Global agriculture

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Sugarcane

Palm oil

Timber, pulp and paper

Land, Food, and Biodiversity

Agriculture currently occupies over 40% of Earth's land area and consumes 70% of available freshwater. Production systems have increased food output in recent decades by improving crop yields. These increases have had consequences such as reduction in the quality of species' habitats through changes in land use, fragmentation of natural land cover, and depletion of soil and water resources. Growth of the human population, projected to exceed 9 billion by 2050, and economic development in many emerging markets such as Brazil, China, India, and Indonesia will require food production to increase 70% beyond 2011 levels. Indeed, per capita demand for food products is increasing because the economies in highly populated countries such as China and India are growing. Additionally, there is an increasing reliance on agriculture to provide not only food and fiber for this growing population, but energy and renewable materials such as plant-based packaging materials.

All this means that pressure to increase conversion of land from natural land cover to agriculture will continue to grow. At the same time, levels of food security, malnutrition, and food emergencies are on the rise as weather events and social and economic disruptions reduce food availability. As a result, we are entering a period of demand-driven agriculture. This period will be marked by increased food prices, periodic shortages, market volatility, regional water scarcity, and the conversion of tropical lands to agriculture to meet society's needs for food, clothing, and fuel. Land and water are becoming scarce resources. Overlay these realities with the potential effects of climate change on agricultural production and it is clear we are also entering a period of uncertainty in agriculture.

Production areas may very well shift, and indeed some agriculture sectors have already begun this migration due to scarce water resources and increasing regulatory requirements regarding water use. Although many stakeholders are discussing production practices—organic versus conventional, smallholder versus large corporations, genetic modification technology versus natural breeding—the real challenge will be to minimize land conversion. Effects on biological diversity can be mitigated through efficient use of land, water, and agricultural inputs. The use of degraded lands, improved irrigation technology, proper use of inputs such as fertilizers, and better management practices can increase yields on existing cultivated areas. Balancing the use of land and water with the need to conserve biological diversity will be among the greatest challenges that confront society.

Overall, the food price index of the Food and Agriculture Organization (FAO) increased 37% between May 2010 and April 2011, but cereals and grains have increased 69% in the same period. Food security has quickly become a dominant global concern. The global food production system has become much more fragile because interruptions to supply due to weather or other factors

that reduce local production can have a global effect. In 2010 wheat production was reduced by drought and high temperatures in Russia, low temperatures in China, and heavy rain in Canada, and drought in Brazil and Argentina increased soybean and corn prices by 50% (Giovis 2011).

Although some may argue that these reductions in production are temporary and that agricultural production has always been subject to variations in weather, these arguments fail to recognize contemporary supply interruptions have a far greater effect on global food availability. Global commodities are interdependent, and food stocks are at historically low levels while demand continues to increase. In addition, these circumstances have triggered changes in producing countries' export policies to ensure sufficient domestic supply. These policy changes, which further tighten global markets, may encourage production of a particular commodity in a region where climate, soil, and water are insufficient for sustained production. These choices may lead to conversions of land cover and inefficient use of land resources and inputs while alleviating local shortages of food. Increasingly, protected areas and national parks are being downsized or degazetted to make room for agricultural and other economic uses (Mascia & Pailler 2011). The Brazilian Forest Code, which protects the Amazon from deforestation, is currently being reconsidered by the Brazilian Congress to free up land for soy and beef production.
Currently, Brazil and Indonesia account for roughly 50% of carbon emissions from land use change. These emissions result from the production of five commodities responsible for the majority of conversion of natural land cover to agriculture: palm oil, timber, pulp and paper, soybeans, and beef (California Environmental Associates 2010). The concentration of land-use change in these two countries offers significant opportunity because efforts can be tightly focused and have significant positive outcomes if successful.

The expansion of palm-oil production illustrates how unrestrained expansion of cultivation can affect viability of native species (extirpations have occurred due to habitat loss) and release large amounts of greenhouse gases. Since 2006, global production of palm oil has increased 34.6%, from 37.3 million t to 50.3 million t. Most of this expansion has occurred in Indonesia, through extensive conversion of tree and peat forest on the islands of Sumatra and Borneo. During this period, palm oil became the leading global edible oil, driven primarily by increased consumption in India and China. The industry's production area in Indonesia expanded from 4.3 million ha to 7.5 million ha between 1995 and 2011. Growth continues at a rate of roughly 300,000 ha/year. The effects on tree and peat forests have been dramatic, and even national parks, such as Tesso Nilo National Park in Sumatra, have been planted with oil palm, which has removed habitat for elephants (Elephas maximus sumatrensis), tigers (Pan- thera tigris sumatrae), and rhinoceroses (Dicerorhinos sumatrensis). Despite this massive expansion and the current global economic recession, prices for palm oil are at record high levels and global available stocks are at historical lows, indicating strong future demand.

There are alternative courses that the palm-oil industry can take to meet growing global demand without converting natural land cover. Although palm oil is the highest yielding edible oil crop on a per hectare basis (yield per hectare is 10 times greater than the second-most produced oil, soybean), there still are significant opportunities to improve yield, primarily through improved management practices. The current average yield in Indonesia is 3.8 t/ha, but when the average yield is compared with the yields of some of the more efficient individual producers, it is not unreasonable to estimate a yield potential of 7.0 t/ha. Yields of 11.0 t/ha have been reported from new hybrids. Palm oil can be produced profitably on a wide range of soil types, and plantations can be established on the alang-alang (Imperata cylindrica) grasslands that regenerated after the forest fires and extensive uncontrolled land clearing that took place in the late 1990s. Just through planting on alang-alang areas and improving yields, palm oil could provide economic development benefits without the undesirable ecological effects that have greatly tarnished this commodity (Fairhurst & McLaughlin 2009).

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Palm oil can be a sustainable crop, have minimal effects on biological diversity, sequester carbon, produce jobs, and offer attractive financial returns. Nevertheless, the industry and the governments of Indonesia have not chosen to pursue policies that could improve the global reputation of this key commodity. The case of palm oil highlights many of the key agricultural effects and challenges society faces and must address to limit effects of the rising demand for agricultural products from a growing and more affluent population.

Among the key factors that have enabled the palm oil industry to expand are lack of governance, enforcement, and accountability of both local and national governments. In Kalimantan, Indonesia, some 5.3 million ha of concessions were granted to develop palm-oil plantations, but of these concessions, only 900,000 ha were actually planted. The development permits were a mechanism to extract timber. Good governance and law enforcement are essential to ensure rational development policies.

Although agriculture will expand, it is possible to help define the conditions under which this expansion will occur. The palm-oil case suggests the real issue is not about the commodity being produced, but rather how it is being produced. There are key lessons from this experience related to land-use planning, governance and law enforcement, productivity, and market drivers.
Credible and effective land-use planning can guide sustainable growth. For example, the Brazilian government has developed and mapped the zones where the Brazilian sugarcane industry can and cannot expand, taking into consideration agronomic, environmental, and social criteria. These zones are reflected in federal legislation and are tied to both public and private lending policies (Embrapa 2009). Although the land-use planning process may be cumbersome and difficult, it offers a long-term path and clarity on land use for both the nongovernmental organizations and industry.

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The absence of governance and legal enforcement is perhaps the greatest enabler of environmental change. The absence of enforcement has been identified as a key driver of extensive deforestation.

Crop yield (also) needs to be a key sustainability indicator. Although there are trade-offs between yield, inputs, and agricultural practices, many opportunities exist to increase yield through improved varieties, reduced waste, and improved fertilization practices, harvesting, and overall crop management.

(For example) If the palm-oil industry were to adopt the use of these high-yield hybrids for all future expansion and were to use these same hybrids in their replanting programs (if palm-oil plantations are not re- planted every 25 years, they become too tall to harvest), the amount of land required to meet the growing demand would be reduced substantially.

Productivity has huge effects on the efficient use of land and water, livelihoods, and financial viability. Thus, productivity is critically important for smallholder agriculture where livelihoods are strongly affected by low yields. Food companies are rapidly becoming aware of the importance of sustainability of production of agricultural commodities to their supply chains. To establish production standards and industry practices, they are actively participating in forums such as the Roundtable for Sustainable Palm Oil, Roundtable on Responsible Soy, Better Sugar Cane Initiative (Bonsucro), Roundtable for Responsible Biofuels, and the Better Cotton Initiative. Efforts are underway to create global standards on beef production through the Global Roundtable for Sustainable Beef. Many of the leading companies are also analyzing their own environmental impacts and taking measures to mitigate and reduce them. This requires engaging companies in the supply chains to improve environmental performance and understanding of the issues and concerns present in the countries or regions where they source their commodities. Although some companies may be taking these actions to maintain or improve their reputations, most are concerned about availability of long-term supply. These market forces have been helpful in encouraging producers to certify their operations because sustainability is increasingly being demanded by U.S. and European markets and customers. Due to the highly variable nature of agricultural supply chains and shifting trade flows, sustainability of each commodity needs to be evaluated separately. Given the shift in trade flows and economic development in countries such as Brazil, China, and India, sustainability considerations need to become mainstream among companies and consumers in these important markets to achieve the required changes in production practices. This will be a key challenge in the future.

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