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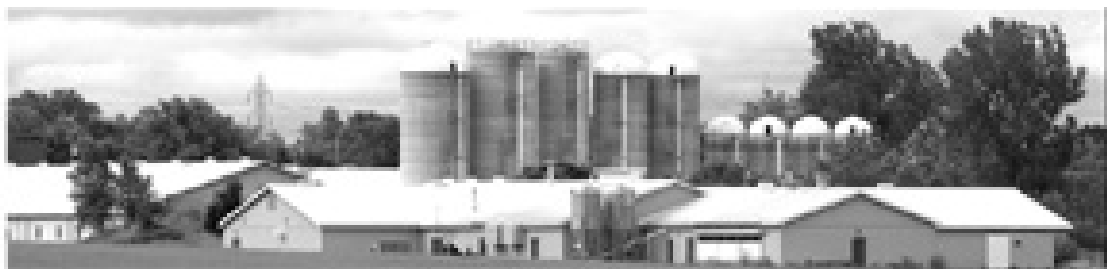

The Developing World Food Crisis

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Following the Second World War, global crop production began increasing while the price of agricultural commodities decreased. The result was a period of consolidation in the farming sector: farms became larger and the number of farms decreased. Today the prodigious food output of the US is based on the activities of less than one million full-time farmers whereas in Canada, only between 1 and 2% of the population is directly involved in food production. Both are a far cry from the 60-80% involvement in developing countries. The decrease in cost of agricultural commodities during the second half of the 20th century was also partly due to intense subsidy competition, largely between the EU and the US. This created hardship for countries like Canada who could not afford the same levels of agricultural subsidies; the effect on the agricultural sector the main economic sector in many third world countries and particularly in sub-Saharan Africa was devastating.

Several other conditions have also been developing over time and these have now come together to cause a radical change in the world food situation, one that is going to have far reaching consequences over both the short and long terms. First, world population has increased at a rate that can only be considered alarming. After several millennia of being in the half-billion range, the industrial revolution allowed global population to begin more rapid growth: by the beginning of the 20th century it was already at 1.5 billion; it is now 6.5 billion and is projected to reach 10 billion by the middle of this century. While increases in crop production outstripped population growth for about 40 years following the Second World War, over the last 15-20 years crop production per capita has fallen. During the period immediately after the Second World War, technologies associated with improved plant breeding, improved nutrient and water availability and improved pest management allowed increases in the rate of crop production in the order of 3% per year. However, as the new technologies were exhausted, the rates of increase began to fall by about 1% per year; in rice-growing regions there has been little or no increase year after year, in spite of increasing populations in those areas. Changes in eating habits, particularly in parts of Asia, during the last 15 years have often been referred to as the meat revolution. Increased meat consumption requires more crop production per capita, which has put increased pressure on world production. In some areas, political instability and warfare have restricted crop production. Probably the most notable current example of this is Zimbabwe, once a major crop producer in Africa, and now with a food limited citizenry. Open warfare has also made crop production difficult in areas like Dafur in Sudan.

Considerable soil degradation over the last few centuries has limited crop yields. Soils in Canada have lost about a billion tonnes of carbon since they were put to the plow, which represents a very meaningful decline in soil organic matter. Soils lower in organic matter generally produce less crop material as they retain less water; crops growing on these soils will become water-stressed sooner, especially if there is a period of little rainfall. High organic matter soils bind and hold higher amounts of water and crop nutrients, making these more available to the crops and allowing less to leach off.

Evolution is a persistent process and, as we develop new pest management strategies, the organisms we are attempting to control evolve mechanisms to circumvent our practices. This strategy/counter-strategy interaction has been going on for the last hundred years or so. We are always vulnerable to emerging resistances and will need to develop more sophisticated methods of evolution management. For instance, over the last few years a new race of cereal rust (UG99) has appeared in Africa, and more recently in parts of the Middle East, causing significant reductions in crop yields. If it spreads to other parts of the globe at this particularly vulnerable moment, there will be some very large challenges with regard to world food supplies.

In 2007 we passed a landmark that is a first in terms of humanity over half of the world s population now lives in cities. The vast majority of cities were established in areas where the surrounding country side was able to provide the agricultural output needed to sustain them. As cities expanded, they began to cover some of the best crop production areas.

In the West, we benefited enormously from the green revolution and are now poised to experience a second technology-based surge in agricultural activity, based on plant genomics. However, the developing world has experienced these benefits unevenly. Sub-Saharan Africa, in particular, has been unable to take advantage of these developments due to such factors as lack of capital and infrastructure. A serious challenge for these poorest of nations has been the severe market distortions resulting from agricultural subsidy wars. For many developing nations, the agricultural sector is the largest area of the economy; in Rwanda for instance it is 80% of the economy. High levels of subsidies elsewhere have resulted in agricultural commodities coming onto markets in developing countries at below cost of production.

Carbon dioxide derived from combustion of fossil fuels, plus the largely agriculturally derived nitrous oxide and methane, all act as greenhouse gases and have contributed to temperature increase. This has resulted in more rapid evaporation of water, leading to larger and sometimes more violent rainfall events, greater sea surface temperatures which have lead to an increased frequency of large tropical storms, an expansion of the tropical Hadley pressure cells which had lead to a northward and southward extension of the dry areas generally found at about 30 degrees north and south, and greater transfer of heat from the equator to the poles has resulted in increased wind speeds globally. These changes to global climatic conditions have seriously affected global crop production through a greater frequency of extreme weather events.

Water limitations are also beginning to affect crop productivity in areas where aquifers are being pumped down, and where urban and agricultural water use compete for the same resource. As

mountain glaciers melt, their water contribution, primarily in summer when crop production is being conducted, will be reduced substantially. Some river basins are now very over-exploited. For instance, the Yellow River no longer reaches the sea during the summer and a large amount of land in the Yellow River Basin that was irrigated in the past is no longer provided with water during the growing season, or receives substantially less than in the past. Limited amounts and quality of water are becoming increasingly serious limitations to crop production.

Global energy costs have risen sharply during recent years. Part of the reason for this is increased demand for crude oil. At the same time, we have about reached peak oil ; the global rate of crude oil extraction will begin to fall over the near term. Increased energy costs affect agriculture; the largest energy input for crop production is generally nitrogen fertilizer, which constitutes about half of the total energy input for corn production. The cost of nitrogen fertilizer has risen with energy costs, increasing the final cost of many crops. Increased fuel prices also elevate the cost of crop production and the cost of crop transport following production. As part of an effort to increase global energy availability and to find renewable energy sources, there has been a strong drive to utilize biofuels. Initial efforts have involved the utilization of food crops corn for ethanol, soybean and canola for biodiesel. This has diverted crop output away from food supplies and into energy reserves for transport, contributing to increased crop prices. There is now a large push to develop second generation feedstocks, which include municipal wastes, crop and forestry residues and non-food crops produced on marginal lands without large levels of inputs. These second generation crops will be cellulosic in nature. There is an urgent need to move in this direction, as quickly as possible.

The combined result of the above conditions has been sharp increases in food prices, with wheat, corn and rice at least doubling in cost; more than 50% of the calories in the global human diet are supplied by just these three crops. Political and social disruptions are already occurring; during the past year we have seen food-price related rioting in Haiti and Cairo, with more likely to follow. All of this presents a significant challenge for humanity and a very large need for focused and coordinated activity by all parts of the agricultural research community. While the challenge is large, there are also some remarkable opportunities. Genomics is now increasing our understanding of how crop plants function, and how we can manipulate them. Over the coming decades, we may well be able to develop crops that require substantially less water, are able to fix nitrogen from the atmosphere, resist most or all pests and have improved nutritional compositions. In addition, the use of global positioning systems and computer technologies is allowing for more efficient use of inputs such as seed and fertilizer through precision agriculture and may allow more efficient crop production. Improvements are needed in areas such as soil and water management, bio fertilizers, seed quality and food storage. There needs to be a high priority concerted effort as the help is needed now.

Don Smith is a James McGill Professor and chair of Plant Science. He is also known to many as the moderator of the *Food for Thought* lecture series.