Can Industrial Agriculture Provide Global Food Security?[1]

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The prevailing agricultural ideology seems to be that "industrial agriculture" – meaning large, specialized, mechanized farms – will be necessary to meet the food needs of a growing global population. The logic or reasoning supporting this ideology is: Global population is destined to grow from the current seven billion to at least nine billion people by the middle of this century. More people obviously will require more food. And, industrial agriculture is the only logical means of increasing global food production.

The basic flaw in this logic is that industrializing global agriculture – meaning replacing the remaining small, diversified farms with large, specialized farms – is *not* the only means of increasing global food production. In fact, with greater scarcity and rising costs of fossil energy and the progression of global climate change, industrial agriculture is becoming less productive and may not even survive the twenty-first century. As we have seen in recent years, the global economy has no nationality, no sense of social responsibility, or concern for the future of humanity. Nations that depend on industrial agriculture for their food security face a future of growing dependence on a few large multi-national food corporations that have no allegiance to anything other than maximum profit and growth.

The blind faith in the future of industrial agriculture is based on its record of increasing productivity over the past 50 to 60 years. Admittedly, yields of crops per acre or hectare of farmland production of meat, milk, and eggs per bushel or ton of feed have increased during this period. However, virtually all of these increases have been linked directly or indirectly to an increased reliance on abundant and inexpensive fossil energy. Cheap nitrogen fertilizers were readily available because of an abundance of natural gas. Climate-controlled buildings for livestock were economically feasible because of low-cost fuel for heating and ventilation. Fossil fuels provided energy not only for traction but also for manufacturing of machinery. Deep-well irrigation likewise depends on low cost energy to pump and distribute water. Most pesticides are also fossil-energy based materials. Industrial agriculture is inherently fossil-energy dependent.

In the United States, for example, approximately 10 calories of fossil energy is required for each calorie of food energy produced.[1] About two-thirds of this total is accounted for by food

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processing, manufacturing, transportation, packaging and other processes of the industrial food system. But, even at the farm level, industrial agriculture requires about three kcals of fossil energy per kcal of food produced. In addition, industrial agriculture is impractical, if not impossible, without an industrial system of processing and distribution. Industrial agriculture depends on a fossil energy dependent food system.

Energy experts differ on their estimates of how much recoverable fossil energy is left to be extracted from the earth. Some experts claim that most economically recoverable fossil energy reserves will be depleted within fifty years while other believe there is enough fossil energy for another 100 to 150 years. However, there is no disagreement that the remaining reserves of fossil energy will be more difficult and costly to extract, as we are seeing with the "fracking" process required to extract shale gas and the costs and risks of deep-sea oil drilling. Beyond some point in each extraction process production will peak; there will be less fossil energy available each year thereafter. Each time demand increases relative to supplies, prices of fossil energy will rise – and eventually will rise dramatically. An agriculture that is dependent on fossil energy quite simply is not sustainable.

With increases in fossil energy demand of 2.5% per year, which is typical of recent years, total fossil energy demand would double every 30 years. This means twice as much fossil energy would be needed by 2045, four times as much by 2075, and eight times as much by 2105. Renewable energy from wind, water, passive solar, and photovoltaic cells eventually must replace fossil energy in agriculture as well as elsewhere in the economy. But, useful energy from renewable sources will be less abundant and more expensive than the fossil energy of the past century. The era of abundant, inexpensive energy is over.

In addition, industrial agriculture places similarly unsustainable demands on fossil water, or slow-recharging aquifers, for irrigation, half of which has already been depleted by some estimates.[2,3] Other estimates indicate that the earth's mineable phosphorus reserves could be depleted in 50–100 years, with a peak occurring around 2030.[4] In addition, industrial agriculture is destroying the natural productivity of soils through erosion, salinization, and agrochemical contamination. Fertilizers and agricultural pesticides also are major contributors to pollution of groundwater, streams, and estuaries. Industrial agriculture is a major contributor to global climate change, and the related weather instability will be a major challenge to global food security in the future.[5] In summary, industrial agriculture depletes the natural resource base that supports its productivity and pollutes the natural environment that sustains the health of humanity. Industrial agriculture cannot possibly provide *long-run* global food security.

Contrary to popular belief, the failure of industrial agriculture to provide food security is readily apparent in the United States. In fact, a larger percentage of Americans are "food insecure" today than during the 1960s, prior to the final phases of agricultural industrialization.[6] More than 20% of American children today live in food insecure homes. Food security means that everyone must have enough wholesome and nutritious food to support healthy, active lifestyles. Food insecurity takes on a different form in nations with industrial food economics. The food insecure people in these nations can often get enough food to satisfy their need for calories or energy but do not get enough nutritious food to meet their nutritional needs for healthy, active lifestyles. Diet related illnesses are rampant in America, including obesity and

related diseases such as diabetes, hypertension, heart failure, and various types of cancers. These illnesses are prevalent in lower-income, food-insecure homes.

Obesity related illnesses alone are projected to claim about one-in-five dollars spent for health care in America by 2020 – erasing virtually all of the gains made in improving public health over the past several decades.[7] A growing body of scientific evidence links the industrialization of agriculture to foods that are rich in calories and poor in essential nutrients, which have helped fuel the epidemic of obesity and other diet-related illnesses in America.[8] The rising costs of diet-related health care have paralleled the industrialization of agriculture. Industrial agriculture in America has produced an abundance of cheap food, but it has failed to provide food security.

Agricultural industrialization has also failed to increase food security in the so-called developing nations. A larger percentage of people in the world are hungry today than were hungry prior to the Green Revolution. The development experts attribute the persistent increases in global hunger to increases in population made possible by increased food production. However, many of those living in developing nations often have a very different view. In the words of Stacia and Kristof Nordin who have worked for years with farmers in Malawi, Africa:

Another drawback to the new [Green Revolution] varieties of crops is their reliance on chemical fertilizers and pesticides to ensure the success of a harvest. This process continually denies the return of organic matter to the nature cycle—the very essence of soil structure. As this depletion of organic matter has taken its toll, farmers have resorted to purchasing and applying greater quantities of chemicals to make up the difference. When these farmers, especially in developing countries, have been faced with these issues many have found themselves caught in a cycle of dependency that has actually left them worse off than before the Green Revolution took hold. People are finding that they are forced to sell off larger amounts of their yields in order to cover the cost of these growing expenditures. The selling of their crops has deprived many families of annual food reserves, nutritional requirements, and increased standards of living. As this cycle of dependency widens, the alternatives for creating healthy lifestyles seem to be narrowing.[9]

Vandava Shiva, a globally-prominent and highly-respected ecologist and Indian food activist summarizes the failure as follows:

The Green Revolution has been a failure. It has led to reduced genetic diversity, increased vulnerability to pests, soil erosion, water shortages, reduced soil fertility, micronutrient deficiencies, soil contamination, reduced availability of nutritious food crops for the local population, the displacement of vast numbers of small farmers from their land, rural impoverishment and increased tensions and conflicts. The beneficiaries have been the agrochemical industry, large petrochemical companies, manufacturers of agricultural machinery, dam builders and large landowners.[10]

Industrial agriculture inevitably increases hunger in developing countries because is displaces subsistence farming families, who are meeting at least most of their basic food needs, and fails to provide them with economic opportunities to purchase foods they are no longer able to produce for themselves. Subsistence farmers typically rely on selling some amount of "surplus" production to meet specific needs that they cannot meet from their farming operations. Such needs may include clothing, medical care, school fees, and transportation. Industrial agriculture invariably is introduced on larger, specialized farms, often with generous government subsidies, because it is incompatible with small, diversified, family farms. The increase in production on these larger farms depresses market prices for the agricultural commodities that subsistence farmers must sell to meet their financial needs, thus often depriving them of their ability to continue farming. This frees up farmland for industrial farms but forces subsistence farmers into the cities in search of employment.

Urban employment for displaced farmers often is not available or doesn't pay enough to meet the food needs of their families. Thus, families that were once reasonably well-fed on subsistence farms are now among the hungry. The experts assume the increased calorie production on industrial farms must have reduced hunger. However, the loss in production on subsistence farms was never accurately counted and thus represents an unknown and often ignored offsetting loss in calorie production due to industrialization. The fact that previous food-importing countries become food exporters simply means the new industrial producers are exporting their products to more profitable markets, rather than selling to poor, hungry people at home. The potential reduction in food prices for those living in the cities is often too small to make any real difference in hunger even in the cities. In addition, reductions in production costs may be offset by increased profits of food processors and distributors and the nutritional quality of food may be diminished, as it has been in the United States. Even in cases where it may appear that industrial agriculture has succeeded, it eventually is destined to fail.

The unsustainability of industrial agriculture is inherent in the industrial model or paradigm of production. Industrialization is motivated by economic efficiency. Efficiency is determined by economic value relative to economic costs. Economic values and costs are determined by scarcity, meaning the quantity of something that is available relative to the quantity that people are willing and able to buy. The industrial revolution advanced most rapidly in those nations and situations where there was a scarcity of labor and management ability relative to land and capital. Industrialization was a new model of organization that allowed production to be increased by relying more on specialized tools, machinery, and equipment and relying less on labor and management. The new technologies eventually included fertilizers and pesticides as well as fossil fuels and machinery and equipment for industrial farming. Financial capital provided the means of acquiring and using industrial technologies. Capital and technology were substituted for labor and management – for people.

The basic strategies of industrialization are specialization, standardization, and consolidation of control. By specializing in producing specific crops of livestock or phases of crop and livestock production, the specific tasks could be carried out more efficiently, meaning by employing fewer farmers. Specialization required standardization, simplification, and routinization of each task and each phase of production so they could be coordinated to complete the entire production process. Standardization allowed control or management of the production

process to be consolidated into few larger farming operations, meaning fewer farm managers. This is the process by which industrialization achieves “economies of scale,” allowing fewer farmers on larger farms to produce more food.

In addition, standardization and simplification inevitably result in the deskilling of the agricultural workforce. Thoughtful, caring farmers are replaced with farm workers who are trained to follow instructions and eventually become capable of performing only simple tasks. The economic costs of labor and management are reduced, but fewer people are employed and those who are employed contribute less to the economy. The economic benefits accrue largely to the few who manage large agricultural operations, the corporate managers who employ or contract with them, and to the stockholders in the large corporations that ultimately dominate or control industrial food systems.

Industrial agriculture cannot provide global food security. But is there an alternative? Can an agriculture that is sustainable over the long run meet the growing food needs of global society over the next fifty years? If we can't feed the world with large, specialized, mechanized farms, can we provide global food security with small, diversified, organic farms? Contrary to what is commonly believed, that question has been asked and answered. No one can foretell the future with certainty, but small, diversified, organic family farms are humanity's best hope for global food security.

First, industrial agriculture is more efficient than non-industrial agriculture only in terms of the number of people employed and the costs of labor and management. Industrial agriculture is not more efficient in terms of production per dollar invested, per calorie of fossil energy, or in terms of resource degradation and pollution per calorie of food produced. It is not even more efficient in terms of production per acre or hectare of land. Industrial agriculture advocates conveniently ignore that small farms already account for at least 70% of global food production, according to United Nations Environmental Program.[11] Furthermore, the research indicates that today's small farms are actually far more productive per acre or hectare than are the large industrial farms. As Peter Rossett of the Institute for Food and Development Policy explains:

Here at the Institute, we've reviewed the data from every country for which it's available, comparing the productivity of smaller farms versus larger farms. By productivity, I mean the total output of agricultural products per unit area -- per acre or hectare. For every country for which data is available, smaller farms are anywhere from 200 to 1,000 percent more productive per unit area. The myth of the greater productivity of larger farms stems in part from the confusing use of the term "yield" to measure productivity. Yield is how much of a single crop you can get per unit area -- for example, bushels of soy beans per acre. That's a measure that's only relevant to monocultures. A monoculture is when a single crop is grown in a field, rather than the kind of mixtures of crops and animals that small farmers have. When you grow one crop all by itself, you may get a lot of that one crop, but you're not using the ecological space -- the land and water very efficiently. Large farmers generally have monocultures because they are easier to fully mechanize.[12]

Miguel Altieri of the University of California, who has spent his entire professional working with small farmers, elaborates on the productivity advantage for small farms.[13]

These diversified farming systems in which the small-scale farmer produces grains, fruits, vegetables, fodder, and animal products in the same field or garden out-produce the yield per unit of single crops such as corn grown alone on large-scale farms. A large farm may produce more corn per hectare than a small farm in which the corn is grown as part of a polyculture that also includes beans, squash, potatoes, and fodder. But, productivity in terms of harvestable products per unit area of polycultures developed by smallholders is higher than under a single crop with the same level of management. Yield advantages can range from 20 percent to 60 percent, because polycultures reduce losses due to weeds (by occupying space that weeds might otherwise occupy), insects, and diseases (because of the presence of multiple species), and make more efficient use of the available resources of water, light, and nutrients.[14]

By managing fewer resources more intensively, small farmers are able to make more profit per unit of output, and thus, make more total profits—even if production of each commodity is less.[15] *In overall output, the diversified farm produces much more food. In the United States the smallest two-hectare farms produced $15,104 per hectare and netted about $2,902 per hectare. The largest farms, averaging 15,581 hectares, yielded $249 per hectare and netted about $52 per hectare.*

Even when single crops are produced in organic rotations, organic methods are found to be competitive with conventional monocropping systems. One 15-year study in the United States found organic farming to have comparable yields of both products and profits. The study showed that yields of organic corn were identical to yields of corn grown with fertilizers and pesticides, while soil quality in the organic fields improved dramatically.[16]

If small-scale, diversified, organic production is more productive and more profitable on a per acre or per hectare basis, why have farmers in the United States and other so-called developed countries adopted industrial agriculture? The answer is that industrial farming strategies allow "each farmer" to manage "more acres or hectares," or in the case of livestock to produce more livestock or poultry. A 5,000 acre farm in that nets $50 per acre in profits gives the farmer/owner a net income of $250,000. A 3 acre farm that net $15,000 in profits per acre gives the farmer/owner a net income of only $45,000. Large industrial farms don't need to yield more production or profit per acre or per hectare to yield more net income for farm managers or owners because they can farm more land using industrial methods. In addition, large industrial farming operations can afford to keep producing at lower margins of profit per acre, per bushel, or head because they produce more bushels of crop or head of livestock. Thus, they have able to produce at commodity prices low enough for long enough to drive more productive smaller, diversified, organic farmers out of business.

The limiting factor of industrial agriculture has been access to capital, rather than ability to work, management skills, or basic agricultural knowledge. Those with access to capital have been able to drive those without access to capital out of business, In addition, as their farming operations expand, access to capital becomes easier and less expensive and they are able to expand even faster. Increasingly, large multinational corporations are providing the capital for industrial farming operations and are using this strategy to gain increasing control of the global food system. Having exploited most of the expansion opportunities in the so-called developed

world, agribusiness corporations are now expanding into the less-developed areas of the world, forcing subsistence farmers off their farms and into urban poverty and hunger.

Even if small farmers are more productive than industrial farmers and are currently producing most of the global food supply, the question remains: Can small, diversified, organic farmers provide food security for a *growing* global population? Again, the scientific evidence clearly indicated that small farms are the best hope for providing food security for the nine-billion-plus people expected by 2050 and beyond.

If small farms were able to double their total production they could increase global food production by 40%, even without more production from industrial farms. A doubling of the current 70% of food currently produced by small farms would result in 170% of current production, enough to meet expected global food needs of 2050. If current industrial farming operations are converted to more intensive farming methods, by dividing into smaller farms, they could easily double their production per acre or hectare as well, resulting is a 100% increase in global food production. In addition, the need for fossil energy for food production would be greatly reduced, scarcity of water and other natural resources would be less restricting of food productive, nature could accommodate agricultural wastes, and soil productivity could be restored, sequestering large quantities of greenhouse gasses in the process. All of these changes would move humanity closer to long-run, sustainable food security.

All of these developments needed to ensure the future of humanity are possible and even feasible with existing agricultural knowledge and technologies. Jules Pretty, Director of the Centre for Environment and Society at the University of Essex in the UK, lists research projects pointing to potentials for increasing yields on small, diversified, organic farms. He highlights: 223,000 farmers in Brazil using green manures and cover crops of legumes and livestock integration have doubled yields of maize and wheat; 45,000 farmers in Guatemala and Honduras have used regenerative technologies to triple maize yields; 300,000 farmers in southern and western India farming in dryland conditions, and now using a range of water and soil management technologies, have tripled sorghum and millet yields; 200,000 farmers across Kenya who participated in sustainable agriculture programs have more than doubled their maize yields; 100,000 small coffee farmers in Mexico who have adopted fully organic production methods, have increased yields by half. [17]

These are but a few examples that have been included in more comprehensive studies of the potential to increase the productivity of intensively-managed, small-scale farms by relying on diversified, organic, sustainable farming methods. For example, a 2008 United Nations study of farming methods in 24 African countries found that organic or near-organic farming resulted in yield increases of more than 100 percent.[18] Another United Nations supported study entitled *Agriculture at a Crossroads*, was compiled by 400 international experts. The report concluded that agricultural production systems must change radically to meet future demand. It called for governments to pay more attention to small-scale farmers and sustainable farming practices.[19]

As Altieri summarizes the ecological and social benefits that can be achieved while yields are increases:

A variety of agroecological and participatory approaches in many countries show very positive outcomes even under adverse environmental conditions. Potentials include: raising cereal yields from 50 to 200 percent, increasing stability of production through diversification, improving diets and income, and contributing to national food security (and even to exports) and conservation of the natural resource base and biodiversity.[20]

The experts challenged the myth that industrial agriculture is more efficient in any respects other than reducing agricultural employment and maximizing economic returns for those who have the capital to invest in industrial farming operation. The narrowly-defined employment and economic efficiencies of large scale production are not necessary for, and are not capable of, providing global food security or long run sustainability. The food security experts called for a shift in global agricultural development programs to focus on supporting a multifunctional agriculture capable of providing global food security while protecting the natural environment, preserving rural communities, and honoring indigenous knowledge and cultures.

Global food security will require a fundamental change in thinking. The industrial model of food production seemed to make sense in an earlier world where people were relatively few, natural resources were abundant, and nature seemed capable of assimilating and neutralizing any amount of toxins and wastes. None of these conditions are true of the world of today. The challenge of the future will be to provide meaningful employment for more people, to transition from nonrenewable to renewable resources, and to reduce pollution to levels that can be accommodated by nature.

The global food system of the future must balance the need for greater productivity and resource efficiency, with the resilience to thrive under uncertain climatic conditions, and the capacity to renew and regenerate the soil, water, air, energy, and other resources needed to sustain productivity. Rather than being mechanistic, specialized, standardized, and centrally controlled, farms of the future must organismic, holistic, diverse, decentralized "ways of life," as well as means of making a living.

This does not mean returning to the manual labor, drudgery, and depravation found on farms of the past – or farms of the present in many parts of the world. Small farms of the future will require and will rely much more on "intensive" management – meaning information, knowledge, and indigenous wisdom – than on labor. Scale-appropriate technologies will be used by skilled laborers to manage complex, holistic farming systems: Thinking workers and working thinkers.

Food systems of the future will be local community-based systems that are guided by collaboration and cooperation, rather than global corporate-based systems guided by competition and domination. The smaller, diversified, sustainable farms of the future will provide greater economic opportunities for people in rural areas and cleaner, healthier rural environments – slowing and eventually reversing the rural-to-urban population migration of the past.

People of the future, in all nations of the world, will have not only enough calories to meet their energy needs but they will have access to enough nutritious foods to meet their needs for healthy, active lifestyles. Healthier people and lower costs of health care will result in healthier economies and societies. All of these things are possible with existing knowledge and

technologies, and the positive possibilities for the future are even greater. Industrial large farms cannot provide global food security, but sustainable small farms can. All it will take is a fundamental change in thinking and the courage to act in the face of corporate opposition.

End Notes

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