HUNGRY CITIES PARTNERSHIP

Discussion Papers

NOVEMBER 2018

NO. 16
CHEAP INDUSTRIAL FOOD AND THE URBAN MARGINS

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Abstract

From the middle of the 20th century onwards, the productivity gains associated with high-input, high-yield monocultures and livestock operations have become increasingly central to global food security and to dynamics of urbanization across the global south. On one hand, competition has deflated prices and helped undermine the viability of small farm livelihoods in many places. On the other hand, rising flows of cheap food have effectively subsidized urban migration in impoverished urban and peri-urban settings. But this cheapness is highly deceptive, as it hinges on the failure to account for an array of biological and physical costs – which can be seen as an implicit environmental subsidy – including heavy fossil energy consumption, greenhouse gas emissions, soil degradation, the loss of biodiversity, proliferating toxicity, rising pesticide and antibiotic resistance, the transformation and pollution of freshwater ecosystems, and the depletion of underground aquifers. Unpacking this implicit environmental subsidy and the mounting problems it masks reveals why the bounty of industrial agriculture is at once destabilizing and ultimately unstable, and poised to fade, and when it does it will not only affect rural landscapes and livelihoods but will raise profound questions about the scale of urbanization. To understand these problems together points to the urgent need to find ways to valorize more sustainable, land- and labour-intensive forms of agriculture in order to simultaneously feed cities better and contain their growth.

Keywords

food security, urbanization, climate change, cheap industrial food, environmental subsidy, migration

This is the 16th discussion paper in a series published by the Hungry Cities Partnership (HCP), an international research project examining food security and inclusive growth in cities in the Global South. The five-year collaborative project aims to understand how cities in the Global South will manage the food security challenges arising from rapid urbanization and the transformation of urban food systems. The Partnership is funded by the Social Sciences and Humanities Research Council of Canada (SSHRC) and the International Development Research Centre (IDRC) through the International Partnerships for Sustainable Societies (IPaSS) Program.

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Introduction

Development policy and planning have long assumed that the industrialization of agriculture, the demise of agrarian livelihoods, and increasing urbanization are more or less inevitable and desirable in the course of modernization. In essence, so the view goes, as fewer people are needed to produce a rising volume of food it can 'liberate' poor farmers from the drudgery, poverty and food insecurity that many face, freeing them to seek out better paying work in cities, which in turn will allow them to buy more food. This modernizing narrative has contributed to a durable urban bias in development policy and planning, with cities long receiving a grossly disproportionate share of services and infrastructure spending, as well as in food policies that have often favoured consumers over producers. In recent years, continuing urbanization has also increasingly been celebrated by some as necessary for biodiversity conservation, with the basic claim that humanity should urbanize and intensify agriculture and resource production as much as possible in order to make 'human-dominated' landscapes as efficient as possible so as to leave more space for self-organizing ecosystems. In agriculture, this case is frequently described as though 'sustainable intensification' can enable greater 'land sparing' (either taking land out of agriculture or de-pressurizing agricultural frontiers) (Tilman et al 2011).

There are a number of powerful reasons to buy into the modernizing narrative that humanity's future is bound to be increasingly urban, small farm livelihoods are fated to decline, and this course is tied to improving material conditions for many people. First, high-input, high-yield monocultures have brought tremendous productivity gains, as they have had a central role in the tripling of world agricultural production since 1960 and the declining share of the world's population suffering from hunger (FAO 2015a, 2017ab). They have also driven the increasing meatification of diets – another powerful though underappreciated promise of modernity – as the average person on earth in 2016 consumed nearly twice as much meat compared with 1961 (from 23 to 44 kg/year), in spite of the tremendous human population growth over this period, from 3 to 7.5 billion (FAOSTAT 2018, Weis 2013).

Second, hunger continues to have a strong rural-urban divide, with most of the world's population of hungry and malnourished people living in rural areas of Sub-Saharan Africa and South Asia (FAO 2015a, 2017ab), while urbanization everywhere is increasingly dependent on cheap agro-industrial surpluses and international trade, with food security at the household level increasingly tied to money. Related to this, the massive progress reducing relative levels of hunger in recent decades has occurred in countries undergoing rapid industrialization and urbanization, most notably China, and this has been disproportionately concentrated in cities. It is also safe to assume that the rapid meatification of diets on a world scale is disproportionately occurring in cities, in inverse relation to how hunger and food insecurity have long been disproportionately concentrated in rural areas.

Third, demographic history and projections suggest an inexorable trajectory. In 1900, less than one-tenth of all people lived in urban areas, by 1950 it was around one-third, and today it is more than half. By 2050, roughly 70 percent of the world's population is projected to live in cities, with almost all future population growth expected to occur within the cities of Africa and South and Southeast Asia, which are expected to account for over 90 percent of the growth of the world's urban population (UNDESA 2017, UN-Habitat 2015, 2016). Between 1990 and 2015, a mere quarter century, the number of mega-cities increased threefold, as did global per capita incomes, from roughly USD5,500 to USD15,500 (purchasing power parity) (World Bank 2017). Urban migration has been widely spurred by the disproportionate wealth of cities (the 'pull') and the combination of rural poverty and hunger (the 'push'), both of which feed into powerful perceptions of cities as sites of opportunity. Taken together, if read in a certain way, all of this can easily add up to a case that the highly uneven 'liberation' from hunger, poverty and farming implies that the advance of agro-industrialization and urbanization are, if anything, incomplete.

These trajectories can also be read in a very different way by considering the biological and physical problems posed by industrial agriculture along with the resource budgets and pollution loads involved in overriding them, which are summarized in the following section [this discussion draws upon a range of sources, including Carolan 2016, Friedmann 2004, Kimbrell 2002, McIntyre et al 2009, Pimentel 2006, Pimentel and Pimentel 2008, Sage 2012 and Weis 2010]. Through this lens, the productivity gains of industrial monocultures can be seen to rest upon a series of ignored and undervalued environmental costs, which amounts to great implicit subsidy and means that cheap industrial food is far from either inevitable or benign. On the contrary, it appears as both a destabilizing force, exerting intense competitive pressures on farming livelihoods, while being highly unstable in the long-term (Friedmann 2004, Weis 2010). As biophysical contradictions become more difficult to manage or existing overrides break down, key resources become scarcer and more expensive, and pollution loads become more damaging to the productive basis of agriculture, this is bound to pose difficult questions for food security, starting with the poorest urban residents. This in turn raises profound questions about the interrelated trajectories of agro-industrialization and urbanization, and why it is necessary to consider how more labour-dense agricultural development – an anathema in many conceptions of modernization – is vital to both feed cities and slow what might otherwise be unsustainable levels of urbanization.

Destabilizing and Unstable: The Productivity Gains of Agricultural Industrialization

Production from industrial monocultures obviously has a tremendous competitive advantage over production from low-input, labour-intensive small farms. This is often simply assumed to reflect superior efficiency, which it does in two basic ways: greater yields (per plant and animal) and vastly greater labour productivity. For instance, an industrial grain or oilseed producer in a country like the US or Canada can operate thousands of hectares with massive machines for seeding, fertilizing, spraying pesticides, and harvesting, and an industrial livestock producer can quickly turn over huge volumes of animal flesh, eggs and milk. This is all in stark contrast with the large majority of the world's farming population who cultivate a few hectares, rely mostly or entirely on family labour, have limited external inputs, may or may not have a few livestock animals, and increasingly rely on on-farm sources of income or remittance. However, the matter of efficiency and comparative advantage are far from straightforward.

The comparative advantage of industrial agriculture has long been fortified by large subsidy regimes in some of the world's leading surplus exporting countries, which have tended to be skewed towards the largest producers, most notably in the US and EU (Clapp 2016, Weis 2007). Explicit subsidies are, however, only part of the story of distorted competitive playing of world agriculture. Even more important is the fact that industrial agricultural production is also implicitly subsidized by a multidimensional environmental burden that is either undervalued or entirely uncounted, which can also be seen in terms of the appropriation and deterioration of ecological surpluses (Moore 2015). Relatively cheap surpluses might continue indefinitely but cannot be assumed in the long run.

To begin to appreciate the environmental burden – and fragility – of industrial agriculture it is necessary to recognize the necessity of biological simplification and standardization, as machines demand uniformity and a high degree of control along with the separation of animals from fields into dense enclosures, with fields and animals re-articulated through immense flows of feed such that industrial livestock production commands close to one-third of the world's arable land (for more on the environmental burden of industrial livestock see: D'Silva and Webster 2010, Eshel and Martin 2006, Pew Commission 2008, Pimentel and Pimentel 2003, Sage 2012), Steinfeld et al 2006 and Weis 2013). The basic imperative of scale creates or exacerbates a series of biological and physical problems that systematically undermine the foundations of agriculture, and these fundamental *biophysical contradictions* that inhere in agricultural industrialization are never resolved but rather are met with a series of external inputs, or *biophysical overrides*. Biophysical contradictions and overrides have a dialectic relation, in that they are not simply problem-and-response (or cause-and-effect) but are entirely bound up together, as the continuing pursuit of scale would not be possible without the overrides, and all the while new risks are being established.

The use of large machines, the planting of single crops (which often, though not always, reduces vegetative ground cover), and the rising use of pesticides (which are tied to heightened risks of insects, weeds, and fungus upon biologically simplified landscapes) together reduce the diversity of soil communities. While the spread of no-till, precision seeding may have reduced the pressures from tillage and problems of wind and water erosion, it does not reduce all of the pressures of compaction during seeding, spraying, and harvest, and heightens dependence on pesticides. Impoverished soil communities and the decline of natural controls along with biological simplification further increases risks of 'pests'. The central override for the depletion of macronutrients in soils is the use of inorganic fertilizers, principally nitrogen, phosphorous, and potassium. The demand for external energy is greatly amplified by the operation of large machinery and animal enclosures, the demand for manufactured inputs (including the transformation of seeds into annually purchased input from something that was once saved and selected), and the fact both agricultural inputs and outputs must move further across space the more that landscapes are simplified, which also ties to the increasing demand for packaging and its attendant materials, energy consumption, and pollution burden. Fertilizers are extremely significant here, owing to their bulkiness and energy-intensive manufacturing and movement. The production of synthetic nitrogen fertilizer is very energy-intensive, requiring tremendous amount of heat that mainly derived from natural gas, which enables its production can be located closer to the land where it is applied, whereas phosphorous and potassium fertilizer are derived from mines and thus tend to move over much greater distances.

The demand for freshwater is amplified by the development of high-yielding seed varieties, less biodiverse soils, reduced groundcover where tillage is used, and the fact that densely-packed animal populations cannot seek their own water and generate biowastes that must be frequently cleaned. These demands make agriculture by far the biggest source of withdrawals from lakes and rivers and underground aquifer pumping. The proliferation of toxic chemicals and genetic engineering to control pests has engendered new long-term risks, with the use of genetically engineered seeds having increased dramatically since the 1990s, though this growth is concentrated in a small number of countries (the US, Canada, Argentina, Brazil, and China) and crops (corn, soy, canola, and cotton). These changes are contributing to the decline of soil health and natural controls and increased pest resistance e.g. the rise of glyphosate-resistant weeds (the world's most commonly-used herbicide). A similar dynamic is evident with the dependence upon antibiotics in industrial livestock production, which poses severe public health risks as pathogens develop antibiotic resistance.

A core element running through the biophysical contradiction-override dialectic is the dependence on fossil energy in machines, animal enclosures, the manufacture and movement of inputs, and the increasing distance and durability of outputs, which translates to CO2 emissions at each turn. This atmospheric burden is augmented by nitrous oxide (especially from nitrogen fertilizer) and methane emissions (especially from livestock), and by the fact that reduced biomass in soils and on monocultures reduces the capacity for carbon sequestration, relative to both ecosystems and more biodiverse farms. Industrial monocultures and livestock operations contribute to a range of other environmental and public health burdens at various scales. For instance: (a) runoff of nutrient loads from industrial fertilizers is a major factor in algal blooms in lakes and coastal ocean regions in many parts of the world; (b) persistent toxins, herbicide-resistant weeds, insecticide-resistant bugs and antibiotic resistant bacteria all present complex and diffuse risks for human and ecosystem health; and (c) prolonged irrigation in semi-arid regions is a major cause of land degradation. The resource budgets and pollution loads of industrial monocultures and industrial livestock operations effectively expand still further as a result of the wastage of useable nutrition in cycling grain and oilseed production through livestock.

In sum, the comparative advantage of industrial agriculture is not because it is incontrovertibly more efficient. Rather, it is more efficient according to a particular logic of *what counts* (most of all, labour productivity) and *what does not* (unsustainable fossil energy consumption, GHG emissions, and the deteriorating biophysical conditions of agriculture). This explains why industrial food is at once so cheap and so precarious (Carolan 2016, McIntyre et al 2009, Moore 2015, Weis 2010). The problem of deceptively cheap industrial food must not be seen only as an agricultural or rural problem but one that bears most ominously on the urban poor and raises profound challenges for the prospects of continuing urbanization.

The Scissors of Cheap Food: Destabilizing Rural Livelihoods and Subsidizing Urban Growth

The role of cheap agro-industrial surpluses in world food security began to grow quickly in the 1950s and 1960s as productivity boomed with the development of high-yielding seed varieties and soaring levels of fertilizer and pesticide consumption. This course was led by the US, which set out on an aggressive program of surplus dumping through aid and subsidized trade, followed by Europe and some other temperate countries (Clapp 2016, Cochrane 2003, Friedmann 1993, 2004). At the same time, for governments in many low-income countries, food aid and cheap imports were embraced as a tool to support urbanization and industrialization (containing wage costs) and help manage rapid population growth. As a result, dependence on food imports deepened quickly. This was especially true in Sub-Saharan Africa, where food imports had been relatively small in the 1960s but had become firmly engrained by the 1980s, especially with wheat (Andrae and Beckman 1985, Friedmann 1990). Today, most of the world's poorest and most agrarian countries (in terms of the share of their labour force in agriculture) are net food importers, evident in the FAO's list of Low Income Food Deficit Countries (see http://www.fao.org/countryprofiles/lifdc/en/)

Cheap industrial food has had a basic two-fold impact on the dynamics of urbanization in the global south. First, the competitive discipline it brings has adversely affected the market conditions that small farmers face, having altered prices and dietary patterns – including among farmers themselves – over long periods of time. This is one important factor in the declining viability of farming livelihoods and ensuing urban migration in search of work. Second, cheap industrial food has subsidized migration to the urban and peri-urban margins by helping poor households survive on low and often erratic incomes (Davis 2006). The urban poor invariably spend very high proportions of their earnings on food purchases, and efforts to stretch food budgets often lead to the prioritization of quantity over quality – and therefore limited dietary diversity (pivoting on a small number of monoculture grains and oilseeds) and a heavy reliance on unhealthy but calorie-dense processed foods that are high in salt, sugar, and fat (Baker and Friel 2016, FAO 2017b, Frayne et al 2014, IFPRI 2017, Ziraba et al 2009). While the so-called 'supermarket revolution' has transformed urban food environments in many parts of Asia, Africa, Latin America and the Caribbean more for the upper- and middle-classes than for the urban poor (for whom wet markets still tend to occupy a relatively more important role), the poor still have much greater access to fast food, sugary drinks and snacks in urban than in rural areas (Singh et al 2015), as well as much greater exposure to the associated marketing that has an influence on dietary aspirations.

The march towards wage labour in cities has long been celebrated in narratives of modernization, while poverty, food insecurity and hunger continue to be disproportionately concentrated in rural areas of the global south. However, urban growth is widely marked by worsening income inequality, and in many parts of the world poor rural migrants face grim job prospects as industrial and service sector development has failed to keep pace with the scale of urban migration while public sector employment has been emaciated by debt and neoliberal policies (Davis 2006, Marx et al 2013, UN-Habitat 2015, 2016). The challenge of labour absorption is further compounded by the fast-moving developments in labour-displacing automation, which are expected to accelerate with the advance of artificial intelligence.

The historically unprecedented scale and nature of urban marginality has been evocatively described by Davis (2006) as a growing 'planet of slums', characterized by a combination of low-quality housing stock, deficient public services and infrastructure (with public spending failing to keep up with growth), and precarious livelihoods. Davis (2006) stresses how access to basic needs in these urban and peri-urban areas is thoroughly mediated by market forces while the ability to earn cash increasingly hinges upon a combination of insecure and poorly paid jobs, petty trading, and various sorts of hustling in the informal sector. More concerning still is the fact that the disjuncture between the rapid pace of migration and the capacity for labour absorption is greatest in those regions expected to contain the lion's share of future urban growth: Sub-Saharan Africa and South Asia. As a result, it is expected that a rising share of the population living in poverty in these regions will soon reside in cities and towns (IFPRI 2017, UN-Habitat 2016, UNDESA 2017).

There is growing evidence that food insecurity in cities is strongly correlated with slum-dwelling, and that conditions of hunger, malnutrition, dietary narrowing (reflected in low dietary-diversity scores) and child stunting in slums are comparable to conditions in rural areas (Battersby et al 2015, FAO 2010, Frayne and McCordic 2015, Frayne et al 2018, Mohiddin et al 2012). There is also growing evidence that the surge in ultra-processed foods, sugary drinks, snacks and fast food is a significant contributor to the increasing numbers of obese and overweight people in Asia, Africa and Latin America in recent decades. This is correlated to rising levels of non-communicable disease (e.g. cardiovascular disease) and the onset of a new dietary-epidemiological condition; that is, malnourished obesity and, where prolonged among children, stunting with obesity (Adeboye et al 2012, Baker and Friel 2016, FAO 2017b, Hawkes 2006, Lim et al 2012, Lobstein et al 2015, Popkin et al. 2012, Mohiddin et al 2012, Ziraba et al 2009).

The Precarity of Cheap Industrial Food

If rising flows of cheap industrial food rest on a series of unaccounted environmental costs, and have inflated levels of urbanization and sustenance on its poorest margins, what happens when these costs come due and food stops being so cheap? One indication of the potential fallout can be seen by looking at the dramatic food price volatility of 2007-8, and to a lesser extent 2010-11, when sudden spikes in world market prices of key staples sparked widespread food-related riots, mostly in cities of the global south. While world food markets subsequently stabilized, these periods of volatility put the dependence of the urban poor on cheap industrial food into sharp relief, and why the impermanence of the implicit environmental subsidies it contains is poised to have highly regressive social impacts (Brown 2011, Holt-Gimenez and Patel 2010, Ruel et al 2010). It is impossible to predict the timing, but the key matter here is not *when* but *how* this subsidy will begin to fade. That is, how are the biophysical overrides that presently enable productivity of industrial agriculture prone to become more expensive or break down?

A basic way this can happen is that key resources composing or enabling the production of overrides become scarcer and more expensive. Much of the attention in this regard has focused on the inevitable limits of fossil energy, especially oil, which is both the largest and most crucial fossil fuel as it accounts for virtually all liquid fuel that powers the global transport systems and trade, and faces more proximate limits than natural gas or coal. For several years, this threat was commonly discussed in terms of 'peak oil', which conveys the fact that sites where oil extraction is easiest and cheapest have long been exploited and new ones are bound to be more difficult, risky and expensive to develop. However, recent technological innovations and discoveries of 'extreme' fossil fuels (most notably the shale oil revolution in the US) have pushed estimates of oil production declines farther into the future. The conception of oil scarcity as an absolute material limit has in some ways been outmoded by a different challenge: that is, the need to politically induce scarcity as an absolute climate change necessity. A large share of existing oil (and other fossil energy) reserves must be understood to be 'unburnable' if there is any hope of reaching the sort of targets for reduced CO2 emissions and atmospheric concentrations climate scientists are advocating. This means that, if governments were ever to get serious about climate change mitigation, policy mechanisms (e.g. quotas, extremely high carbon taxes) would need to be found to ensure most of the carbon contained in the world's fossil energy reserves stays in the ground rather than being combusted and ending up in the atmosphere. In the language of fossil energy corporations and finance capital, this means transforming existing reserves into 'stranded assets' (Jakob and Hilaire 2015, Klein 2015).

Whether materially or politically-induced scarcity plays out obviously entails drastically different scenarios for climate change, but both promise to bring rising oil prices that will increase the costs of industrial agricultural production, from running harvester-combines and industrial livestock operations to manufacturing and applying fertilizers and pesticides to processing, packaging and transporting food over long distances. Yet, in spite of this fossil energy dependence, the pressure to find new sources of liquid fuel also gave impetus to the use of rising volumes of grain and oilseed production for ethanol and biodiesel fuel since the early 2000s, which expanded even as the biophysical and social illogic was becoming clearer (Righelato and Spracklen 2007, Weis 2010). In contrast to the green imaginary of agro-fuels (as if they entail a renewable cycle of sequestering and then releasing carbon), little more ethanol and biodiesel ultimately comes out than the fossil energy that goes into grain and oilseed production and processing. This poor energy return on investment is made much worse by the vast land area needed, which has negative impacts on biodiversity, water, soils and CO2 sequestration, meaning that land could far better serve climate change mitigation if put to other uses. The agro-fuel boom has slowed with the expansion of extreme fossil fuels and may in the future face some pressure from other sorts of technological innovation (e.g. the electrification of automobile fleets). However, the power of various interests promoting agro-fuel production (e.g. corporations involved in grain and oilseed processing, agro-inputs, energy, and automobile manufacturing; finance capital; and governments viewing it as a means to improved energy security) suggest it is unlikely to disappear soon. The demand for grains and oilseeds as fuels has inherently regressive dynamics, with relatively affluent car-drivers ultimately contributing to rising prices of basic food staples for poor consumers.

Along with being a major contributor to climate change, industrial agriculture is highly threatened by a series of vicissitudes. In the past, there were suggestions that warmer average temperatures, longer growing seasons and higher atmospheric CO2 concentrations might enhance agricultural productivity in some of the world's temperate 'breadbaskets' like the US, Canada, Ukraine, Russia and Argentina. On the other hand, negative impacts from heightened aridity and heat stress, drought, declining annual run-off from low- and mid-latitude glaciers, intensifying storms and coastal salinization would be largely confined to the tropics and semi-tropics. While this might worsen the unevenness of production and food import dependence, it would at least help to stabilize total production. Climate science has long made it clear the worst and most immediate threats to agriculture reside in many of the world's poorest countries that are already home to large populations of food-insecure people, and there are numerous indications that problems are intensifying, especially in hot and arid regions (IPCC 2014). But it is also increasingly evident that potential benefits for temperate productivity were exaggerated while many risks loom. For instance, hotter and drier conditions are also expected to constrain productivity in parts of the temperate world, especially in semi-arid regions that rely heavily on irrigation, like large areas of the US, Australia and the Eurasian steppe, and changing ecological conditions are bound to raise other challenges such as shifting distributions of pests and pathogens and rising evapotranspiration from plants and soils.

The fertilizer, pesticide, pharmaceutical and irrigation overrides all face mounting and interlocking stresses (see Carolan 2016, Kimbrell 2002, McIntyre et al 2009, Pimentel 2006, Pimentel and Pimentel 2008, Rickson et al 2015, Sage 2012, Weis 2010). The ability of nitrogen, phosphorous and potassium fertilizers to continue overriding soil nutrient depletion is made problematic by (a) the materially or politically-induced limits to fossil energy; and (b) the inevitable scarcity of high-grade phosphorous ore, which will reverberate first in rising costs before posing more intractable problems. In the meantime, fertilizer runoff remains a major force disrupting the health of many freshwater lakes and near-shore ocean environments. The pesticide and pharmaceutical overrides are threatened by the advance of herbicide, insecticide and antibiotic resistance, which drive the perpetual search for new pesticides and animal pharmaceuticals (and, in some cases, a return to older and more toxic pesticides). The diffuse toxic burden also connects to the declining health of many key pollinators, most worryingly of bees. The irrigation override is threatened by the dangerous overdraft and desiccation of many rivers and underground aquifers along with a series of climate-change-related stressors. These include diminishing annual cycles of glacial accumulation and runoff that feed many rivers; the growing demand for irrigation with warmer and drier conditions; and increasing levels of evapotranspiration, which in turn raises long-term risks of salinization (IPCC 2014).

Climate change and the extent of mitigation are the great variables overarching all uncertainty of how long existing overrides can continue to function and subsidize cheap food. Will urgent and drastic mitigation efforts be taken? Can average world temperatures be stabilized at 1.5 or 2oC above pre-industrial levels (the common political aspiration, which many climate scientists say is both too high and already impossible)? Or will average temperatures rise much higher before stabilizing? Of course, there is also tremendous uncertainty as to what sorts of technological innovations might emerge in efforts to override chronic or newly-established problems (e.g. solar-powered machinery and animal enclosures; large-scale biodigesters; moisture-sensing farm implements; genetically engineered plants, animals and soil micro-organisms; and drones for pollination and precision weed- and insect-killing). As with fossil energy, it is impossible to guess what steps governments might take to internalize other under-accounted environmental costs that would affect the cheapness of industrial food, such as the burden of persistent toxins, plastics and declining antibiotic effectiveness.

Dominant actors within industrial capitalism have long used the combination of complexity and uncertainty to sow doubt about the big picture and justify the status quo (Oreskes and Conway 2010). But when industrial agriculture is understood in terms of its biophysical contradictions and overrides, there is little reason to think that it provides a durable basis for existing levels of urbanization, much less a world with roughly 2 billion more urban residents in the coming decades. Rather, to hold on to a faith in the permanence of cheap food is to do little more than wait for the social convulsions that will occur when it fades.

Conclusion

Virtually all debates about the future of agriculture now pivot on the interwoven imperatives of climate change mitigation and adaptation, which are interconnected with prospects for biodiversity conservation and the challenges posed by impending resource limits. To limit atmospheric GHG concentration and associated warming, urgent and drastic efforts are needed to reduce GHG emissions, transition away from fossil fuel consumption, and enhance CO2 sequestration capacity. At the same time, a wide range of efforts is needed to respond to the scale of climate change that is already in motion irrespective of these responses, with mitigation efforts setting the parameters for adaptation possibilities.

While the need for action on climate change mitigation and adaptation is unassailable, competing visions of agricultural development conceive the challenges in diametrically opposed ways. For advocates of industrial agriculture, cheap food would not be possible without the great increases in yield and labour productivity, and it is a basic social necessity in an increasingly urbanized world and given the extent to which many of the world's poorest people have come to depend on it. From this vantage point, climate change and other biophysical problems associated with industrial production represent primarily technical challenges in need of innovations including more genetic engineering, greater precision in applying inputs (e.g. seeding, chemicals, irrigation), more information (e.g. soil moisture and nutrients, pest threats), more sensing technologies from drones to tractors, more labour-saving technologies (e.g. advancing robotics for weeding, spraying, milking, animal handling and slaughter) and more efficient conversion of animal feed to flesh, milk and eggs. To some, the magnitude and urgency of the challenge also involves the even bigger-scale technological fix of geoengineering.

For critics of industrial agriculture, however, new high-tech responses fail to resolve fundamental problems while heightening risks, including the extreme narrowing of power in who is determining responses and benefitting from them (Bonny 2017, IPES 2017). From this vantage point, rather than technologically-intensifying monocultures and livestock operations, there is a need to rethink the rationality of economies of scale that may underpin cheap food. A different sort of ecological rationality is needed to approach the challenges of climate change, biodiversity loss and impending resource limits, which prioritizes soil formation, nutrient cycling, species complementarity, natural pest control, carbon sequestration, and strives to minimize erosion, fossil fuel consumption, GHG emissions, toxicity, distance and packaging (Altieri 1995, Altieri and Toledo 2011, McIntyre et al 2009, Sage 2012).

An ecologically rational conception of agriculture must also consider the need to contain agricultural frontiers and reduce the total land area presently devoted to agriculture to enable restoration, as captured by the notion of land sparing. There is considerable evidence that low-input, biodiverse small farms can generate more net nutritional output per land area compared to industrial agriculture, owing to the greater use of space that can occur with intercropping, beneficial associations and staggered planting cycles (rather than with single crops planted in rows). Furthermore, small farms can greatly widen possibilities for climate change adaptation by increasing crop diversity and broadly dispersing the basis of innovation, grounding it in bioregions, farming cultures and farmer-innovators, rather than narrowing the locus of innovation into laboratories, a few genetically engineered seed varieties, and a search for ever-more-sophisticated biophysical overrides.

All of this points to the need to invert the modernizing conception of agricultural development as 'freeing' people from the burden of farming, as there is no escaping the fact that ecologically rational farming is skilful and laborious, and therefore vastly inferior to industrial agriculture in the pivotal metric of labour productivity. For some, the greater labour intensity of ecologically rational farming will undoubtedly seem like a step back in time, an anti-modern fantasy, but it could also be understood to converge with some pressing social concerns. In particular, it could provide one very big answer to the momentous questions surrounding the future of labour absorption and the strain of migration on many cities, especially in the context of accelerating automation and artificial intelligence.

To consider the case for more labour-intensive agricultural development, it is important to avoid romanticizing it and to recognize the immense barriers. Replacing machines and inputs with people can unfold in many ways, and there is every possibility it could happen without changes to property relations and with extremely exploitative social relations, as is evident in contemporary large-scale organic monocultures, so-called 'Big Organic', where chemical inputs are replaced with very poorly paid, insecure wage labour (Guthman 2004). Another barrier is the pervasiveness of anti-agrarian attitudes, both among urban dwellers and within some rural households. Many urbanites undoubtedly see themselves as too far removed from the land and from the knowledge of farming practices to even imagine pursuing an agricultural livelihood. An even greater barrier lies in the aversion to farming among many rural youth who are exposed to much wider cultural influences than in previous generations and whose autonomy is sometimes stifled by powerful generational hierarchies (White 2011). This is compounded where young people have only seen experienced poverty and food insecurity through farming. In short, there are good reasons why the vision of industrial agriculture as freeing people from the land has had so much traction.

Yet it is also very plausible that the negative connotations of small farming are bound up in enduring contexts of inequality, like highly uneven distributions of land and capital and unfair market conditions. This implies that the problem is not farming per se but the *social relations of farming*; in fact, farming has the potential be immensely rewarding, combining skill, continual learning and intellectual challenges, physical exertion and a strong sense of meaning in meeting the most fundament human need (Friedmann 2002, van der Ploeg 2008). Such a hopeful vision of work not only contrasts with many agrarian livelihoods today, but also with the proliferation of poorly paid, highly alienating jobs in which tasks are broken down into smaller and smaller pieces of the whole production process.

Viewing the problems of industrial agriculture together with the problems of food insecurity, unhealthy diets and precarious incomes on the fast-growing urban margins can give a sense of foreboding and social volatility. But it is also possible to envision some very hopeful synergies if ecologically rational small farms can be valourized and connections between cities and their foodsheds enhanced. Improved rural livelihoods could help contain urban growth, while cities could be supplied with healthier, more culturally appropriate foods less prone to the vagaries of world markets (Altieri and Toledo 2011, van der Ploeg 2008). Almost everywhere, the valorization of small farming would have to start with redistributive land reform and be accompanied by major public investments in agro-ecological research, training, extension and distribution networks, as well as policy mechanisms to ensure that healthier food is accessible to the urban poor at the same time as small farmers are better compensated for their labour. Clearly, this presents immense political and economic challenges, particularly in confronting existing property relations. However, as this paper has argued, the status quo is unstable for many reasons, and radical agricultural alternatives can have a vital role addressing some of the most pressing challenges of the global urban transition that is underway.

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