

**Draft 11.01.2010 - Not for Quotation**

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## **Agricultural Trade after the Peak Oil**



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This paper will be published soon by the EcoFair Trade project under the responsibility of Misereor and the Heinrich Böll Foundation.

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## Acronyms:

ADB – Asian Development Bank  
AFTA - ASEAN Free Trade Area  
ASPO – Association for the Study of Peak Oil  
ASEAN - Association of Southeast Asian Nations  
COMESA - The Common Market for Eastern and Southern Africa  
CRA - Charles River Associates  
DEFRA - Department for Environment, Food and Rural Affairs, UK  
ESMAP - Energy Sector Management Assistance Programme  
EU - European Union  
FAO - Food and Agriculture Organization  
FAPRI-MU - The Food and Agricultural Policy Research Institute at the University of Missouri  
FEASTA – The Foundation for the Economics of sustainability  
FYM – Farm Yard Manure  
GDP - Gross Domestic Product  
GEF - Global Environment Facility  
GHG - Greenhouse gas  
HYV - High Yielding Varieties  
IAASTD - International Assessment of Agriculture Science and Technology for Development  
IATP - Institute for Agriculture and Trade Policy  
IEA – International Energy Agency  
IMF - International Monetary Fund  
k cal - kilo calorie  
MAFF - Ministry of Agriculture, Forestry and Fisheries, Japan  
MEA - Millennium Ecosystem Assessment  
MERCUSOR -  
NAFTA - North American Free Trade Agreement  
OECD - Organization for Economic Co-operation and Development  
PAN-Pesticide Action Network  
PCI - Post Carbon Institute  
RCT - Resource Conserving Technologies  
RDA - Recommended Daily Allowance  
RFA – Renewable Fuels Association  
RTA – Regional Trade Agreement  
R&D - Research and Development  
SEFI - Sustainable Energy Finance Initiative  
SOFA - The State of Food and Agriculture  
SUV - Sport Utility Vehicle  
toe - tons oil equivalents  
TWN- Third World Network  
UK – United Kingdom  
UNCTAD - United Nations Conference on Trade and Development  
UNDP- United Nations Development Programme  
UNEP - United Nations Environment Programme  
US – United States  
USA – United States of America  
USDA - United States Department of Agriculture  
WCGSD - The World Commission on Globalization and Sustainable Development  
WTO - World Trade Organization

## 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 is manifest as increasing homogenization of agriculture, and industrial substitution and appropriation of the sector, most specifically its chemical and mechanical energy components. Among the key actors in the food-fuel complex, the most important ones making decisions about energy supply and use are governments and industry. 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, number of energy transformations (and wastage) and industrial ownership of energy and agricultural operations increases as we move from Type 1 - farms that use no oil and produce 4-10 kilo calories (k cal) of energy in output or food for every k cal energy used, to Type 2 - the state subsidized and controlled green revolution, to Type 3 - large industrial agriculture that derives 90 percent or more of energy from oil and use 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 share of processed foods in global agricultural trade. All these undermine the environmental integrity and democratic sovereignty of nation states which are dependent on energy intensive and increasingly expensive food imports from a few countries channelled mainly through a few transnational corporations.

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, political and ecological disruption although their production systems are the most energy efficient. As freight becomes expensive distributional impacts will be increasing regional trade, worsening access to food particularly for the poorest in developing countries, and increasing investments in transport and storage facilities, with an overall 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 - bio-fuels, 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, reducing barriers to regional trade, and similar policy induced systemic changes. In conclusion, the paper asks if a politically

conscious systems thinking to address agri-food systems and energy use, is possible. The twin crises of persistent poverty and climate change make it imperative that the role of energy and the macro-economic logic of economic and ecological disruption be analysed 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, which plants fixed from the sun millions of years ago) 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, and political geography do offer the tools to address these structural issues. But 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 like a tax on every additional energy transformation in each food item, increasing and enhancing the value of agricultural labour (mechanical energy) in farming – especially female work force 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 multi-functionality of agriculture, starting a de-homogenization of agri-food systems and building local capacities for food security decision-making. All these echo the EcoFair recommendations for democratizing the food chain, investing in multi-functionality, 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 burden that past development choices have imposed on us. This EcoFair Trade Discussion Paper focuses on the possible impacts of the 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 20-80 percent of their national income from agriculture and yet have to buy or beg for food in the international market. Moreover, innumerable cases of agriculture induced ecosystem degradation, some of them irreversible, are being reported every day. Agriculture contributes about 10-14 percent of global anthropogenic green house gas emissions; and is an icon of the unequal access to energy. Every year, the agri-food sector in the USA 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 acknowledgement that agriculture will change drastically once oil and natural gas supply starts 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 fixes solar energy and makes it available for other production processes. Though food is not to be reduced to its energy equivalents, agriculture produces the energy required for the application of human labour to its own and other production processes. Historically, human evolution from hunter-gatherer to cultivator marks a major shift in global energy use, where the biological process of fixing solar energy is supported by physical or mechanical energy supplied by human beings. Later, other sources of energy like fossil fuels that human beings extract, are added to enhance agricultural production and for further distribution of its products. 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. As oil becomes more expensive and is 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 bio-fuels. 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 bio-fuels. 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. Energy efficiency decreases and number of energy transformations (and wastage) increases as we move from Type 1 - farms that use no oil and produce 4-10 kilo calories of food energy for every k cal energy used, to Type 3 - large industrial agriculture that derives 90 percent or more of energy from oil and use 10-20 k cal of energy to produce 1 k cal of food energy. 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. Bio-fuels, 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, and 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 bio-fuels, 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 re-consideration of energy creation and use in agri-food systems is possible. Fossil-fuel dependence is a structural problem where the industrial agriculture and trade is legitimized in the name of millions of hungry mouths to be fed, where the macro-economic 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 subsidise 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 twin crises of climate change impacts and persistent global poverty, hunger and environmental degradation.

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

In this brief introductory section we lay out the relationship between agriculture and fossil fuels, evident in production and distribution of agricultural commodities – especially food, feed and energy. The dependence of agricultural production and trade on fossil fuels is part of an accepted worldview of agriculture, rural labour and natural resources as facilitating inputs that feed into industrial development.

Many would argue that the jury is still out on the very phenomenon called “peak oil”<sup>ii</sup> The fact that there are several potential peaks (oil, gas, coal and uranium in energy and phosphorus in agricultural inputs) we 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 the 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 behaviour when faced with material scarcity, warns us that price volatility is an important signal of an existing or approaching peak.

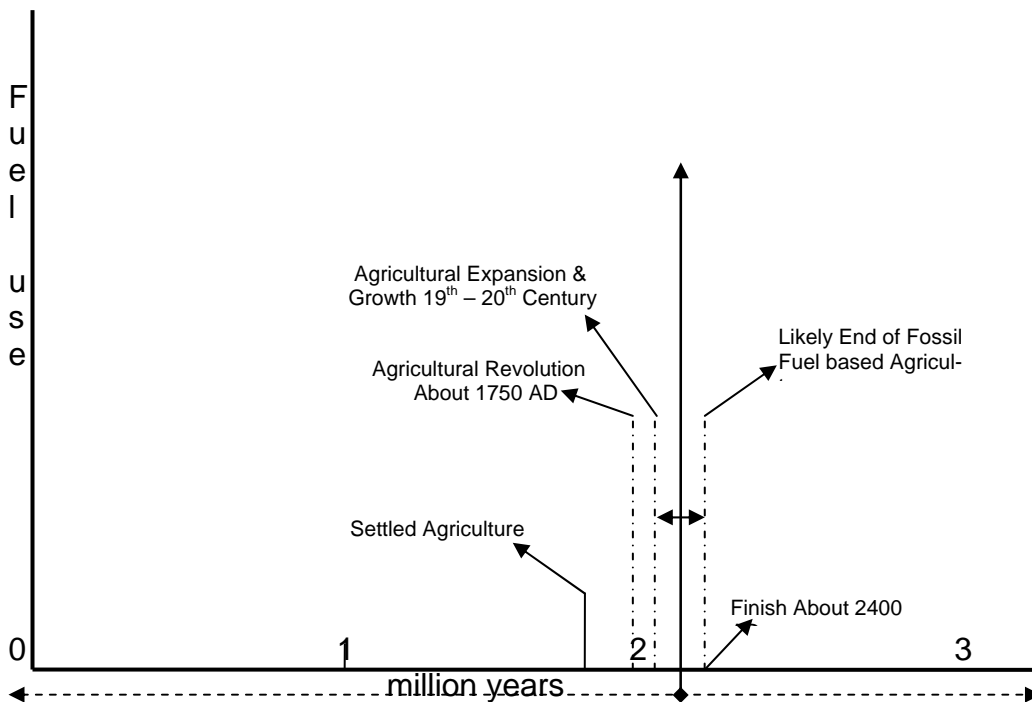
Fossil fuels account for 86 percentage of global power consumption, and the consumption of fossil fuels as well as other primary energy sources has grown by 40 percentage globally during 1980-2000 (IEA, 2009). Globally, the 13 petagrams (billion metric tons) of biomass harvested per annum as biomass (food, feed, energy, other bio-materials) equals about 240 exajoules or 5.7 billion metric tons oil equivalents (toe) which is close to the amount of fossil fuels used per annum (about 390 exajoules) in energy terms (Wirsenius, 2007). Less 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 was ever 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 U.S. is 500 gallons of oil equivalents,” second only to the amount of fuel used per person in automobiles in the country (Pimentel, 2008); in the food system in the UK, 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, fast to cook and 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 life styles, and profits. Urban food systems demand long haul, processing, storage, refrigeration, etc. all being convenience demanded by urban consumers and delivered by the agri-food industry using anywhere between 10-20 calories of energy for 1 calorie of food (Giampietro, 2009; Murray, 2005; Tomczak, 2005; Pirog et al, 2001; USDA, 2005a). Food production and supply in the UK accounts for 21 percent of the total energy use in the UK (Lucas et al, 2007). The spatial dimension of food systems becomes evident in the share of this chemical energy equivalent accounted to producing the food and processing it (34 percent) and to transporting it to the consumers (18.5 percent). It is estimated that 20 % of the fossil fuels used in the US 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 U.S. long distance food transportation is a luxury, using up immense quantities of oil, to provide “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. The high-input industrial agriculture produces almost 75 percent of global food grains and feeds about 60 percent of the world population (Pfeiffer, 2004; Sachs and Santarius, 2007). Marked by the least bio-diversity and highest fossil fuel consumption, food grain production from industrial agriculture (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 EU and NAFTA together account for over 55 percent of the global agricultural trade (agricultural exports from this region accounts for US\$397 billion out of a total of US\$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, pg.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. Dairy industry (milk and milk products) which accounts for almost half of global export subsidies (USDA, 2006; 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 UK, where 4400 tonnes of icecream is exported to Italy and 4200 tonnes imported from there annually. Or, 22,000 tonnes of potatoes imported from Egypt and 27,000 tonnes exported! (Johnson and Smith, 2009, 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, 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, a part of almost all production investments, technologies and policies, 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), and the chief resource that runs the global food production and distribution regime (McMichael, 2009), it has a vile and 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 human kind and of agriculture (see Figure 1 above).

Starting in the 1950s (the immediate post-war era) when the Marshall Plan successfully de-peasantized, modernised the agricultural production system, and provided surplus labour and capital for industrial growth in Europe, there was a concerted attempt to ‘transform traditional agricul-

ture' 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 legitimisation for macro-economic 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 increasing trade, mainly as food (as aid and commercial sale) and manufactured goods imports by developing and least developed countries. These were all exported by (heavily subsidized) developed country production systems, which had by the 1950s built a comparative advantage in access and use of cheap energy (oil) for agricultural production and distribution. The international exchange of agricultural products in terms that were increasingly unfavourable to developing countries and to their agricultural exports, was thus a necessary condition to maintain manufacturing sector growth (surplus accumulated and labour made available)<sup>ii</sup>.

There is indeed a direct and significant relationship between energy use and crop productivity (Pimentel and Pimentel, 2008). But the increase in fossil fuel use in industrial agriculture, which has increased by over 40 percent (1980-2005) and crop production, which has increased by over 250 percent, do not add to food availability or access. 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 population rhetoric (of millions of hungry people to feed) of the 1960s and 70s still holds sway<sup>iii</sup> (Pimentel and Pimentel, 2008; FAO, 2005) despite the evidence about wasteful energy and input use in agriculture. The 323 million tonnes of foodgrain used as livestock (feed which can feed 1 billion people) (Pimentel and Pimentel, 2008), the role of surplus labour and surplus agricultural output in enhancing industrialisation 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). A similar assessment of the role of knowledge and policies that cater to these production successes and accompanying social and ecological misery, was supported recently by the FAO, UNEP, World Bank and several governments (IAASTD, 2009).

The paradigm of industrial agriculture, of producing and distributing food by displacing and disabling peasants or small farmers and making them dependent on imported or supplied food goes against the empirical evidence about the productivity and high energy efficiency of small farms (Sen, 1999; Pretty, 1995; IAASTD, 2009; Ong'wen and Wright, 2007). Value addition, by processing, storing, marketing and transporting food across the globe is sustainable only because energy and labour that feed into agri-business and other industry are maintained cheap (Pimentel and Pimentel, 2008; IATP, 2008).

The bedlam caused by diverting scarce land, water, nutrients like phosphorous (an impending peak) and heavy subsidies to bio-fuel production and worsening the current food crisis (FAO, 2008; Cutas et al, 2007; Vaccari, 2009; Pimentel et al, 2009) reflects the prevailing world-view that agriculture, peasants and rural labour are all mere facilitators (as inputs and pre-conditions) for industrial and service sector growth. Feeding hungry populations and conserving environments are not central concerns.

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 other chemicals). Besides, the history of oil is one of violence, social and ecological disruption. Oil seems to comply with a post-national global order where even democratically elected governments have little control over the ways in which energy is supplied and accessed by people. 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 legitimisations 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). In climate change negotiations there is a bizarre demand for awarding C credits to cultivate GM crops! 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 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 number of energy transformation involved, modern agri-food systems can no longer be categorised 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>iv</sup>

Though farmers are the ultimate decision-makers about energy use in each farm, farmers themselves are no longer the chief actors in today's agri-food systems. The food-fuel complex is rigged with various parallel and intersecting relationships among increasingly fewer actors.<sup>v</sup> Farmers, national governments (and their policies), industry, international monetary and development agencies, and consumers have different stakes in fossil fuel intensive industrial agriculture. Decisions, especially about the chemical and mechanical energy components are increasingly made by national governments. Despite contrary reportage, the high-energy industrial agriculture is like the green revolution production systems which are highly subsidised and supported by governments (Patel, 2007; 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. Now, after mid-2009, the world has hopefully seen the worst of the economic downturn spurred by high oil prices over the past few years.<sup>vi</sup> Yet, there is little evidence of ability of governments to control or regulate the food price rise, increase in share of agricultural commodities traded in commodity futures, or any of the highly speculative market practices that resulted in food crisis and riots (IATP, 2008).

Industry is the major actor gaining from the subsidies be it for production (fertilizer subsidies in particular, Gulati and Narayanan, 2003) or export. Increasingly, global food production and distribution is concentrated among a few key corporate sector actors.<sup>vii</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, food importing and exporting states. Multi-national agri-business 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 behaviour as well as on policy decisions made by governments (WCGSD, 2004; IAASTD, 2009).

Consumers with increasing percapita 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) and processed food and intermediary products have increased their share (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, characteristic of industrial societies, is now being imitated in some metropolitan centres in developing countries subsidized heavily by national governments (Giampietro, 2009).

Nevertheless, 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 there is an international food-fuel complex, transcending conventional developed and developing country distinctions, which 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 de-skilled and alienated from their land, water and local labour systems. The

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

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

<p><b>Type 3</b>  1 calorie produces 1/10<sup>th</sup> –1/20<sup>th</sup> of a calorie  35 K cal to produce 1 K cal of animal protein (beef);  Agriculture accounts for 10-30% of total energy use in society;  Production accounts for 1/5 of total energy use in agriculture;  Transport, processing, packaging, storing, selling accounts for 4/5 of total energy use</p>	<p>Private sector/ industry bred or designed, produced, marketed and protected planting material or genetic stock.  Chemical-specific crop choices (Round-up Ready varieties) and modified crops for producing bio-fuels (more chemical energy).    5-10% of energy inputs in production</p>	<p>Vertically integrated mechanical operations with minimal human energy and no draught power.  Completely mechanized industrial operations.  Specific infrastructure and energy systems for transport, storage, processing, packaging and marketing.    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 homogenisers, preservatives (especially in perishable produce).  Fuel for mechanical operations, and long distance transportation of inputs and outputs.    Fossil fuels account for over 85 % of energy in agricultural production and distribution.</p>
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Source: Compiled and synthesised from Pimentel and Pimentel, 2008; Pfeiffer, 2004; Wirsenius, 2007; Giampietro and Pimentel, 1994

Energy intensive agricultural production and distribution transcends fundamental ideological differences between capitalist and socialist development ideologies.

The rudiments of similar trans-national networks do exist, in several small farmer or peasant movements (say, Via Campesina), environmental movements or coalitions (PAN, TWN, etc.), the right to food campaign and the slow food movement, transcending ideological differences and based on environmental and social values. 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 petroleum' 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 percentage of the fossil fuel use in that product. This typology (Table 1) is useful to identify the different energy components, the major stakeholders, and thereby the likely impacts that they will face after peak oil.

Type 1, the small peasant farming systems where every kilo calorie (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, the energy intensive cereal crop production (green revolution) supported by the policies and institutional arrangements put in place by nation states, where every kcal of energy used results in 2-5 k cal of energy output in grain. Type 3, the industrial agri-food systems where 10 –20 kcal of energy is used to produce 1 kcal of energy as agricultural output, is the least energy efficient but is considered the most productive among all the three types of agriculture in terms of grain yield per unit area cultivated. In Type 3 systems, a mere 1/5<sup>th</sup> of the total energy used is used for production; the rest is used for processing, packaging and transporting food.<sup>viii</sup>

Type1 agriculture where human labour is the major mechanical energy input, is the most energy efficient. If fossil fuel use in the production of implements (say, hoe and axe used by labour in corn production in Mexico, yielding 10.7 k cal of corn per k cal energy expended) is included, then the output of corn per k cal of fossil fuel energy used is 422 k cal. In Type 2 grain production systems

the ratio of energy output per unit energy input is 2:1 for wheat and rice and 5:1 for oats in the USA. Though the grain yield per ha is much higher than in the developing countries producing the same crop, US agriculture has a much lower output:input ratio because much of the human labour used is replaced with fossil fuels. When compared with sorghum production in Sudan, where human labour is the main energy input, producing a calorie output input ratio of 14.43:1, the fossil fuel dependent grain production systems in the USA become worrisome though grain productivity would be much higher (Pimentel and Pimentel, 2008).

The green revolution (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 mechanisation (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 during the 1950s to 1989, the trend since the 1990s is noteworthy with India (at 14 Million tons of N fertilizer per annum) and China (at 30 Million tons) accounting for the highest consumption.<sup>ix</sup> While rising natural gas prices led to the shut down of ammonia plants and reduction in production (2/3<sup>rd</sup> of the pre-2000 level) in the USA (IEA, 2006; Schnepf, 2004), India and China recorded an increase in production and a renewed commitment to investment in fertilizer production and subsidies, even in the 2008-2009 period when oil prices went on a roller-coaster ride. Similarly, in several African countries like Malawi (which had previously withdrawn state support for agriculture based on World Bank advise), re-introduction 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>x</sup> Irrespective of the ideological orientation of national governments or trans-national 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. It is only recently (since the mid-2000s) that developing country governments, wary of stagnating productivity growth rates and in response to global trade pressures, 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 FDI in agriculture.

In Type 3 production systems, the on-farm energy uses account for one small share (about 18-20 percent in the UK, USA and other industrial agriculture systems) of total energy use in the product that finally reaches the consumer, and are part of global decisions made by the corporate suppliers or traders (Pimentel and Pimentel, 2008; Smil, 2002; FEASTA, 2007; Pfieffer, 2004; Murray, 2005; Church (*Energy Bulletin*), 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.

What distinguishes Type 1 production from Type 3 production systems is the nature of ownership of energy components and the number of energy transformations involved. Type 1 agri-food systems are different from Type 2 and Type 3 in that in these, industry has substituted capital inputs for land, labour 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 fixed 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

firms (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 slaughter house by-products (Wirsenius, 2007). The loss is further aggravated by the organization of livestock industry, where crop residue and by products are not used as feed, and animal manure is mere waste, not recycled as farm yard manure.

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

Whether it adds to production or productivity, mechanisation is significantly high in the developed countries. Europe and the USA mark the highest number of tractors per unit of arable land. While their share of arable land is almost a fifth of the global arable land, their share of tractors is almost half the global share (FAO, 2005). Argentina, Brazil and India appear more mechanised than China; but Russia, sub-Saharan Africa, Central America and Caribbean are less mechanised. Compared to mechanization, it is the chemical energy component that is predominant in the Southern countries (Sachs and Santarius, 2007; FAO, 2005). The capitalization of agricultural inputs, farming methods and practices, as well as product markets, processing industry, and sale, is a feature of Type 3 agriculture.

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:

- (i) increasing share of chemical and mechanical energy components as agriculture moves from Type 1 to 3
- (ii) fossil fuel based chemical energy controls the biological energy components (seed) and mechanical energy (human labour, tools and machines)
- (iii) energy inefficiency, wastage and number of energy transformations increase in Type 2 and Type 3 production and distribution systems
- (iv) industrial ownership and concentration of energy components absent in Type 1 and highest in Type 3
- (v) national public policy 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, 2007). 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 commitment from governments and investors to enable more of Type 3 systems. An international assessment that pointed out evidence of and relationships between stagnating yields from irrigated agriculture, deteriorating soil and water systems and climate change, and persistent poverty and hunger (IAASTD, 2009), continues to be ignored by governments.

### 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 the peak oil. Which ones among the three major energy components (biological, chemical and mechanical) in agriculture will succumb to the decline in fossil fuel supply? Which ones 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 a decision that is highly dependent on the nature of state investment in agriculture and the political clout of the farm and agri-business 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 percentage reduction in energy use. But peak oil is likely to have a significant impact when supplies start to decline. Increasing oil prices driven by 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, 1995; Hagman and Tekin, 2007). Even a 10 percentage decline in supply of fossil fuels will lead to a drastic change in agricultural production systems – leading to a fall in yield and higher prices for commodities (Dvoskin, 1976, quoted in Buttel and Youngberg, 1982).

**Type 1 production systems** (as in Table 1), with the least dependence on fossil fuels or external sources of energy will face the least impact of price increase of chemical inputs into agricultural production. For these subsistence agricultural production units or the more advanced ecological agriculture systems or organic agriculture systems, the increase in fossil fuel price or decline in supply makes no change in the amount of compost, FYM, or other forms of green manure and integrated pest management or non-pesticide management practices (Pimentel, 2008; Heinberg, 2007; Kimbrell, 2001).

Many small farmers will shift their crop choices to low risk traditional food crops, as they are in India now (Chand, 2007) and in doing so 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 analysed and validated to enable low fossil-fuel agri-food systems. Peasant farming or traditional farming, being largely 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 S&T systems, very little funding or support will be available for outreach of know-how in these energy-efficient multi-functional farming systems that are least fossil fuel dependent.<sup>xi</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, pushing down the little that has been achieved in poverty reduction and other millennium development goals (UNDP, 2007; 2008; IAASTD, 2009).

**Type 2 production systems** will witness increasing state support following the peak oil. In developing countries where the Type 2, state supported commercial food grain and other cash crop (sugarcane, cotton, soya bean, etc.) production systems prevail, it is likely that the state will invest further in the same chemical and mechanical energy intensive production inputs, to ensure that agricultural production and food security are assured. (IAASTD-ESAP, 2009). The increasing support to the medium to large farms in irrigated food grain tracts, will further reduce the scope for and availability of resources to support (through appropriate infrastructure and services) sustainable Type 1 production by peasants, especially in low chemical energy, high labour input (mechanical energy) farming systems in the drylands and mountain ecosystems.

The evidence that increased application of nitrogen and phosphorous cannot be as effective in increasing yields because of diminishing returns (Figure 2 b in Santarius et al, 2002; Roy et al, 2009), the fact that increasing input use, especially those subsidised by governments, cause severe degradation of land and water systems, will not stop governments from expanding 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 - euphemistically called a "second green revolution" (Swaminathan, 2005; IAASTD, 2009). The Government of India, in its new production strategy for fertilizers emphasizes a shift from oil based to natural gas based ammonia production, and a steady reduction in fertilizer - especially urea and ammonia - subsidies (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 ground water use) once the cost of pumping water increases.

There is a difference between the chemical energy (fertilizer) component in agri-food systems in the west (the OECD) and in the major (Type 2) production system in developing countries (see 2.b above). Fertilizer (N), the basic chemical energy that gets transformed into biological energy (feed-stock- 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 to sustain the industrial livestock production systems (Smil, 2002). In Southern developing countries, which account for more than half the global fertilizer consumption, N fertilizers will be applied aggressively, because of the national food security legitimization - energy 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 towards 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 irrigation-fertilizers-machines-High Yielding Varieties (HYVs) package that characterised the green revolution will be broken when fuel costs prohibit pumping water at current rates (where annual withdrawal is 130-160 percentage of recharge). This dismembering of the package may help governments view alternatives (especially resource conserving technologies (RCTs) and energy efficient small farm systems with high productivity) more favourably, 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 processing industry. Once fuel supply declines and fuel-based technologies hard to access and use, credit currently available to farmers from domestic and international banks, cooperative and private lender 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 (Foodcrisis, 2009). In response to all these, individual governments will increase the subsidies available to farmers to permit increasing (resource degrading) input use, and further deterioration of environmental and food security. A major fallout of the peak oil in Type 2 agri-food systems will be a re-think on the nature of subsidies and the role of the state in the agriculture sector, 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 developed country governments) to support and subsidize their production and distribution systems. The most recent evidence is the re-introduction of export subsidies to dairy industry in two G20 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; DEFRA, 2008), the pressure to increase energy efficiency will increase post peak oil (USDA, 2006; 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 in reducing input use or increasing production costs (Kingwell, 2003; FAPRI-MU, 2009)<sup>xii</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% of energy inputs in industrial agriculture.

Much 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. Livestock (especially beef) and dairy products being 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 on 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; Sorenson, et al, 2006)<sup>xiii</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; Japan Government, 2009; 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 increasing 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 future. International aid will continue to support many such wasteful energy conversion technologies, and all in the name of agricultural productivity and development investments (DFID, 2008; 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 industry, fertilizer and pesticide manufacturing, and agro-machinery will become subsidiaries or affiliates of trans-national corporations.

As the downward spiral of industrial control, state impotence, international collusion, and environmental degradation continue, and human rights as well as food rights get 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. Local responses to increasing inequality will drive many of these alternatives to Type 3 agri-food systems.<sup>xiv</sup> Many will, with actors in the civic space and local rooted capital, 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 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 trans-national corporations make a bee line to acquire more land in developing countries to produce the grains (for feed and biofuels) they need to account for declining availability of fossil fuels and C 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 and heavy dependence of these economies on agriculture (ADB, 2006; IMF, 2008). In the Asian green revolution tracts, these input price increases alter the ways in which inputs are produced, accessed and used (IAASTD-ESAP, Ch. 3, 2009; Leng, 2008). Type 2 production systems will be shielded from 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 seen in India, China, Ukraine and Argentina in 2007-08. Though expertise seems to ignore and grossly under-estimate the peak oil impacts and energy demands in Asia (Nel and Cooper, 2009), 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>xv</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 intra-regional changes that may have global impacts. In many parts of South Asia, North Africa, Latin America and Caribbean, oil price increase is likely to have major intra-regional impacts by pushing small farmers and tenant farmers out of agriculture. This could mean a distressed population ranging from 40 to 65 percent of total population in these areas. Increasing consumer price index and likely hike in rents along with increasing input costs will make share-cropping or other forms of tenancy unviable. In addition to the recent rabid land grabbing by richer nations to cultivate and ship bio-fuels (to keep their own oil supplies steady), a peak oil induced loss of tenant cultivators will encourage governments to invite corporate (trans-national) investors to buy or lease more land in developing countries.<sup>xvi</sup> The loss will also be in the form of knowledge and expertise vested with these small tenant farmers who achieve some scale effects by leasing in land from larger and richer land owners. This in turn will have a tremendous impact on governments, research and development organizations and donor agencies, who 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 other manufacturing and service sector growth. In India the poorer eastern regions will have to pay much more for their groundwater after the peak oil. This is because of India's "energy divide."<sup>xvii</sup> All the diesel pump operated areas (the

Nepal Tarai, Eastern India, and Bangladesh), the poorest areas in South Asia, will face a massive decline in production –especially irrigated *rabi* crop, once oil becomes expensive. Increasing 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 developing country land 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 intra-regional inequality and political tensions in the developing world with 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 governments, especially in food importing developing countries, the message that the global agricultural trade regime was not a reliable one that could feed their people, at the recently concluded G-20 meet global leaders have pledged that global trade will flourish and capital to support trade will be made available to sustain economic growth (OECD, WTO, UNCTAD, 2009).<sup>xviii</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. How will trade respond to rising oil prices and declining supplies? This section explores how fuel price changes will affect agricultural trade, transport and access to food.

#### **Agricultural trade:**

Global trade in agriculture has grown rapidly since the 1990s, but with an increasing share of developed countries in the export market (Agriculture and natural resources team, 2004; 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 is low for raw material imports (cotton, cocoa, etc.) and massive for finished products. With increasing oil prices and correspondingly more expensive transport costs, the balance should ideally tilt in favour of developing countries, increasing intra- and inter-regional trade (lower transport costs), increasing investments in local processing facilities, a reduction in expensive imports of processed foods and food grains from the developed countries, and a corresponding increase in food available for intra-regional 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 maize based diets with traditional diets. But this is unlikely to be the case. Market access itself is influenced by the increasing export subsidies available to developed country industrial agriculture and increasing domestic support given to (mainly cereal crop) production systems in developing countries. Some international measures to protect developing country farmers from dumping and consequently reducing domestic prices and production capacities may emerge (Sachs and Santarius, 2007; Agriculture and natural resources team, 2004; IAASTD, 2009). Yet, the prescriptions for the future focus on increasing international trade and capital investment in agriculture (UNCTAD, 2009; EU, 2009; OECD, WTO, UNCTAD, 2009). And to add to

the disadvantage of oil and food importing developing countries, both the US and EU have reaffirmed their export subsidies (dairy industry).

Once oil prices increase, developing country governments wedded to input intensive methods of cultivation and industries that produce agricultural inputs, as well as developed country governments concerned about competitive agricultural exports will both increase domestic support steadily. Given that ultimately even complete removal of domestic support can only change a maximum of upto 20 percent of energy use in agri-food systems (even in the most energy intensive countries like the USA or UK), domestic support for production is unlikely to be reduced significantly due to fuel price increase; much of the increase in support will be export subsidies.

#### **Access to food:**

Let us recall that over the latter half of the 20<sup>th</sup> century, with worsening terms of trade, agricultural incomes are not sufficient for subsistence<sup>xix</sup>. Currently, roughly a third to half the income of cultivator households in rural in Asia, Africa and South America comes from non-farm or peri-urban labour or services (Reardon and Vosti, 1999; 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 here), to access green manure or compost from local markets or to pay for labour.

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

When grain prices rose worldwide (2004-06 first and then again in 2007-08) producers of maize, soybeans, wheat or cassava that have surpluses to sell, did gain. But for the nearly one-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, p.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 5 major exporters will face a range of peak oil price impacts; increasing food import bills, a decline in domestic production and productivity of staples (especially in Type2 production systems), increasing expenditure on food as a share of household income, and increasing domestic support 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>xx</sup> Global food price increase will stretch both food import bills and food aid budgets beyond any preceding level the world has witnessed. Because India and China, the EU, and many developing countries are major

food importing countries than food exporters, the precariousness of global food security and its susceptibility to fuel and food price volatility will be a major concern.

Local food systems '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 situation. The recent spurt of farmers markets and local food systems in the US 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 (2009) and the FAO, SOFA (2008) are premised on past petroleum 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 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 (kilotonnes) 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 minimal per capita C emissions) (UNCTAD, 2009)<sup>xxi</sup>. Yet, 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 of increasing the technical efficiency of existing and future vehicles, increase the production and use of bio-fuels (especially advanced bio-fuels with low well to wheel GHG emissions) and aggressive adoption of 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 expanding rapidly in developing countries now (USDA, 2005; Stokke, 2007), rapidly replacing traditional processors, retail, and transport systems.

Alternatives, sustainable economically and ecologically, are emerging from community initiatives (GEF, 2006), though policies that address the agri-food and transport sector linkages are few. These involve a combination of locally adapted options of mass transit, non-motorised transportation, emissions monitoring and reduction, and production and use of bio-diesel (with a much higher energy conversion ratio and emissions compared to corn ethanol). The latter, bio-diesel or bio-fuels production and local use (as in cases in Mozambique, Ghana, India, Papua New Guinea and Barbados, is a far more sustainable and genuinely renewable alternative to fossil fuel because of the energy components, biological (organic agriculture, cultivation of bio-diesel crops), mechanical (where womens groups use the diesel to operate flour mills) and chemical (extraction and use of bio-diesel in local production activities) are locally owned, operated and used (GEF, 2006).

To recap, the price impacts of peak oil will negatively affect production in Type2 and 3 agri-food systems, though the nation states, international organizations – in finance, development aid, trade, agriculture and agricultural research, will continue to support the 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 increasing trade distortions and production investments that favour the industrialised regions. This will reinforce global capture of agricultural, environmental and human resource in the guise of attempts to survive the fuel crises, thereby creating major political and economic imbalances, 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 the 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 fore-armed 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, role of bio-energy, and the policies of governments. (FAO, 2008b, p. 2)

In section 2 we have 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 energy use are being considered and promoted. Here we discuss bio-fuels and policy regimes for fuel supply and regional collaborations that may come into effect in a post peak oil world.

##### **4.a Bio-fuels, organic agriculture and technological alternatives**

Biofuels, which receive the largest investments currently,<sup>xxii</sup> reveal the same slick alliance between governments and corporate actors that mark fossil fuel based industrial agriculture. Secondly, there is serious concern that these are not alternatives enough. 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, 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 institutionalising fuel mandates and policies. Globally, as demonstrated by a US \$180 billion of 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, national mandates, all point to a commitment to find sustainable and renewable alternatives to fossil fuels and fossil fuel induced pollution and global warming.

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. Fargione *et al.* (2008) estimated 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. They find that this “carbon debt” would take 48 years to repay in the case of Conservation Reserve Program land returned to maize ethanol production in the United States of America, over 300 years to repay if 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 percent 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, 2007; 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>xxiii</sup> Biofuels are now known to cause several negative impacts, the worst being impacts on food security and the environment (FAO, 2008b; Holt-Gimenez and Kenfield, 2008; IAASTD, 2009).<sup>xxiv</sup>

Hydrogen cells too, need energy; 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 mechanisation and chemical energy inputs in agriculture will demand a complete overhaul of existing industrial agriculture infrastructure – demanding massive re-capitalization and maintaining 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 (30 % or more), especially fossil fuel consumption in agricultural production (Ziesemer, 2007; The Organic Centre, 2006). But 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 (upto a maximum of 20 percent even in industrial agriculture) and the relatively high industrial concentration in both organic and industrial agriculture (in certification, value-addition, transport, retail, etc.) (See, Twarog, 2006). Organic beef-grass, corn and soya use much lower fossil fuels (50, 31 and 17 percent less than conventional production), conserve soil moisture and reduce soil erosion, use more labour (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 de-industrialization. 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 macro-economic 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 agri-businesses), tariff on imported biofuels, process subsidies for biofuels (investment for distribution, storage and transport), and direct subsidies to the industry for research (2<sup>nd</sup> 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 bio-fuel 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, 2006). Fiscal and financial measures will include subsidising 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 out of the dependence on fossil fuels and the environmental degradation and climate change caused by them, then a “quick-fix” from bio-fuels 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, 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. Such alternative political frameworks and value systems, are features 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). 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 OECD – EU and NAFTA- in global agricultural trade (except the MERCUSOR, which has an increasing share of agriculture in their trade -within 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 (IAASTD-ESAP, 2009) standing loyalties and trade relationships between regional and OECD partners and regional trade infrastructure and market development (which is rather weak in the COMESA region)<sup>xxv</sup>. It is because of this standing loyalty that a RTA may not help address the 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), forcing an increasing integration with global trade (with NAFTA and EU) will continue to erode the terms of trade in agriculture, making MERCUSOR draw less value for more exports and pay more for imports from the EU and NAFTA members.

Current RTAs are in many ways like multi-lateral trade systems – all the subsidies and domestic support systems prevail in member countries. But the capacity of governments to address intra-regional inequality, to support small producers, infrastructure development for regional trade, and the trans-border mobility of goods and services are 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 the COMESAN regional trade volumes or value. Developing and least developed country governments will, in the near future, seek and implement policy instruments that directly address some of these non-trade barriers and improve their RTA, especially in agricultural and rural products (IAASTD, 2009). Incentives for development and marketing of traditional foods or 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 bio-fuels or organic agriculture or even the hydrogen cell can address the problem of fossil fuel dependence unless the unambiguous policy goal is the generation and maintenance of sustainable agri-food systems. 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 no 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 5, we explore how peak oil is likely to induce a change in 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 the 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 asymmetric development and access to energy, without questioning or changing the current production 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 assessments and agency reports analyse peak oil, oil prices and implications for food and agriculture (Alekklett, 2007; UNDP, 2007; IMF, 2008 UNCTAD, 2006; Nel and Cooper, 2008; APPGOPO and Reset, 2008, San Francisco Peak Oil Preparedness Task Force, 2009, Berkeley Peak Oil and Gas Resolution, 2007, 2020 Task Force, 2007, Preparing for Peak Oil - Local Authorities and the Energy Crisis, 2008, PCI, 2008, PCI, 2009, etc.) All conclude that peak oil will hit the vulnerable populations in the developing countries already facing the limited employment and livelihoods opportunities, crises 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 increase in hunger as well as hunger induced migration for the small peasant the world over – Type 1 agri-food systems will face doom in the wake of the 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 subsidised 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 degrading 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 labour resources located in developing countries. With international agencies and governments planning how to regulate the trans-national 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 not merely increase FDI in developing country agriculture (UNCTAD, 2009). Post peak oil agricultural distribution systems will give the trans-national 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, 2007) was successful in drawing the attention of governments, industry, farming communities and civil society to the evidence on the structural and functional distortions in our agricultural and food systems.<sup>xxvi</sup> Most specifically, the IAASTD presented evidence about current global norms of trade which 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 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 the 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. Everyone becomes part of an insane system that mindlessly exploits the environment (natural capital) and starves part of the human population (social capital), to keep profits flowing

(financial capital). It is likely that industry and most governments will invest in socially and ecologically sustainable alternatives in agriculture only when profits from current production and trade dry up completely. 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 must 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 or 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 visualise 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 favourable terms of trade for agriculture and re-formulating the economics that subsidizes 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 and 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, seasonal variation knowledge, preservation and processing methods, 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 USA, the peasant coalitions and markets for bio-diversity 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 provide simple incentives to foster energy efficient and nil 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 MEA, 2003) 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 (year) in his analysis of energy related literature in the early economics and natural science literature, argues that Podolinsky's case for 'labour to increase the accumulation of energy on earth' through increasing labour in agriculture for fixing 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 our valuation of labour, 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 labour (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 supply of oils 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 and economic geography (for instance, Soderbaum's (2002) positional analysis). The academic and policy clout of neo-classical 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 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 C- 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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<sup>i</sup> 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.

<sup>ii</sup> 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).

<sup>iii</sup> 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>iv</sup> 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 labour, etc. into two composite and neat compartments of direct and indirect energy (Williams, et al, 2006).

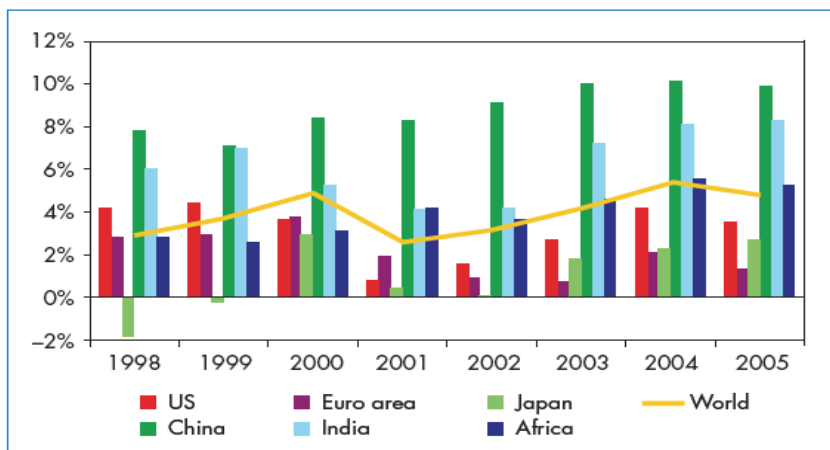
<sup>v</sup> Many have written about these intersecting, colluding networks and actors in the food-fuel complex

“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 labelled ‘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.

<sup>vi</sup> Let us recall that initially, the early-mid 2000s oil price increase did not have the expected macroeconomic impact. Even oil importing countries like India and China did well in terms of economic growth –especially compared to the OECD countries.

Figure: Global growth rates (GDP)



Source: IEA, 2006.

This was because they had sufficient current account surpluses to withstand the deficits caused by increasing fuel import bills. These countries, India in electronic and information technology software and China in manufactured goods, enjoyed significant non-agricultural export earnings too during this period. Contrary to the current accounts in some developing countries, the US current account deficit was alarming.

<sup>vii</sup> 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 4 firms (relative to 100%) in each food industry in the USA, it is a few actors who control production, processing, transport and marketing decisions. For instance, concentration ratios are, 83.5 per centage for beef packers, 66 per centage for pork packers, with broiler and turkey production rating 58.5 and 55 percentage respectively. For flour milling, the CR3 (the market concentration of top 3 firms) is 55 percentage with 80 percentage of soya crushing being controlled by 4 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 USA. 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 percentage. Together the CR4 for global commercial seeds is 29 percentage.

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

<sup>ix</sup> Compared to this, the USA uses only 10 Million tons of chemical N fertilizer (Fertiliser Association of India 2007 and International Fertiliser Industry Association 2008; from Tirado, 2009; pg.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).

<sup>x</sup> The range for population engaged in agriculture is from 2.6 percentage of the national population in the USA to 62 in India and 75 in Kenya. The range for per capita energy consumption is 76.6 (10<sup>6</sup> Kcal) in the USA and 1.1 in India and 0.6 in Kenya.(Pimentel, 2001).

<sup>xi</sup> Traits such as drought resistance, suitable quality for food and fodder, competitive performance in different crop-ecosystems, performance of intercroops and mixed farms, compatibility with family labour 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).

<sup>xii</sup> 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 percentage increase in fuel, natural gas and electricity prices respectively by 2050 (reported by CRA International) the Missouri crop production costs will increase by 8.1, 8.8, 4.4 and 10.4 percentage for dryland corn, irrigate corn, soyabean and wheat respectively (FAPRI-MU, 2009). Compare this prediction with the 'post food surplus era' (Vidal, 2007) where energy prices pushed maize and wheat prices up by 50% within a matter of weeks and that of rice by almost 75%!

<sup>xiii</sup> Nitrogen's post-harvest fate is very different in the 2 principal food streams. About 700% of N in harvested food crops become available, after processing and losses, for human consumption. In contrast, some 33 Mt N in feeds produce only about 5 Mt N in animal foods which means that, on the aver- age, 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).

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<sup>xiv</sup> Let us here recall here Milanovic (2003) quoting Kuznets;

*One could argue that the reduction of physical misery associated with low income and consumption levels...permit[s] an increase rather than a diminution of political tensions, [because] the political misery of the poor, the tension created by the observation of the much greater [income] growth of other communities... may have only increased. (Simon Kuznets, 1965, p. 174)*

<sup>xv</sup> 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 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).

<sup>xvi</sup> In June a Global AgInvesting 2009 Conference, held in New York, 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](http://www.workers.org), 2009)

<sup>xvii</sup> Western India, South Interior India and South Coastal India have almost all 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 pumps are the maximum 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).

<sup>xviii</sup> They note that

"The main risk is that G20 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).

<sup>xix</sup> This is not to argue that small farms or 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).

<sup>xx</sup> Global food price increase fuelled by an increase in oil prices saw the poorest most food deficient countries dish out the maximum revenue to access food (FAO, 2008 a). Besides, food aid volumes in 2007-08 have fallen to 2/3<sup>rd</sup> of their 1993-94 level, and imputed value of food aid is only half of what it was in 1993-94. (FAO, 2008).

<sup>xxi</sup> Within the transportation sector, maritime transport accounted for 10 % of emissions, and road transport accounted for 73%, with air and rail coming up to 12 % and 2% respectively (in 2005, UNCTAD, 2009).

<sup>xxii</sup> Investments in biofuels have 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 litres to almost 60 billion litres, while biodiesel rose from 1 billion litres to 9 billion litres, almost ten-fold. Biodiesel, the other major biofuel, is produced mainly in the EU, with 4.8 billion litres of production in 2006, compared with 850 million litres in the U.S. (FAO, 2008b)

<sup>xxiii</sup> Besides a slow down 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 report assumes (rightly so) that the same ownership, exchange and control mechanisms that work with fossil fuels will work for biofuels too.

<sup>xxiv</sup> Growing crops for biofuel 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 U.S. National Academy of Sciences (2007), consumes 200 times more water than the water used to process corn into ethanol, which involves about 4 litres of water per litre of ethanol, compared with 1.5 litres of water per litre of gasoline.

<sup>xxv</sup> 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 percent of agricultural trade) compared to the other RTAs (say AFTA and MERCUSOR, in which the agricultural trade among members is a maximum of 23 percent or less than 5 percent respectively in 2005).

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<sup>xxvi</sup> The IAASTD (2009) 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 USA, 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.