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Beyond Industrial Agriculture? Some Questions about Farm Size, Productivity and Sustainability

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Although modern agriculture has increased food production faster than population growth in recent decades, there are concerns that existing models of 'industrial agriculture' are unsustainable due to long-run trends towards increased fossil energy costs. This has led to suggestions that food production in future will need to be based on smaller-scale and more labour-intensive farming systems. This paper examines political economy arguments that large-scale capital-intensive agriculture has proved more productive. It counterposes these to ecological economics approaches that emphasize the low energy efficiency of capital-intensive mechanized agriculture. The paper argues that discussion of a 'post-industrial' agriculture remain polarized between visions of a more energy-efficient mechanized agriculture on the one hand, and labour-intensive farming by 'new peasantries', on the other. The paper identifies questions that are neglected by this debate, in particular those concerning the productivity of labour in food production and its implications for food prices and the livelihood basis of farming.

Keywords: Farm size, food supply, industrial agriculture, labour productivity, sustainability

INTRODUCTION

The long-run decline of agricultural commodity prices in the second half of the twentieth century is a testament to the growth of aggregate agricultural production outstripping aggregate demand for food, despite the human population almost doubling over that time (Spielman and Pandya-Lorch 2009). As with all aggregate measures, this statement masks local variations that include some regions where people are unable to produce or purchase sufficient food and others where formerly agricultural land has been left uncultivated in order to reduce surpluses of production. The consequent existence of malnutrition in a world in which agricultural output is quantitatively greater than total food demand is a source of much criticism of contemporary agricultural systems, but this paper is primarily concerned with a different criticism: that the aggregate production achieved by modern agriculture will not be sustainable in future. In practice, the question of farm scale looms large

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in discussions of both distributional and sustainability problems in agriculture. Smaller farms are widely advocated as both providing opportunities for food security for the poor and also as being more appropriate for the implementation of ecologically beneficial farming practices.

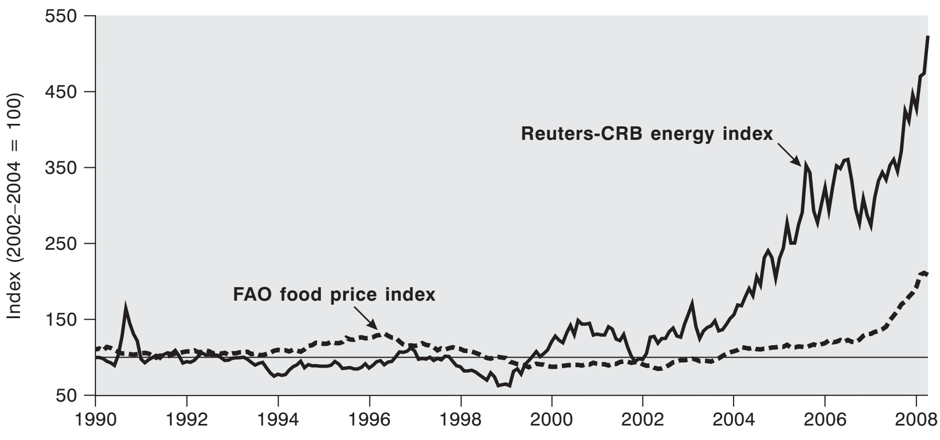
Such arguments have been given renewed impetus by recent volatility of prices of fossil fuel sources, raising the prospect of greatly increased costs of mechanized production methods that form the basis of large-scale farming. This scenario has been argued persuasively by Weis (2010, this issue), who also maps out the logic of a switch to smaller-scale, more labour-intensive food production. In this paper, I briefly review the sustainability threats posed by modern capital-intensive agriculture and the ways in which these may be altered by changes in the availability of fossil energy. The paper then considers the relationship between farm scale and productivity. This has been the subject of research and debate for more than three decades (Lipton 1977), and remains a key theme in the political economy of agrarian change (Byres 2004). This paper summarizes the conclusions of political economy analyses undertaken to date – that productivity in large-scale capitalist agriculture is superior to that in small-scale 'peasant' production – and asks whether these need to be modified in the light of changing energy costs. In doing so, the paper seeks to draw on experience where mechanized agriculture has had to be adapted in the face of greatly reduced availability of petroleum-based fuel and industrial inputs.

THE SUSTAINABILITY OF MODERN AGRICULTURE

The imperative to increase agricultural productivity has been strongly associated with industrialization, driven partly by growth of new markets constituted by an urban and industrial workforce (see Moore 2010, this issue), and partly by the need to increase farm labour productivity as its growing cost and scarcity reflected increased demand for labour in industrial centres. Industrialization has also provided the principal means through which agricultural productivity has increased: mechanization and agro-chemicals (especially inorganic fertilizer and pesticides). The balance of 'inputs' has tended to vary according to local 'factor scarcity', and in particular the land/labour ratio. Thus, where land/labour ratios were relatively high (land relatively abundant, e.g. the United States), greater emphasis was initially placed on mechanization, whereas where the ratio tended to be small (land scarce, e.g. Japan), greater emphasis was placed on fertilizer (Hayami and Ruttan 1985). Despite these differences, productivity in 'industrial agriculture' has tended to converge on a similar set of technologies that combine agrochemical use with mechanization and improved water control (irrigation and/or drainage) and the selection of crop varieties adapted to thrive when provided with them. In each case, both the means and ends of increasing agricultural productivity are to be found in industrial development. Since the 1960s, this model of industrial agriculture has been successfully applied to bring about aggregate increases in cereal output – the 'Green Revolution' – in less industrialized countries such as Mexico and India. However, growing criticisms of 'industrial agriculture' identified a series of negative environmental effects.

These include soil compaction through excessive machinery use, contamination of groundwater and surface drainage with fertilizer (phosphates and nitrates) and pesticide residues, reduction in ecological biodiversity (including, as a consequence,

Figure 1. The relationship between food and energy prices

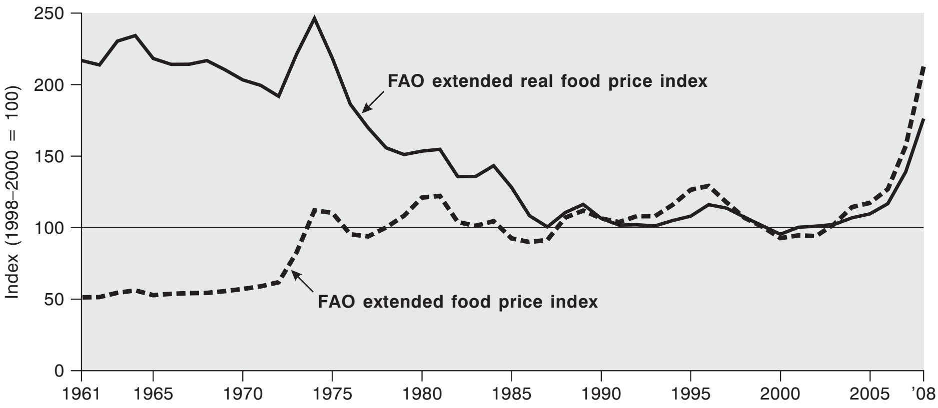


Source: FAO and Reuters-CRB.

increased vulnerability of crops to pests), and high rates of carbon emission due to petroleum consumption (as fuel and in fertilizer manufacture). In arid climates, the requirement for irrigation, alongside inputs of fertilizer, pesticide and machinery, has been identified with a range of further negative environmental impacts, including depleted groundwater and salt accumulation (salinization) in soils where drainage is inadequate (see Mollinga 2010, this issue). In addition to these environmental concerns, the capital investment required to purchase inputs of machinery and agrochemicals means that industrial agriculture has been identified as favouring an increasing scale of farming, resulting in concentration of control of land and increasing landlessness among rural populations, with negative effects on agrarian societies.

To these long-standing concerns about the social and environmental sustainability of industrial agriculture has been added a set of questions arising from its dependency on cheap energy derived from fossil fuel. These questions are of two kinds. The first relates to the direct consequences of rising cost of energy used in agricultural production, while the second relate to the impacts on agriculture of measures to mitigate climate change through reducing carbon emissions. Although distinct, these can be seen to be mutually reinforcing. Concern over the vulnerability of agricultural output to rising oil prices draws particularly on the rapid rise of food prices in 2007–8 following three years of rising energy prices (Figure 1). Even sharper increases for individual commodity prices (100 per cent in the case of wheat) are reputed to have caused riots in 37 countries (Imai et al. 2008; Bush 2010). While these rapid price movements may owe much to market deregulation and speculative activity (Ghosh 2010), they also illuminate a tighter coupling of energy and agriculture markets. It is evident that rising energy costs have a direct effect on food production costs, mainly via fuel and fertilizer prices, and high food prices were associated with past episodes of rapidly rising oil prices in the 1970s (Figure 2).

Figure 2. Trends in food prices



Source: FAO.

However, the contemporary linkage between agricultural and energy prices is principally driven by a combination of environmental and security concerns that have diverted agricultural output from food to biofuel production (FAO 2009a). Thus, the perception of rising oil prices as indicating diminishing oil stocks and threatening future security of energy supply prompted governments in the USA and EU to fund subsidies – estimated at over US$10bn in 2006 alone – for the production of biofuel from agricultural crops. In 2007, this diverted some 30 per cent of US maize output or 12 per cent of world maize output into ethanol production (FAO 2009a). The political climate favouring production of biofuel in future energy policy is reinforced by environmental arguments that it constitutes a renewable energy source that can substitute fossil fuel (petroleum), and thus reduce net carbon emissions as part of a strategy to mitigate climate change. Biofuels are therefore the link through which growing concerns with climate change reinforce and accentuate the rise in agricultural commodity prices arising from higher fossil fuel costs in agricultural production. It is important to note that not only is most[1] biofuel production uneconomic, requiring subsidies as observed above, but it does not necessarily produce a net reduction in carbon emissions (Pimental and Patzek 2005). From a sustainability standpoint, therefore, the best that can be hoped is that biofuel, if not a futile distraction, represents a strategic investment by governments with a view to stimulating a search for 'second generation' technologies that are more viable from both an economic and environmental perspective. The more important conclusion is that perceptions of scarcity or insecurity of oil supply have become a factor driving up agricultural commodity prices and are likely, as a consequence, to promote competition for control of land, water and other inputs to agricultural production.

In terms of agricultural sustainability, these developments suggest, on the one hand, a prospect of higher prices for agricultural commodities, providing increased

[1] The exception being ethanol produced from sugar cane in Brazil (FAO 2009a).

incentive to technical innovation, and, on the other hand, a renewal of interest in alternative systems of agricultural production, and particularly alternatives that have lower dependence on oil and lower net emissions of carbon. Weis is not alone in seeing these changing constraints on agriculture as presenting an opportunity to foster smaller-scale production using less machinery and more labour. In the following sections, I first review debates about the relationship between farm size and productivity and then consider whether these require modification in the light of the changing context of energy and climate.

FARM SIZE AND PRODUCTIVITY

In many respects, the 'food crisis' has intensified a search for alternatives to industrialized agriculture that long preceded it. At least since the 1970s (Lipton 1977; Berry and Cline 1979), there have been calls to invest in small-scale agriculture as a means of improving the efficiency of resource use in farming. More recently, this logic has provided the basis for arguments in favour of redistributive land reform (Griffin et al. 2002), and for models of 'food sovereignty' that provide a focus for international coalitions of 'anti-globalization' rural movements such as La Vía Campesina (Pimbert 2009). Since these arguments in favour of small-scale agriculture have also been subject to detailed criticism (see below), it is worth recapping the main elements of that critique before reassessing the prospects of improved agricultural sustainability through a reduction in farm scale.

An initial problem with arguments about the effect of farm scale on productivity is that they frequently confound three different types of comparison: those of farm size, farm scale and farm type (Ellis 1988). Farm size comparisons relate to differences in size of farm area, and are the most frequent basis of arguments that larger farms are associated with lower productivity per unit area – the 'inverse farm size / productivity relationship'. One explanation for the 'inverse relationship' is simply that farmers with larger landholdings do not cultivate all their land. Thus, comparisons of productivity may need to be based on the area cultivated, rather than total farm area. Moreover, strict comparisons of farm size imply similar levels of technology across the size range. However, in explaining empirical relationships of land productivity and farm size, it is evident that this condition may be 'relaxed' and that other types of comparisons are brought into play. For example, it is often argued that productivity on larger farms is lower due to less efficient labour supervision, compared to smaller farms that use a higher proportion of family labour. Here, then, the comparison of farm size is conflated with the type of farm: 'family farms' using predominantly family labour compared to capitalist farms using hired labour, or large farms using arrangements such as labour tenancy.

A second explanation of the inverse relationship argues that factor prices of land, labour and capital are different for larger and smaller farmers. For smaller farmers, the cost of labour is lower, whereas for larger farmers the cost of capital and land is relatively lower (Ellis 1988; Griffin et al. 2002). As a consequence, larger farmers tend to use more capital and land, and smaller farmers more labour, in agricultural production. It is then argued that in economies with abundant labour and scarce land and capital, where the social opportunity costs of labour are low and those of capital and land are high, the investment pattern of smaller farms is more 'socially optimal'

(Ellis 1988) or provides higher 'Total Factor Productivity' (Griffin et al. 2002), because it maximizes use of a cheaper factor (labour), rather than more expensive factors (capital and land). This in essence was the basis of Lipton's original (1977) advocacy of support to small farms as the basis of rural development. It is evident that the comparison here is not a simple one of farm size, but of investment patterns, and in particular the substitution of labour by capital, properly denoted as a comparison of 'farm scale'. Although farm scale may often increase as farm size increases, by virtue of mechanization, it is possible for farm scale to increase independently of farm size, for example, in cases of intensive livestock or horticultural production.

These details prove important in critiques of the postulated inverse relationship of farm size and productivity. Byres (2004) and Dyer (2004) have both argued that the explanation for higher land productivity of smaller farms arises not from greater efficiency, but from greater self-exploitation, of family labour. This, they argue, is borne out of indebtedness and forms of unequal exchange that create conditions of distress for many smaller farmers. Where comparisons involve differences in scale of production (i.e. capital investment), the empirical evidence for an inverse relationship between farm size and land productivity often breaks down (Dyer 2004). Khan (2004), drawing on evidence of borehole irrigation in Bangladesh, argues that the inverse relationship may only be characteristic of traditional, non-mechanized farming.

A large number of writers have argued that claims of productivity advantages for small farms are based on flawed empirical analysis. These include failure to take account of spatial heterogeneity; for example, observations that higher density of settlement, on more productive land, imply a reverse causality: higher productivity causes smaller farm size (Dyer 2004). Others have pointed to failures to analyze rigorously the historical processes that gave rise to successful, highly productive, small farms in East Asia during the twentieth century (Bramall 2004; Karshenas 2004), in particular the resource flows between agriculture and non-agricultural economic activity. Of particular significance for the purposes of this paper is the observation that a minimum farm size is specified by the amount of land needed to meet the needs of those it is to support. Khan (2004), for example, observes that landholdings of 0.5 ha that would be created by redistribution to provide equal land for all in Bangladesh are regarded as 'non-viable', as are many of the small plots created by de-collectivization in China (Bramall 2004). Dyer (2004, 51n) similarly cites comparisons of 'optimal' land allocations in India of one acre per household with the minimum of 15 acres required for a reasonable standard of living or 7.5 acres required to fully employ household labour. Effectively, therefore, lower limits to 'viable' farm size are determined not by considerations of productivity per unit area (on which the inverse relationship is predicated), but on total returns to farm labour.

Questions of labour productivity have received much less attention in agronomic research than those of land productivity. It has been assumed that increases in land productivity will be accompanied by increases in labour productivity, and it is certainly the case that agricultural intensification has achieved this, even without significant mechanization as in irrigation improvement in nineteenth-century Japan (Karshenas 2004). More generally, however, technical change that increased land productivity has required more labour – at least in the short term. This was the case of the early Green Revolution, where labour requirement was increased for fertilizer application, weeding, water control and harvesting. Where capital has been available, this higher labour demand has been subsequently reduced by mechanization (Hossain et al. 2007), resulting in much higher labour productivity. Investment is therefore key to raising labour productivity and, logically, investment in agriculture will only take place if farming can pay a wage higher than the opportunity cost of labour.

Labour productivity in agriculture thus presents two questions of critical importance. First, does the existing productivity of labour in agriculture match the opportunity cost of labour in the wider economy? Second, does the investment of more labour through 'labour-intensive' farming deliver a higher return on that effort? It seems clear that in many rural areas, even in the relatively non-industrialized economies of Africa, the answer to the first of these questions is negative, producing an exodus, temporary or permanent, of the more able workforce from agriculture. The low productivity of labour in much 'traditional' agriculture in Africa has led some to argue that only capital investment and a consequent increase in farm scale can achieve the significant increase in food productivity that increasing urbanization in Africa requires (Sender and Johnson 2004). It is significant in this regard that analysis of rural income composition in East Africa, summarized by Ellis and Freeman (2005, 43) shows, first, that non-farm income constitutes a higher proportion of income as total income rises, so that the better-off are less dependent on agriculture. Second, however, farm productivity also rises (fivefold between lowest and highest income quartiles in Tanzania, for example) as total income rises, suggesting that higher returns from non-agricultural work are critical as a source of investment to raise farm productivity. This process was identified as the mechanism for financing terrace construction, leading to environmental improvement and agricultural intensification, in Machakos District, in Kenya from the 1930s to the 1990s (Tiffen et al. 1994). The Machakos case also suggests that this process is both influenced by, and greatly magnifies, socio-economic differentiation over time (Murton 1999). The consequent skewed nature of productive capacity in East Africa was evident during the period of high food prices in 2007–8, when FAO (2009a) found little evidence that smaller producers were able to increase their crop output to take advantage of better prices. A major factor identified was that relatively few producers had regular links with agricultural marketing chains, so that even in areas where 80–90 per cent of households grow maize, such as Kenya, Zambia and central Mozambique, only 25–35 per cent normally sell it.

The answer to the second question posed above seems to be that, in the absence of a significant shift in productivity and/or much higher agricultural prices, more labour-intensive farming will further reduce labour productivity, signifying an even lower 'labour wage', tantamount to a form of agricultural involution (Geertz 1963). I turn now to consider whether this analysis is significantly altered by the prospect of increasing oil and food prices.

FARM SIZE AND PRODUCTIVITY

The Imperative of Energy Efficiency

I observed above that rising food prices were linked to rising oil prices both directly, via rising agricultural input costs, and also indirectly via diversion of food crops to manufacture substitutes (biofuels) for oil-based fuels. It is also important to note that, if international concern over climate change is sustained, in future agriculture – as all other economic activity – can be expected to be subject to 'climate change mitigation strategies', and modified in order to improve its 'carbon balance' by maximizing the amount of carbon absorbed from the atmosphere and minimizing the greenhouse gas emissions produced by agricultural processes. An early effort to envisage such 'low greenhouse gas agriculture' (FAO 2009b) estimates that agriculture is responsible for 10–12 per cent (5–6 Gt of CO_2 – equivalent) of annual global greenhouse gas emissions. It considers a number of alternative ways of reducing this and argues that switching to organic production methods would reduce net emissions by 36 per cent, principally by eliminating the use of industrially manufactured fertilizer in favour of fertilizer made from organic farm waste. The study identifies a possible further 30 per cent reduction in net emissions through the use of 'no-till' farming in which soil is not ploughed. It is estimated that the overall savings of 65 per cent of greenhouse gas emissions from agriculture can be achieved at the cost of yield reductions of 30–40 per cent compared to the most highly productive industrial agriculture. In areas with lower productivity, it is argued that yield reductions would be much less.

These estimates relate to arable crops and pastures, not flooded rice paddies, and their projection from experimental station measurements in Europe and North America to provide estimates of 'global' impacts is evidently open to question. Of greater interest to our discussion here is that the FAO study does not refer at any point to questions of reducing mechanization and increasing labour inputs to agriculture. Indeed, the advocacy of a combination of organic and no-till farming has a certain irony in that one of the main proving grounds for 'no-till' technology in the 1970s and 1980s – then, as now, primarily practiced using herbicide applications[2] to kill weeds and stubbles rather than burying them by ploughing – was that emblem of industrial agriculture: soybean production in Brazil and Argentina. Thus far, then, there seems little indication, from FAO at least, that the impending crisis will require a major restructuring of agricultural production.

We observed above that, under current market arrangements it is unlikely that smaller producers will have better access to markets than larger producers, but would a rise in costs for fuel and other industrial inputs make smaller producers less vulnerable to competition from larger-scale agriculture? What would a more sustainable, smaller-scale agriculture look like? Arguments in favour of greater sustainability of smaller-scale, less industrial, agriculture relate to greater energy efficiency of systems that are less dependent on fossil fuel (Martinez-Alier 1990). An example of this approach is that of Weiner et al. (1992), who compared the energy contained in inputs and outputs for mechanized commercial farms and small-scale African farms in Zimbabwe. Their figures (Weiner et al. 1992, tables 3 and 4) showed that total energy inputs (of which half were accounted for by nitrogen fertilizer) were three times larger on mechanized farms than on those using ox-drawn ploughs,

[2] The FAO advocates an 'organic' form of 'no-till' which avoids herbicide use, but commercial 'no-till' farming is largely herbicide-based, initially using paraquat, manufactured by ICI, later substituted by glyphosate, manufactured by Monsanto, which requires the use of crops 'genetically modified' to be herbicide-tolerant.

whereas yields of maize were only 32 per cent higher. This translated into an overall energy efficiency (energy output/energy input) twice as high on the smaller-scale farms using draft oxen. Perhaps more surprisingly, the data show higher human energy inputs on the larger farms (in this regard, at least, consistent with Sender and Johnson 2004), so that returns to human labour were actually lower on the mechanized than on the animal draft systems. However, as the authors of the study note, the data for the ox-draft system are fairly optimistic, both with respect to maize yield (3.7 t/ha) – only likely with good rainfall and manure applications – and availability of draft oxen, since at least a quarter of households in Zimbabwe's communal areas had no oxen at all. For many, therefore, labour input would be much greater, and yield much lower, providing much less favourable figures for returns to labour productivity. As indicated in the previous section, the key factor determining the viability of the ox-draft system was access to non-farm (especially wage) income with which to finance the purchase of oxen and equipment and to hire additional labour where necessary (Bonnevie 1987).

A more recent example of efforts to establish a more sustainable alternative to industrial agriculture is the promotion of 'agro-ecological' agriculture by the state government of Rio Grand do Sul (RS) in southern Brazil, between 1999 and 2002. 'Agro-ecological' farming shares some characteristics with organic farming, notably in avoiding use of industrially manufactured agrochemicals, and more generally seeks to maintain rather than disrupt ecological processes (Gliessman 1997). The programme in RS offered credit to 'family farms' in order to encourage adoption of agro-ecological farming methods and linked this to the establishment of dedicated markets for their produce, particularly in the state capital, Porto Alegre. Comparison of inputs and outputs on both agro-ecological and conventional farms (Fernandes and Woodhouse 2008) showed that over 70 per cent of fossil fuel energy on conventional farms was accounted for by nitrogen fertilizer, and that this was reduced by more than half on agro-ecological farms. While this offered a clear cost advantage (and one that would be expected to grow as oil prices rise), it was offset by the additional costs incurred by marketing through separate agro-ecological marketing channels, leaving agro-ecological households with a slightly lower per capita income from farming.

What this and the other examples considered above suggest is that it is possible to reduce quite radically the energy efficiency (and hence sustainability) of 'industrial agriculture', although the route to achieve this may lie most immediately via reductions in the use of industrially manufactured fertilizer (and its substitution through organic approaches to maintaining soil nitrogen levels), rather than reductions in mechanization. This is clearly not the whole story, since it omits the energy requirements of transportation and agro-processing that form as much a part of industrial agriculture as its on-farm activities, but it does not suggest immediate gains from smaller-scale, more labour-intensive farming.

Escape from Fossil Fuel Dependency? The Case of Cuba

Perhaps the most comprehensive experience of implementing an alternative to conventional industrial agriculture is provided by Cuba during the 'special period in peacetime' in the 1990s. Following the end of preferential trade terms with the

Soviet Union in 1989, the value of Cuba's exports, of which two-thirds were provided by sugar, fell by 50 per cent in 1991 (Deere et al. 1994) and exports during 1991–5 averaged 30 per cent of their value during 1985–9 (Pollit 2009). The consequences were a greatly reduced capacity to import oil, reduced by 55 per cent from 1989 to 1992 (Deere et al. 1994) and machinery spare parts. A programme of increasing mechanization of agriculture pursued during the 1980s was thrown into reverse as the government sought to maintain production on state farms by recruiting more labour into agriculture and also reducing the scale of production. Labour recruitment took the form of seeking more permanent workers by offering better pay and conditions, including new residential areas in rural areas, and also mobilizing volunteers for two-week periods to meet peak demand at planting, weeding and harvesting. Deere et al. (1994) estimated that in Havana province in 1991, some 7,600 permanent (two-year contract) and 146,000 temporary (two-week contract) workers were mobilized in this way. In addition to this labour mobilization to maintain production in the face of lack of fuel and spare parts to keep machinery running, the crisis prompted a reorganization of the scale of production, with large state farms being subdivided by both area and type of enterprise, initially as managerial units (Unidades Básicas de Producción – UBPs) and subsequently as worker-run co-operatives (Unidades Basicas de Producción Cooperativa – UBPCs) leasing land, buildings and equipment from the state (Deere et al. 1994). More generally, smaller-scale production of root crops, plantains and vegetables was fostered by intensifying marketing efforts among existing peasant farmers, and allowing individuals access to unused state land, not only on state farms in rural areas but also on any available space in urban areas.

The Cuban experience of reorganizing agricultural production has been widely hailed as an 'organic revolution' showing that an alternative to industrial agriculture is possible. The shortage of imported animal feed, industrial fertilizers and pesticides generated alternative 'organic' input supply chains to provide seeds, compost and pest-control methods, and stimulated innovative ways of recycling agricultural waste (Koont 2008; Premat 2009). Hundreds of thousands of oxen were trained and deployed to replace tractors (Deere et al. 1994). In assessing what can be learnt after two decades, it must first be acknowledged that the outcomes are not as straightforward as the discourse of 'organic revolution' might suggest. One reason for this is that Cuba's 'special period' effectively came to an end with the opening of bilateral trade agreements in Venezuela after 1999. This not only provided a new source of oil imports on favourable terms, but has also been accompanied by a growth in export earnings from tourism and from health and education services supplied by Cuban doctors and teachers to Venezuela and other parts of Latin America (Pollit 2009). The effect of this transformation in the composition of Cuban export earnings places Cuban agriculture, once the primary source of export earnings, in a different political and economic context with two quite distinct outcomes. The first appears to be an enduring success of 'urban agriculture' in self-provisioning the urban population with vegetables, with some published estimates of 4.2 million tons produced from small plots totalling 70,000 ha in 2006 (Koont 2008). Integral to this success has been a shift in the social organization of production and operation of local markets, combined with technological innovation in techniques of organic fertilizer and pesticide production and use. Effective state-led political mobilization is regarded by some observers as having played a critical role: 'strong, disciplined central direction and guidance are combined with decentralised action in input provision, marketing and production' (Koont 2008, 287).

A second, distinct, outcome has been the collapse of the Cuban sugar industry and the stagnation of Cuban agricultural output more generally. From an annual output of about 8 million tons during the 1980s, the initial crisis in oil and spare parts availability resulted in a drop of 40 per cent in sugar production by 1993, with output averaging 3.7 million tons by the end of the decade (Pollit 2009). A further reorganization in 2002 sought to close half of the milling capacity and concentrate production on the more productive areas, but output in 2006–7 fell further, to 1.2 million tons. The retrenchment of the sugar industry saw 100,000 workers laid off and 600,000–700,000 ha of land transferred to non-sugar agricultural production. However, non-sugar agricultural production has, in aggregate, failed to expand significantly, and food imports rose by 50 per cent between 2004 and 2006. Commentary on the success of urban agriculture and the comparative lack of dynamism in Cuban agriculture more generally tends not to link the two, although possible interactions, such as reduced urban demand for higher-value vegetable output from rural areas might be relevant.

For my present purpose, what does the experience of the Cuban 'special period' tell us about 'labour-intensive' food production as an alternative to industrial agriculture? At a basic level, it suggests that, where supported technically and organizationally, it has been possible for small-scale, labour-intensive production to provide a significant proportion of fresh vegetables needed to satisfy local demand. In drawing this conclusion, it is important to emphasize context-specific conditions, notably the exceptionally strong political mobilization and organizational capacity in Cuban state and society, Cuba's unrivalled human resource of agricultural scientists and technicians, and relatively favourable year-round growing conditions provided by tropical temperatures coupled with urban water-supply infrastructure. There seems much less evidence that the production of staple cereals and pulse crops has been adequately secured by a switch to labour-intensive production methods. Nor is there yet any clear picture of the impact on productivity of moves to reorganize agricultural production on co-operative lines (Deere et al. 1994). Part of the reason for this may lie in the nature of agricultural markets in Cuba, as argued by those seeking market deregulation (e.g. Alvarez and Puerta 1994). Part may also lie in the complex relations of state farm/co-operative workers' allocation of labour between their wage-earning agricultural jobs and their individual plots, as Kitching (2004) described for post-Soviet Eastern Europe. It is evident that such competing demands on labour will be intensified by lower labour productivity in agriculture. It is relevant here to note that urban agriculture can tap labour inputs with relatively low opportunity cost, such as those of retired people, as observed by Premat (2009). Low returns to labour might therefore be expected to be less of a problem in urban agriculture.

From the examples I have examined thus far, it is possible to argue that a rise in price of oil-based inputs could be countered by a switch to non-oil inputs, including increased use of animal and human labour. Moreover, it seems this could constitute a more environmentally benign system of food production if supported by the scientific effort employed by the Cuban government in its promotion of small-scale vegetable production. However, there are also grounds (see FAO 2009b) to suppose that, in contrast to Cuba's experience, reduction in mechanization might not be the primary effect of increased oil prices, since reduction in industrially produced nitrogen fertilizer in favour of organic fertilizer is likely to have a larger impact on both production costs and environmental costs (carbon emissions). With this caveat, then, if it is the case that rising energy costs result in a move to more labour-intensive, smaller-scale production methods, what are the implications?

'New Peasantries'?

A systematic presentation of the type of farming that might be consistent with the labour-intensive approach to food production advocated by Weis and by the growing campaigns for 'food sovereignty' is that of van der Ploeg (2008) who argues that 'new peasantries' are the vanguard in struggles for autonomy and sustainability. It is a key element of van der Ploeg's conception of such peasantries that they represent a turn away from market-mediated relations of production. Land access is achieved below 'market' rates by inheritance or by drawing on 'communal' property systems. Production inputs are generated on the farm by more intensive labour input. Indeed, notions of diminishing returns to labour intensification in farming are dismissed (in addition to any possibility of agricultural involution) as a temporary phenomenon to be overcome by more sophisticated knowledge and management of nature, leading to an increase in value added in production (van der Ploeg 2008, 46). This is consistent with the assertion that farm labour should also be 'distanced' from markets.

There are tensions within this formulation, however. On the one hand 'pluri-activity' (i.e. work outside the farm) is recognized as an important source of capital investment for the farm (as we observed in the cases of African farming, above), but on the other hand it is necessary that labour – as other resources on the farm – is valued at below 'market' rates: 'If all resources used on the farm had to function as capital (i.e. generate at least the average level of profitability) and all labour was to be remunerated as wage labour, then nearly all Dutch farms . . . would go broke' (van der Ploeg 2008, 49). There are, therefore, questions of the extent to which labour is subject to (external) market relations or (intra-family) priorities, which involve assumptions about processes of power and authority and decisions on levels of individual consumption. This point is reinforced by van der Ploeg's observation (2008, 263) that 40 per cent of Dutch farming families derive less than the legal minimum income from farming. It seems hard, therefore, to avoid the conclusion that new peasants' 'autonomy' from markets and sustainability of natural resource stewardship is to be achieved by relative poverty of income. This has important implications that need to be recognized in arguments for alternatives to industrial agriculture, not least in relation to the level of food prices.

LIVELIHOODS AND FOOD PRICES BEYOND INDUSTRIAL AGRICULTURE?

Uncertainty over the impacts of climate change on agriculture, together with the perception of threats – physical, economic and political – to future energy supplies have raised questions about the sustainability of industrial agriculture. These reinforce earlier concerns about the ecological, economic and political impacts of large-scale capitalist farming and trends toward concentration of transnational corporate control of input supply and market chains, evidenced in the increasing prominence of anti-globalization movements and campaigns for food sovereignty. The papers by Weis and Moore both capture, and provide a rationale for, this sense of industrial agriculture having reached certain biophysical and political-economic limits, with an implication of more or less abrupt 'crises' and breakdown, to be replaced by something else. The contours of what this alternative food production system will be remain unclear, however, other than that it should be labour-intensive, correcting deficits of rural employment and income, and that it should be more ecologically benign than current food production practices. To these can be added expectations that it will provide food of better quality and through markets governed in ways that prevent exploitative terms of exchange, food dumping and other practices that currently disadvantage smaller-scale producers (for a statement of 'food sovereignty' principles, see e.g. Pimbert 2009).

Within a broader concept of new society–nature relations, an important element of an alternative food production system is that it will employ different types of technology from those used by industrial agriculture. Substantively, this is often stated in terms of organic or agro-ecological methods that eschew industrially manufactured agrochemicals in favour of those derived more directly from nature: farmyard manure, phosphate rock, pest control by natural predators or adjustment of planting dates, and so on. Within this perspective, there is a tendency to emphasize farming skill and 'indigenous' technology – that is technology capable of manipulation and control by agricultural producers themselves. The papers by Wield et al. (2010, this issue) and Kloppenburg (2010, this issue) suggest a need to reassess this vision to include the possibility of linkages beyond the farm, or farmers' associations, that enable the exploitation of science more explicitly in the process of agricultural innovation. More specifically, the trajectory of 'GM' seed varieties for agricultural crops seems not to be determined exclusively by transnational biotechnology corporations, despite the capacity of these corporations to influence legislation on property rights within national jurisdictions. The exploration of 'open-source' models of genetic improvement by Kloppenburg offers a mechanism through which 'GM' technology might respond more directly and consistently to a wider constituency of agricultural producers, although, as with all 'commons', much depends on how, and by whom, the system is governed. A degree of self-government is implicit in the open-source model, but the role of the state (or an international body bringing together national governments) would seem fundamental, both in terms of directly funding and executing the necessary research and development of biotechnological applications and also as a regulator and arbiter of rights and obligations of (private-sector) agencies involved in development and use of the technology (seed varieties, 'biopesticides' etc.). Certainly, state agency has been prominent in generating technological innovation for Cuba's 'organic revolution', as noted above, as well as in China's promotion of '*Bt*' cotton (see Wield et al.).

These considerations of political governance of biotechnology underline a sense that, while the ecological dimensions of a new nature–society relationship for food production may be discerned, this cannot be said for the political economy of food production. This is to say that, while considerable disagreement may exist over the risks posed by ecological threats such as soil erosion, or genetic crosses of GM crops with wild species producing 'superweeds' (emphasized by Moore), there is at least an awareness of what those threats are and what technical approaches might be explored to overcome them in order to sustain food production. In contrast, the economic and political relations of alternatives to industrialized capitalist agriculture seem not to have advanced beyond polarized debates between 'small-scale', labour-intensive 'peasant' or 'family' farming and large-scale, mechanized 'industrial' farming. I would argue that such binary confrontation – displaying similar characteristics to that identified by Mollinga for debates of agricultural water use in India – fails to address the basic problem that greater labour intensity in agriculture introduces a contradiction between returns to agricultural labour and food prices, and hence questions the livelihood basis of farming. As I observed above, in the discourse of 'new peasantries' this is accommodated by a below-market return to labour in peasant households, offset by below-market costs of access to land and capital investment generated by non-farm income earned at market rates. Does this invalidate the small-scale labour-intensive model of food production?

As noted, successful 'peasant' producers are critically dependent on off-farm income, both to compensate below-market returns to agricultural work (cf. van der Ploeg 2008) and also to generate investment to increase productivity. In wealthier, industrialized societies (e.g. the EU, Japan, USA), state policy has effectively undertaken a similar role, through agricultural price support or direct income transfers, enabling capital investment and increases in labour productivity on 'family' farms. To an extent, this can be regarded as having assisted otherwise 'non-viable' farmers to survive as small-scale producers, or to increase the scale of their production, in a market where food prices have tended to fall. If, as seems likely, capital-intensive agriculture suffers a significant increase in costs, through input price rises and more costly environmental protection measures (e.g. climate change mitigation through reduced greenhouse gas emission), the returns to labour in labour-intensive agriculture will also be improved, and may enhance the viability of small-scale farming as a consequence – but only as long as output prices stay high.

A further implication of labour-intensive food production is that a larger part of the total labour available is dedicated to food production. To the extent that there is surplus unemployed labour (i.e. with zero income), this may be regarded as a positive development, and forms the justification for land redistribution and resettlement promoted by movements such as MST in Brazil. If the long-term reality is low income, however, the non-income resettlement benefits, such as healthier rural residential environments, may be insufficient to persuade settlers' children to stay on the land. These considerations suggest that adherence to a small-scale labour-intensive 'peasant' model as the alternative to capitalist farming may be misplaced, unless it is explicitly linked to the development of additional, higher-earning (i.e. higher labour productivity) sources of employment .

There is no evidence, as yet, that small-scale labour-intensive production will offer advantages over larger-scale, highly capitalized farms, even where energy prices rise, particularly for lower-value staple food crops. Moreover, it is conceivable that (some) large-scale producers will adopt more sustainable agricultural practices, as FAO (2009b) anticipates. For higher-value, typically more labour-intensive, crops, such as vegetables, it seems more likely that smaller-scale production will be able to generate sufficient returns to make labour-intensive production 'viable', and here a rise in prices could significantly shift the structure of production, along the lines of Cuba's urban agriculture. For many urban areas, the opportunity cost of labour of those in employment will be a disincentive to labour-intensive agriculture, although those with access to well-paid jobs have a greater capacity to support labour-intensive food production, by paying higher prices for food, or by diverting part of their own labour to producing food. Paradoxically, where non-agricultural income is very high, it provides an opportunity to treat part-time agricultural work for self-provisioning as a form of consumption choice (as, for example, in the case of middle-class urban residents renting municipal-owned 'allotments' to grow their own vegetables in the UK). This suggests that labour-intensive small-scale production may well have a role in post-industrial agriculture, but mainly as part of a more diversified portfolio of income-earning activity. This would allow the comparatively low economic return from 'farming' to be covered by earnings from other, more remunerative activity.

For reform of the existing, large-scale 'global' food system, in which much of the value chain of food is controlled outside agriculture itself, it would seem that more attention needs to focus on governance of the system, to discipline its drive to profit and accumulation by the effective introduction and imposition of social goals. As yet, steps in this direction have hinged on 'consumer activism' (e.g. in 'fair trade' campaigns) which have demonstrated the capacity of highly concentrated food marketing systems to implement broad, if incremental, change. A radical change in state regulatory stance (e.g. in relation to food quality standards and trading margins) also seems likely be required to achieve significant change towards a more ecologically benign and 'socially optimal' food system. While squeezing the margins of value chain intermediaries might minimize the contradiction between higher prices for food producers and avoiding higher prices for food consumers, it is unlikely to postpone indefinitely a reassessment of the resources to be devoted to food production and their relationship to 'viable' farming livelihoods.

CONCLUSIONS

This paper took as its starting point the notion of an impending crisis in the established pattern of 'industrial agriculture', precipitated by cumulative environmental impacts and the rising cost of fossil energy, and the argument that smaller-scale, more labour-intensive patterns of food production would provide a more sustainable alternative. While there is evidence that smaller-scale production is more efficient in terms of energy use, it generally involves lower labour productivity, and hence lower earnings, than either large-scale agriculture or non-farm work. This may present fewer problems in some contexts, such as 'urban agriculture' where food production may be able to tap labour with low opportunity costs. However, the paper questions whether an emphasis on small-scale production skills may obscure evidence of the importance of systematic application of science in technical innovation, whether commercial, state-led or 'open-source', in increasing labour productivity, and of the (as yet largely untested) capacity of large-scale agriculture to adopt the range of more sustainable farming practices already identified. More generally, the paper asks whether proposals for small-scale alternatives to industrial agriculture need to recognize more explicitly the need for cross-subsidy of food producers' 'farm' income from non-farm activity and the implications this has both for food prices and concepts of food producers' 'autonomy'.

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