian rainforest is converted for soybean biodiesel production, and over 400 years to repay if tropical peatland rainforest is converted for palm-oil biodiesel production in Indonesia or Malaysia (FAO 2008a).

The inadequacy of these alternatives (especially corn ethanol, which derives almost 75% of its own energy from fossil fuels) to substitute for or reduce in any significant manner the consumption of fossil fuels is now well established (Wirth 2007; Avery 2006; Hill et al. 2006). The *Gallagher Review* recommends that the government reduce its biofuel targets; it must proceed to higher targets only if sustainable sources of biofuels are guaranteed (RFA 2008).<sup>22</sup> Biofuels are now known to cause several negative impacts, the worst being impacts on food security and the environment (FAO 2008b; Holt-Giménez and Kenfield 2008; IAASTD 2009).<sup>23</sup>

Hydrogen cells need energy, too; the energy required to break hydrogen bonds in molecules (since free hydrogen does not exist on the planet) is massive. Moreover, it is not certain whether cost-effective, durable, safe, and environmentally desirable fuel-cell systems and hydrogen storage systems can be developed and introduced in society. Even

an immediate shift (at least for short-term relief) from oil to natural gas brings with it the problems of new infrastructure, fuel and transport systems, safe storage, and management (Wirth 2007). Introducing hydrogen-cell mechanization and chemical-energy inputs in agriculture will demand a complete overhaul of existing industrial agriculture infrastructure – demanding massive recapitalization and the maintenance of current ownership and control mechanisms. If use is focused on transport, it may reduce a fraction of the complex fossil fuel–food problem.

Organic agriculture has tremendous potential to reduce energy use (by 30% or more), especially fossil-fuel consumption in agricultural production (Ziesemer 2007 ). Two major issues that assail the organic agriculture versus industrial agriculture argument, stem from the relatively low level of energy use in agricultural production anyway (up to a maximum of 20% even in industrial agriculture) and the relatively high industrial concentration in both organic and industrial agriculture (in certification, value-addition, transport, retail, etc.) (Twarog 2006). Organic beef-grass, corn, and soya use much lower levels of fossil fuels (50, 31, and 17% less than conventional production), conserve soil moisture and reduce soil erosion, use more labor (thus generating employment), and survive even during drought seasons, yielding more than conventional crops under drought conditions (Ziesemer 2007; Pimentel 2006). But the intensity of post-harvest handling and transport, as well as certification and retail, are just as high as in industrial agriculture (Sachs and Santarius 2007). Therefore, while organic agriculture can pave the way to energy reduction in agriculture, it is also now in need of deindustrialization. When part of local or regional food systems, organic agriculture has the potential to reduce fossil-fuel use and emissions in the agri-food system (Ho et al. 2008).

#### **4.b Alternatives – policies and values**

Policies to promote alternatives are now being actively pursued. In this section we ask whether they address energy use within the same paradigm of energy-intensive economic development at exorbitant social and environmental costs that are not even acknowledged. If yes, then they are not really alternatives to fossil-fuel dependence. The peak oil threat demands policies and policy instruments that pose a fundamental challenge to energy-guzzling agri-food systems and their macroeconomic logic.

Renewable energy is a global policy goal. The policy instruments chosen are those that enable use of renewable energy technologies. Five main policy instruments are used – mandates (or fuels standards), subsidies (ranging from blenders credits to direct biofuel

production subsidies to farmers and agribusinesses), tariff on imported biofuels, process subsidies for biofuels (investment for distribution, storage and transport), and direct subsidies to the industry for research (second-generation cellulosic biofuels) (UNCTAD 2006; Pimentel et al. 2009; Roberstson et al. 2008; FAO 2008b). In agriculture, specific legislative and regulatory recommendations offered are (i) to promote biofuel-driven tractors and pumps – in hybrid systems where possible, (ii) mandate agricultural equipment manufacturers to support renewable energy research using a fraction of their profits (UNDP 2007). Fiscal and financial measures will include subsidizing renewable energy and creation of low interest-rate funding for farmers to access renewable energy technologies (ibid.). The policy for direct public investment will be in R&D to generate more knowledge and technologies for agriculture (ibid.).

If the idea is to move away from dependence on fossil fuels and the environmental degradation and climate change caused by them, then a “quick-fix” from biofuels is certainly not the answer. There are more fundamental changes needed in the transport sector (the single largest consumer of fossil fuels) and trade; in the energy ownership and operation patterns; and in people’s capacities to decide about food production and consumption. Organic agriculture originally was part of a political and ecological commitment to break free from production and consumption systems that were socially and environmentally degrading. Similar political frameworks and value systems are common to all the alternatives that have now been reduced to “technological solutions.” In these value systems, the environment provides production support among other functions, and therefore an analysis of technologies (say biofuels, chemical-energy production from agriculture) would demand comprehensive and multiple valuations of the environmental and social systems.

Increasing Regional Trade Agreements (RTAs) are also policy choices; they do seem to be net-trade creating and the flow of goods between countries is less expensive (contiguous borders, coastlines, etc., offering advantages) (Korinek and Melatos 2009). The declining share of agricultural trade in total trade (in US\$ from 1990–2005) is a feature that applies to all RTAs, with current domination of the OECD (EU and NAFTA) in global agricultural trade (except the MERCUSOR countries – Argentina, Brazil, Paraguay, Uruguay, Venezuela, Ecuador, Chile, Bolivia, Peru, and Columbia – which have an increasing share of agriculture in their trade, inside and outside the region). While regional trade offers a substantial reduction in transport costs, its attractiveness as an effective alternative to global multilateral trade in agriculture is threatened by the asymmetries within regions

(Wen Jiajun et al, 2009); standing loyalties and trade relationships between regional and OECD partners; and regional trade infrastructure and market development (which is rather weak in the Common Market for Eastern and Southern Africa (COMESA)).<sup>24</sup> It is because of this standing loyalty that a RTA may not help address MERCUSOR regional food security or energy security in agriculture; the region is well integrated into the industrial agriculture of the West, with Brazil and Argentina accounting for 90 percent of the trade in MERCUSOR, and with similar comparative advantage. This asymmetry within regions is a hindrance to regional trade (Korinek and Melatos 2009) and forcing increased integration with global trade (with NAFTA and the EU) will continue to erode the terms of trade in agriculture, resulting in MERCUSOR drawing less value for more exports and paying more for imports from EU and NAFTA members.

Current RTAs are in many ways like multilateral trade systems – all the subsidies and domestic support systems prevail in member countries. But the capacity of governments to address intraregional inequality, to support small producers, to create infrastructure development for regional trade, and to ensure trans-border mobility of goods and services is less constrained in RTAs. Though RTAs may increase in response to peak oil, national governments will have to make special efforts to design policy instruments that allow for increasing exchange of agricultural and food products within the region. For instance, removal of duties does not seem to increase COMESA regional trade volumes or value. Governments of developing and lesser-developed countries will, in the near future, seek and implement policy instruments that directly address some of these non-trade barriers and improve their RTAs, especially concerning agricultural and rural products (IAASTD 2009). Incentives for the development and marketing of traditional foods or the development of regional decentralized infrastructure for nutrient management can be achieved within a RTA.

It is unlikely that current alternatives promoted as energy technologies, like biofuels or organic agriculture or even the hydrogen cell, can address the problem of fossil-fuel dependence unless the generation and maintenance of sustainable agri-food systems becomes the unambiguous policy goal. Technological and policy interventions that provide additional energy or cut corners in some miniscule way – without addressing the flagrant waste and inefficiency in current energy-consumption levels and patterns – are not real alternatives. Globally, peak oil will force decision-makers to confront the current fossil-fuel-dependent agriculture as *the* outcome of an unfair and grossly bigoted system.

## **5. Energy for sustainable and fair agri-food systems**

[The] immense danger now facing the human species, it should be understood, is not due principally to the constraints of the natural environment, whether geological or climatic, but arises from a deranged social system wheeling out of control (Foster 2008).

Here, in the concluding section, we explore how peak oil is likely to induce a change in the perception of the agriculture–fossil-fuel dependence equation. We have discussed the role of energy – biological-, chemical-, and mechanical-energy components in agriculture – and the changing relationship of agriculture with industry as agriculture “develops” from highly energy-efficient and productive Type 1 agri-food systems to oil-intensive, inefficient, polluting, and wasteful Type 3 industrial agri-food systems. We then explored the price-impacts; though the energy-guzzling Type 3 agri-food systems will be the most unsustainable after peak oil, governments and international agencies alike will support these industrial agri-food systems. Many of the alternatives discussed in section 4 will remain unsustainable because policies and policy instruments continue to promote wasteful, inefficient and asymmetric access to and use of energy, without questioning or changing the current production practices and trade systems. Fossil-fuel dependence in agriculture will not be addressed unless it is acknowledged as part of a larger structural problem in the global economy. Here we discuss a few options for governments and concerned actors to confront and address these structural issues that distort the relationship between the environment, agriculture, and industry.

### **5.a. Energizing a systemic response**

Several international and local assessments analyze peak oil, oil prices, and implications for urban life, food and agriculture (Aleklett 2007; UNDP 2007; IMF 2008; UNCTAD 2006; Nel and Cooper 2008; House of Commons APPGOPO and Reset 2008; San Francisco Peak Oil Preparedness Task Force 2009; Berkeley Peak Oil and Gas Resolution 2007; 2020 Task Force 2008; The Oil Depletion Analysis Centre 2008; PCI 2008, 2009). All conclude that peak oil will hit the vulnerable populations in developed and developing countries already facing limited employment and livelihoods opportunities, impacts of climate change, and environmental degradation. Overall, despite their low dependence on external energy sources, an increase in energy prices will result in a decline of purchasing power and production capacities and an increase in hunger as well as hunger-induced migration for small peasants the world over – Type 1 agri-food systems will face doom in

the wake of peak oil. Rural populations, especially peasants, will lose their political voice and capacity to articulate alternatives once the peak-oil-menaced nation-states support, on a war footing, the corporate stakes in industrial agriculture and give up their current commitment to foster the Type 2 agri-food systems that they built and subsidized to guarantee food security. Globally, without any developed/developing/least-developed distinctions and beyond the ideological differences between various political regimes, governments and industry will support the energy-guzzling, ecologically and socially disruptive Type 3 production systems.

Industrial agriculture, or Type 3 energy-use in agriculture, has an ally in global financial capital, which now seeks direct control over the land, water, and labor resources located in developing countries. With international agencies and governments planning how to regulate the transnational lease or purchase of arable land in developing countries, the next phase of outsourcing has begun in globalized industrial agriculture. With an obligation to reduce subsidies and GHG emissions, the developed North will do more than increase FDI in developing country agriculture (UNCTAD 2009). Post-peak oil agricultural distribution systems will give the transnational actors the market access they had long sought over global agri-food systems.

However, some alternatives are available in the multiple forms of agriculture and agri-food systems found the world over, even today, despite such a significant homogenization of agri-food systems. The IAASTD (2009) like the EcoFair Trade Dialogue (Sachs and Santarius 2008) was successful in drawing the attention of governments, industry, farming communities, and civil society to the evidence of the structural and functional distortions in our agricultural and food systems.<sup>25</sup> Most specifically, the IAASTD presented evidence about current global norms of trade that have major negative distributional impacts on small farmers and rural livelihoods and, among the options for actions, suggested a differentiation in policy frameworks and institutional arrangements, keeping social and environmental sustainability at the core. This is what the EcoFair Trade Dialogue advocates, too – new rules of the game to govern the way we handle agriculture, the environment, and trade. But we know that decision-makers do not think systemically; concerned stakeholders in agri-food systems must find other ways besides presenting evidence and making recommendations to decision-makers tuned to mainstream, energy-intensive, and polluting agri-food systems.

## **5.b. Ways ahead**

If peak oil were a Broadway show, it would have been a tremendous success. It has a comic and insane storyline – one with no winners. When the world runs out of oil, it does not matter where you are – in a developed or developing country, in a food-exporting or importing one. Whether you are an industrialist, farmer, trader, food importer, financier, herder, or fisherman, you are bound to be a loser. But governments, along with other actors in the civic space, can make politically informed choices about promoting alternatives to the current structure and function of agriculture in the global economy. Global agri-food systems with their multiple roles and functions can find a way out of industrial substitution and appropriation of energy, and find appropriate valuation of energy flows and the ecosystem, beyond monetary values of production and ecosystem services.

First and foremost, the industrial substitution and appropriation of agricultural energy components – biological, chemical, and mechanical – must be acknowledged, measured, and reduced steadily. In this new millennium, with rapid growth of agricultural trade and supermarkets the world over, it is difficult for decision-makers to visualize the world of agriculture in the 1950s, when fossil-fuel-based industrial inputs and services were not cheap relative to the produce of the land. Seeking favorable terms of trade for agriculture and reformulating the economics that subsidize environmentally and socially expensive growth of a select few actors who control oil, will not be easy. But in a world battling financial black holes and climate-change risks and uncertainties, it is clear that with increasing hunger and misery and environmental degradation of the South, it will be impossible to keep global economic growth going under current terms of exchange.

Two immediate options (both supported by ample evidence) to reduce the industrial appropriation and substitution of agriculture, and thereby address fossil-fuel-free agriculture are (i) promotion of Type 1, small energy-efficient farms; and (ii) promotion of organic agriculture in local food systems. At the very least, conscious efforts to combine crop and animal production and ensure fewer energy transformations can be initiated locally. Since decisions about the mechanical- and chemical-energy components are made by government or other international agencies or the corporate sector, it is best to initiate local agri-food systems based on control over and promotion of biological energy components (seeds, planting material, pest-management practices, knowledge about seasonal variation, meso-level ecosystem changes, preservation and processing methods, local cost-effective storage, etc.). There are many alternatives and lessons from the oil-free

agriculture and horticulture in Cuba, the local or regional community-based food systems in the United States, the peasant coalitions and markets for biodiversity and ecosystems in Latin America, the ropeways of Nepal for agricultural and rural transport, and civil-society-led organic agriculture and local food systems in Asia. An important feature of all these systems is the local ownership of all the energy components and accountability of the rooted, socially accountable capital that supports such production and distribution. Cuba had to break up the big state-owned farms and start small farms, with local curricula for agriculture and measures to boost farmers' incomes. All the participants in these local food systems share similar ecological and social values, and have a shared understanding of causal relationships.

Local governments conscious of energy expenditures can demand an energy accounting of agri-food systems and implement taxes for every wasteful energy transformation in agri-food systems. They can provide simple incentives to foster energy-efficient and no- or low-oil agri-food systems. And that brings us to the second and perhaps even more formidable challenge: that of ensuring proper environmental assessments and energy accounting. Even assessments of ecosystem services today (as in the Millennium Ecosystem Assessment 2005) can afford to ignore energy stocks and flows and reduce them all to monetary values. Driven by peak oil, we now need to look back and ask what is wrong with our energy accounting. Martinez-Alier (1986), in his analysis of energy-related literature in the early economics and natural science literature, argues that Podolinsky's case for "labor to increase the accumulation of energy on earth" through increased labor in agriculture for utilizing solar energy was a fundamental breakthrough in energy accounting. Ignoring this point, he argues, was a grave mistake; energy accounting could have given a scientific basis to our valuation of labor, agricultural, and industrial outputs, and most of all the environment. The sun provides enough energy (as vital energy) every half hour to meet annual global energy requirements. Pimentel and Pimentel (2008) point to the need to increase labor (mechanical) energy in agri-food systems to substitute for current fossil-fuel-based mechanical- and chemical-energy inputs (used in tillage, weeding, pest management, harvesting, processing, etc.).

As the world prepares to face a physical decline in the supply of oil and other fossil fuels, it is important to bear in mind that there is a major lapse in our energy accounting. Several alternative valuation methods have been developed within institutional and evolutionary economics (for instance, Soderbaum 2000) and economic geography. The academic and policy clout of neoclassical economics remains unchallenged as of now; peak oil may well

transform that supremacy of convenient selective perception. A peak-oil-driven search will enrich our understanding of the relationship between agriculture and the environment; it is now reduced to an agricultural production function with the environment (soil quality or water withdrawal) thrown in as another variable, the context or history notwithstanding (see Murphy and Santarius 2007, critique of the World Development Report).

The best option open to us as an intelligent species is to reduce oil consumption and encourage oil-free production and distribution systems. Trade that uses energy in such a wasteful and polluting manner, cuts into the economic opportunities available for development in least-developed and developing countries, and enhances economic inequality within nations and regions is not an answer to either carbon emissions or fossil-fuel consumption. Governments must design and implement public policies that maintain social and environmental public goods. For this to happen, global trade regimes must respect the national and regional decisions and foster local decision-making capacities that can enhance social and ecological sustainability of agri-food systems. The EcoFair Trade Dialogue has already suggested new rules and norms for slow trade and sound farming principles for a sustainable future of agriculture; this discussion paper adds to this demand for fundamental changes in the rules that govern global agricultural production and trade. While the support of national governments and international agencies (the UN in particular) is essential, a few experiments in developed and developing countries to foster fossil-fuel-free agri-food systems must be initiated. These will be the precursors to healthy human and ecological systems in the world.

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1 Oil and other hydrocarbon reserves and supply may never peak, they contend, because there are technological solutions possible, and many reserves are yet unexplored and unexploited. See the discussion between those who model and predict the reality of and the non-existence of peak oil – especially note the differences in assumptions in Phil Hart and Kjell Aleklett (discussion) and Peter Jackson (reply). (<http://www.spe.org/spe-app/spe/jpt/2007/06/DissReply.htm>). Also see Aleklett (2007), warning that the OECD countries will have to face a decline in oil imports in the near future. And the latest acknowledgement comes from the oil industry, the IEA itself (2009), that the peak is likely by 2020.

2 As industrial substitution and appropriation of farm production activities, inputs, and service increased, and terms of trade declined further in the increasingly productive Southern countries, there was a gradual subsidization of the economic growth of the North by the Southern economies (Singer 1950; FAO 2004).

3 The latest in this series is Lovelock accusing the third world of uncontrolled breeding and causing climate change, when Sub-Saharan Africa, whose population grew the most during the past two decades, contributed the least to emissions and global warming (Monbiot 2009).

<sup>4</sup> In climate change negotiations, there is a bizarre demand for awarding C credits to cultivate GM crops! (see Chris, 2009) This comes from the US firm Arcadia, to get carbon credit for planting their GM rice in China, and agribusiness lobbying for C credits for South American GM soya.

5 The conventional classification of energy-use in agriculture presents two components – direct and indirect energy (Pimentel and Pimentel 1979; Schnepf 2004; Ziesemer 2007). When measured as standard units of energy use (joules, calories, or per unit of land or per unit of food), it is possible to combine all forms of energy – fossil fuel, human labor, etc. – into two composite and neat compartments of direct and indirect energy (Williams et al. 2006).

6 Many have written about these intersecting, colluding networks and actors in the food-fuel complex. “Paradoxically, as industrialization unifies agriculture, it blurs its boundaries. To ignore this reality, because of the convenience of national and sectoral statistics, is to miss the opportunity to understand, for example, the connections among extensive cattle production in the Amazon, intensive cattle production in Mexico, canned beef in supermarket freezers throughout the world, and McDonald’s in Budapest and Hong Kong. These intertwined ‘beef chains’ intersect with parallel ‘potato chains’ and many other chains of inputs to complex final products, which are somewhat arbitrarily labeled ‘agricultural’ (irradiated potatoes) (frozen chips) or ‘service’ (hot chips)” (Friedmann 1992).

These networks have become stronger and actors fewer with greater control over oil (IATP 2008; Roberts 2008; McMichael 2009). Lack of knowledge or information did not hinder nation-states from considering the gravity of the food crisis and taking appropriate action.

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7 Hendrickson and Heffernan (2007) provide estimates of concentration ratios in agri-food systems. They reveal the control that industry has over agri-food systems and decisions made therein about energy use. Estimated as CR4, the concentration of the top four firms (relative to 100%) in each food industry in the United States, it is a few actors who control production, processing, transport, and marketing decisions. For instance, concentration ratios are 83.5 percent for beef packers, 66 percent for pork packers, with broiler and turkey production rating 58.5 and 55 percent respectively. For flour milling, the CR3 (the market concentration of top three firms) is 55 percent, with 80 percent of soya-crushing being controlled by four firms. A similar concentration is seen in the input industry, too, with two firms accounting for about 56 percent of all corn seed sold in the United States. And one firm accounts for 90 percent of all the genetically modified corn, soya, cotton, and canola seeds sold globally, with the second market leader accounting for about 4 percent. Together, the CR4 for global commercial seeds is 29 percent.

8 One of the key problems in a typology of energy use in agri-food systems is that many nonagricultural factors need to be factored in to get an accurate quantification and categorization. This, in turn, demands more research (see Zieseemer 2007) and more information, especially about the nature of ownership, investments, operational costs, etc., much of which is not available through governments or accessible to the public (see Heffernan and Hendrickson 2007; Friedmann 1992; Murphy and Santarius 2007; Schnepf 2004).

9 Compared to this, the United States uses only 10 million tons of chemical N fertilizer (Fertiliser Association of India, 2007; International Fertiliser Industry Association, 2008 – from Tirado 2009, p. 15, Figure 3.1). Being the largest consumers, they have fertilizer production and supply measures that ensure a steady supply to farmers (Roy et al. 2009; IAASTD-ESAP 2009).

10 The range for population engaged in agriculture is from 2.6 percent of the national population in the United States to 62 percent in India and 75 percent in Kenya. The range for per capita energy consumption is 76.6 ( $10^6$  k cal) in the United States, 1.1 in India, and 0.6 in Kenya (Pimentel 2001).

11 Traits such as drought resistance, suitable quality for food and fodder, competitive performance in different crop-ecosystems, performance of intercrops and mixed farms, compatibility with family labor availability, intra-seasonal weather variations, cooking and storage properties, etc., are hardly researched (Altieri 2003). Formal agricultural research systems find it easier to conduct research on genetically engineered crops and animals than on low-input agro-ecological production systems (IAASTD 2009; GM Freeze 2009; Lotter 2008).

12 The FAPRI-MU study conducted to assess the response of Missouri farms to high energy prices in the wake of The American Clean Energy and Security Act of 2009 ( H. R. 2454) estimates that using the 11-, 34-, and 45-percent increases in fuel, natural gas, and electricity prices respectively by 2050 (reported by Charles River Associates International), the Missouri crop production costs will increase by 8.1, 8.8, 4.4, and 10.4 percent for dryland corn, irrigate corn, soyabean, and wheat respectively (FAPRI-MU 2009). Compare this prediction with the “post-food surplus era” (Vidal 2007), when energy prices pushed corn and wheat prices up by 50 percent within a matter of weeks and that of rice by almost 75 percent!

13 Nitrogen’s post-harvest fate is very different in the two principal food streams. About 700 percent of N in harvested food crops becomes available, after processing and losses, for human consumption. In contrast, some 33 million tons of N in feeds produce only about 5 million tons of N in animal foods, which means that, on average, nearly 7 kg of feed N are needed to produce 1 kg of edible N in meat, eggs, and dairy products. This account makes it clear that there are enormous opportunities for reducing N-leakage from the food system beyond the fields. Two related measures – more efficient production of animal foods and gradual dietary transformations – would be particularly helpful (Smil 2002).

14 But experts recommend that given the opportunities of globalization and the low energy-efficiency in developing countries, it is better for all oil-importing countries if the developing countries would all reduce their oil imports – it will relieve the upward pressure on international oil prices (IEA 2006). Moreover, in

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Asia they argue that the economic gains from reduced oil-import bills will roughly equal “all the capital required for gas-supply infrastructure” (IEA 2006, p. 314).

15 In June a Global AgInvesting 2009 Conference, held in New York, was aimed at investors eager for opportunities to invest in agricultural lands, commodities, and infrastructure. It brought together top players from the global agricultural and investment industries, including Soyatech, Altima Partners, Bayer CropScience, Brazil AgroLogic, DuPont, Rabobank, and the World Bank. The participating firms own and/or manage over 11 million acres of productive farmland worldwide (www.workers.org).

16 Western India, South Interior India, and South Coastal India almost all have electric pumps (85%, 94%, and 94%) with very low tariffs in the South. In Tribal India the ratio of electric to diesel pumps is 3:1, in Punjab and Haryana, it is 1:1. The percentage of diesel WEM in Pakistan is very high, at 82 and 90% in Punjab and Sindh. In India, diesel pump penetration is highest in Eastern India (92% of total WEMs) and in Nepal Tarai and Bangladesh, too (at 79 and 63%). The extent of electrification and quality of power supply is what determines the dependence on oil for water extraction in South Asia (Sahuquillo et al. 2005).

17 They note that: “The main risk is that G-20 members will continue to cede ground to protectionist pressures, even if only gradually, particularly as unemployment continues to rise. The danger is of an incremental build-up of ‘sand in the gears’ of international trade that could aggravate the contraction of world trade and investment and undermine confidence in an early and sustained recovery of global economic activity.”

And the second risk is that current protectionist measures and profits thereby will create “a legacy of uncompetitive industry” and create sector overcapacity, which may demand more protectionist measures (OECD, WTO, UNCTAD 2009, p. 6).

18 This is not to argue that small farms or the peasantry are not productive – they are more productive than large farms (Sen 1999). But their dependence on national and global agri-food systems for some food items (pulses and oil seeds) is high, and their contribution to rural energy (crop wastes, cow dung); soil and water conservation; workforce (generating local employment); post-harvest incomes (local processed foods/beverages), etc. are not acknowledged or valued in the national monetary systems (Pretty 1995; Ong’wen and Wright 2007).

19 Global food-price increases fueled by an increase in oil prices saw the poorest, most food-deficient countries dish out the maximum revenue to access food (FAO 2008a). Besides, food aid volumes in 2007–2008 have fallen to two-thirds of their 1993/94 level, and the input value of food aid is only half of what it was in 1993/94 (FAO 2008a).

20 Within the transportation sector, maritime transport accounted for 10 percent of emissions, and road transport accounted for 73 percent, with air and rail coming up to 12 and 2 percent, respectively, in 2005 (UNCTAD 2009).

21 Investment in biofuels has grown rapidly since 2000, accelerating especially in OECD countries and Brazil since 2003, when oil prices began to climb above \$25/barrel to surpass \$100/barrel in early 2008. Between 2001 and 2007, world production of ethanol tripled, from 18.5 billion liters to almost 60 billion liters, while biodiesel rose from 1 billion liters to 9 billion liters: almost tenfold. Biodiesel, the other major biofuel, is produced mainly in the EU, with 4.8 billion liters of production in 2006, compared with 850 million liters in the United States (FAO 2008b).

22 Besides a slowdown in biofuel targets, the review demands new datasets to assess how much more land will be needed to sustainably produce biofuels, arguing that there is sufficient land for food, feed, and biofuels if advanced technologies are used, only marginal and idle lands are used, and the access to food for the poorest is not negatively affected (RFA 2008). In other words, this means that the marginal land available in the Third World can be used for producing biofuels for the transport sector in the West. The *Gallagher*

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*Report* assumes (rightly so) that the same ownership, exchange, and control mechanisms that work with fossil fuels will work for biofuels, too.

23 Growing crops for biofuels not only ignores the need to reduce fossil energy and land use, but exacerbates the problem of malnourishment worldwide (Pimentel et al. 2009). Growing corn to produce ethanol – according to a recent study by the US National Academy of Sciences (2007) – consumes 200 times more water than the water used to process corn into ethanol, which involves about four liters of water per liter of ethanol, compared with 1.5 liters of water per liter of gasoline.

24 The OECD, especially the EU and NAFTA, which together account for over 50 percent of global agricultural trade, will continue to dominate, with even more well-integrated trade among members (accounting for 50% of agricultural trade) compared to the other RTAs (e.g., ASEAN Free Trade Area and MERCUSOR, in which the agricultural trade among members was a maximum of 23%, or less than 5%, respectively, in 2005).

25 The IAASTD goal was to assess how agricultural knowledge, science, and technology can address development goals like hunger and poverty, rural livelihoods, and environmental, economic, and social sustainability. It offers an important lesson in the fact that the major OECD players – the United States, Canada, and Australia (among 61 governments) – had major reservations about the content of the assessment, especially about the sections on biotechnology and trade. Specific reservations from these affluent governments were about the impact of multilateral trade on poverty, small farmers, and the peasantry, and food security, as well as on the need to compensate revenues lost as a result of tariff reductions.