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Safe, sustainable, crop production: meeting the goals

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How do we balance the imperative to provide the planet's inhabitants with safe, nutritious food and the imperative to preserve the planet's ecological systems? The short answer is that we don't and won't. But let me start again and work around to that grim but obvious conclusion.

Our governments have made the astonishingly radical promise to do 17 seemingly impossible things, all by 2030. Goal #1 of these Sustainable Development Goals is ending poverty; #2, ending hunger, as well as Goals 13, 14 and 15 are, in order, to manage climate change, protect life below water and protect life on land. The first two and the latter three appear mutually exclusive. Present forms of economic development destroy the climate and marine and terrestrial ecosystems. So, the economic development required to end poverty and hunger would accelerate that destruction. In addition, several other SDGs come into play that impact these goals…. # 3-ensure healthy lives and promote wellbeing, # 5 achieve gender equity and empower all women and girls, # 6 clean water and sanitation, # 12- responsible consumption and production, and # 17 partnerships.

However, we have the tools to achieve all the SDGs, always keeping in mind that hunger cannot be ended with *enough* food, only with enough *safe* food.

Availability of fruits, vegetables, grains, tubers and legumes and the systems used to produce them play a critical role in human and animal nutrition and peoples' livelihoods. However, the quantity and safety of plant-based food and feed will be affected by more frequent outbreaks of pests and diseases associated with climate change. Integrated pest management will require new breeds of plants, as well as new pesticide regimes and better extension services. These will raise food production costs, but if they increase yields while maintaining or improving safety, we may be able to stay in a rough break-even range.

One way to improve productivity is to use crops that are best suited to the environment in which they are grown. Vertical farming, by more precisely controlling inputs and environmental conditions may contribute to intensification efforts with highly nutritious foods and short supply chain and limit water and fertilizer waste and pollution. However, the nature of the system will require a very different approach to food safety management. In that protected environment, once there is introduction of a microbiological contaminant, it may multiply quickly. Such agriculture will be expensive but may prove cost effective if the externalities associated with fields, such as fertilizer run-off and soil depletion, are calculated differently. It should be noted that such production systems may be of importance for high value vegetables, they will never

meet the demand for crop derived carbohydrate and protein, which will continue to be produced in fields.

In some places, climate change will reduce cropping duration due to increased temperatures and erratic rainfall patterns, increasing safety challenges. Yet in many cases, faster crops rotations will avoid some of the pest and weed hazards of climate change and may become a breeding goal. For example, the development of peanuts that mature faster, enables farmers to overcome some weather/climate challenges in the southern United States.

Precision farming offers the promise of less environmental contamination and minimization of pesticide and other residues on foods. However, this will never reach small-scale farmers unless they are made efficient suppliers for large agricultural businesses, that is, unless they are better integrated into national economies. Some chocolate companies have been considering a "nucleus and plasma" approach to cocoa farming, with the nucleus being a cocoa processing plant and the 'plasma' being a surrounding population of small cocoa farmers, who would be offered fertilizer, productive germplasm and training, along with, in time, drones and satellite imagery to better manage their holdings.

Big data and modelling can help manage farming and predict crop disease or contamination. Blockchain technology, most famous for keeping track of cryptocurrencies, could have a big impact on nutritional security and food safety by providing a precise description of a food supply chain for every product at every moment. This would allow processed foods, commodities, fruits and vegetables to be followed backwards from the stores to the middle-market negotiators to the producers, to the farmers and to the fields in which they were grown to guarantee safety or to identify unsafe steps. Recent work at the University of Kashmir has described how blockchain could decrease the corruption in and increase the efficiency of India's vast food distribution system.

Water, quantity and quality is a limiting factor for food production in many regions. However, it can be better used and, even better, re-used. In most places, water is a triple anomaly: scarce, cheap and wasted. Practices and policies to conserve and protect water, at the same time providing a sufficient supply of water necessary and is fit for food production is critical. Water re-use practices can be guided by risk assessments to determine impact on food safety. One water-saving practice that has worked is alternate wetting and drying (AWD) which has been shown to reduce water use by up to 30% in Arkansas and Mississippi, with no reductions in yields. AWD also reduces methane emissions and can be used with other conservation practices to further reduce water and energy consumption, improving farmers' profits.

Increased food availability can be achieved by decreasing losses throughout every element of a food system. For example, aflatoxin is a potent carcinogen that has been estimated to impact approximately 4.5 billion people each day. Moreover, the pressure of aflatoxin-producing fungal infections in susceptible crops is expected to increase with elevated crop production intensification and potentially because of climate change (drought periods in the field). Several approaches are possible to mitigate this expected increase. For example, many food production and food safety tools involve genetic manipulation of one sort or another and work with the CRISPR gene editing technology is seeking to rid plants of aflatoxin. Another approach has had excellent results using Host Induced Gene Silencing (HIGS) to suppress aflatoxin production in corn (maize). Additional investments in training about post-harvest handling and storage practices can limit aflatoxin contamination and food waste.

CRISPR and other gene editing techniques will also be used to alter crops so that they are more resilient in the face of diseases and climate change. Cocoa swollen shoot virus disease is killing cacao trees in West Africa, and research is underway using CRISPR to find a way of defeating this disease. CRISPR has already proved promising in increasing per hectare yields of many major crops, and increasing productivity could, if managed properly, allow us to protect ecosystems.

The 2018 World Resources Institute synthesis report "Creating a Sustainable Food Future" concluded that based on current trends, the world would need to produce 56% more calories in 2050 than it did in 2010. Yet if that demand is met by clearing more forests and other ecosystems for cropland and pasture, an area the size of India would be needed. That would make it nearly impossible to stay below 2 degrees Celsius of global warming.

Knowledgeable field experts have watched as African farmers increased cacao production not by breeding or using fertilizer but by cutting down forests, often in parks, and planting more cacao trees. Average production is about 500kg of cacao per hectare, as it has been for about a century. However, agriculture outputs are often governed by quality of inputs and by training farmers in best agricultural practices, and by getting them better planting stock and fertilizer, we could increase that yield 16-fold, allowing us to reforest vast tracts of degraded lands. Use of organic soil amendments to increase soil fertility should be coupled with training about methods to use these valuable nutrients while at the same time limiting possible food safety hazards.

Cacao needs more research. I have advocated a "checkoff" scheme to pay for an international cacao research center. This approach has been successful in the United States, where farmers "check off" a box to put some of their income from a farm product toward providing money for research, or even for advertising, for that product. The big chocolate companies could do that to support cacao research that would involve farmers and lead to increased yields and higher income for farmers.

Likewise, the same approach could be made to any internationally traded farm product, focusing on safety and productivity. My international focus is because so many food supply chains are global and we do not have adequate, well enforced global laws to control them nor global tax systems to support them to benefit farmers.
Genetic modification could also make farming more sustainable by creating plants that do not need additives such as pesticides or fertilizers. Of course, we already have this with crops that are, as some refer to them as roundup ready, the controversy around which shows how much more research needs to be done. A recent discovery of a variety of corn in Mexico that fixes its own nitrogen was published in the August 7, 2018 PLOS Biology makes the point that we must explore and seek to create nitrogen-fixing rice and other big commodities. Decreasing the use of synthetic nitrogen would not only save energy, reducing greenhouse gases, but decrease the run-offs that poison large stretches of waterways.

Market forces will drive increased crop productivity and food production in and for developed economies. But what of places where markets reach farmers, and farmers reach markets, not at all or ineffectually? An excellent example is one where several global scientific experts are involved in an uncommon collaboration called the African Orphan Crops Consortium (AOCC), which is sequencing the genomes of 101 crops grown in the back gardens of the 600 million people who live in rural Africa, and training 150 African plant scientists to do this work. I am pleased to be a part of this effort, which has the possibility to stimulate a global orphan crops revolution. The idea is to make these "orphan crops" – crops little studied by science – more nutritious, more productive and more resilient against the ravages of climate changes, pests and

diseases. The farming is sustainable, as few of these farmers have fertilizer to add and the crops have evolved to suit local conditions. They are generally considered safe in that they are grown by the families who eat them and likewise present income generation opportunities.

Eight graduates of the AOCC's African Plant Breeding Academy in Nairobi presented their work at the FAO in 2018, and the FAO has formed a partnership with the AOCC to globalize the orphan crops approach.

I began this paper predicting failure. Why? The themes of this conference gives us a clue. It noted that sustainable agriculture must consider "a host of other multi-sectoral topics such as economic planning, trade, education, social affairs, health, energy, transport, natural resources and the environment."

It is not just that these topics must be "considered," they must be strictly and efficiently coordinated, and this must be done internationally, as so many food supply chains are international. In terms of effective and efficient food safety management, we need to take these elements into account as we develop the necessary international agreements on genetic manipulation, as well as water, fertilizer, pesticide and herbicide use. We need governments to cooperate so that farmers, and their governments, can master the use of these inputs.

We all know the definition of sustainable development: meeting the needs of the present without compromising the ability of future generations to meet their needs. But the Brundtland Commission, which defined sustainability more than 30 years ago, offered a more profound vision: "Yet in the end, sustainable development is not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are made consistent with future as well as present needs…. Thus, in the final analysis, sustainable development must rest on political will."

Let's be honest…Do you see any evidence, any slight hint, that the level of political will through global commitments, cooperation, coordination and resources are in place or are emerging to fulfill the aspirations detailed in the recommendations of the ICN2, the SDGs and other UN goals by 2030? I think not; so, I close with these four action points to urge change to success: (1) we must use this International Food Safety Conference (IFSC), to hold the IFSC conveners accountable-- the AUC, FAO, WHO, WTO and others-- to encourage that they build and support the several platforms, initiatives and scientific and institutional capabilities required to mitigate the negative social, economic, health and environmental impacts of unsafe foods; (2) we must insist that these efforts link food safety to all phases of agriculture, climate change, sustainability and other collateral components to enhance the likelihood that safe, affordable and nourishing foods will become available to everyone; (3) we must foster an intellectual revolution in decision making and politics among in national and international institutions and among other stakeholders including the private sector to give food safety the priority attention it must have in order to achieve the 2030 Sustainable Development Agenda; and (4) we must take giant steps to ensure that no one is left behind because the alternative of continuing to slide backwards toward when our damaged ecosystems can no longer support our economies, and food systems is totally unacceptable.