ACHIEVING GLOBAL FOOD SECURITY FOR ALL: FOCUS ON SUB-SAHARAN AFRICA AND ASIA

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The global population of 7.6 billion people in 2018\textsuperscript{1} is expected to grow to around 9.8 billion in 2050.\textsuperscript{2} Of all 794.6 million undernourished people globally, 779.9 million live in developing countries. Food availability and rising prices are not just threatened by climate change effects, such as drought, temperature extremes, salinity / alkalinity and flooding, Today’s world also faces enormous social challenges, including the threat of global socio-political instability due to conflict, migration and seemingly increasing intolerance of “the other”. These factors will prove progressively linked into the future.

The good news is that the world, at least in principle, is better prepared thanks to advances in scientific thinking and methodology. These breakthroughs are gaining attention from investors / funders / donors as well as governments. The perceived new demand for enhancing technologies is spurring on higher investments by private companies. However, governmental policies can still be erratic, including in developing countries, despite even continent-wide agreements on how to move forward, such as e.g., by investing at least 10% of all national budgets into the agricultural sector in Africa, which has not happened.

If / when food production does increase, quality storage facilities for agricultural produce are likely to be limited. Nobel laureate Norman Borlaug had already raised this issue 50 years ago, as the Green Revolution generated huge increases in wheat and rice production with no convenient place to store the “bumper crop”. In recent years, the senior author has again stressed this lack of proper storage conditions to senior political authorities. Even when grown successfully, a third of the world’s food grown is still prone to loss and waste.\textsuperscript{3}

\textsuperscript{1} Online FAOSTAT database, July 2018.
\textsuperscript{3} HLPF, Food losses and waste in the context of sustainable food systems: A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome, June 2014.
FOOD INSECURITY

Here we will focus on those populations with the highest Global Hunger Index scores, those in Sub-Saharan Africa (SSA) and Asia. Presently, Asia, with more than 500 million hungry people, represents 65% of all hunger-prone people globally. But the recent implementation of mitigating policies, advances in technology adoption and a declining rate of population growth are improving the situation in major parts of Asia.

Africa also seems to have many positive aspects coming together for increased food production; renewed economic growth; half of the world’s remaining untouched but potentially arable land and unexploited irrigation options; low crop yields that can often be quite readily doubled or even tripled; and new incentives for private sector investment.4 At the same time, however, Africa’s global agricultural exports are losing to competitors, such as Brazil, Indonesia and Thailand. In fact, Africa is now a net food importer, even as domestic demand is booming. This is especially true in the cities, where consumption is expected to increase fourfold by 2030. Poor road infrastructure strangles local business initiatives to transport food within-country from the rural to high-demand urban regions.

The yield gap in Africa is partly due to 20-50% lower cereal yields (an average of 1.5 tons per hectare [t/ha]) compared to those in Asia. Some of the solutions are well-documented, e.g., very low fertilizer and irrigation use, but need investment. By 2050, cereal production in SSA will double. But, at the same time, cereal and meat imports will triple compared to 2010, while prices will go up due to yield-limiting climate effects in exporting countries. While pulse production will also double, imports will increase by a staggering near-tenfold. Despite these locally sourced or imported increases in food availability, the African hunger-prone population will only drop by a mere 10% from 209.5 million in 2010 to 188.7 million in 2050. East Africa will face the largest increase in undernourished individuals.

These predictions have led several authors to be pessimistic about SSA’s agricultural sector.5 In other words, despite the positive developments noted above, SSA’s quantitative and qualitative food insecurity is likely to increase further as the population continues to expand exponentially.

INFLUENCE OF CLIMATE CHANGE

The goal of the Paris Agreement on Climate Change regarding anthropogenic climate change is to maintain global mean temperature at a maximum increase of 2°C

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5. Ibid.
above pre-industrial levels by the end of this century, ideally at an increase of just 1.5°C. If the 2 °C temperature increase cap limit cannot be achieved, then cropping systems will be very negatively impacted. This combination of damaging environmental factors, including the reduced crop production itself, will lead to declining soil carbon content and the subsequent reduction of plant nutrition and the nutritional value of the harvested crop. Apart from such external negative impacts on agricultural production, some agriculture-related processes themselves worsen matters by compromising future sustainability. These processes include large-scale deforestation to expand agricultural lands, and fertilizer overuse to pursue maximum yields, resulting in water spoilage. Agriculture is therefore both a victim of climate change, requiring adaptation measures, and a culprit of climate change, requiring mitigation measures.

CURBING THE POPULATION MONSTER

Increasingly, climate-smart, corrective measures are being taken on the food security front. However, it is very likely that a fully sustaining food supply derived from an environmentally benign agriculture cannot be achieved worldwide without also curbing the exponentially growing global population. Nobel laureate Norman Borlaug called it the “overpopulation monster”6.

A recent United Nations (UN) study concluded that by 2100 the world population will reach 9.0–13.2 billion, with no end in sight for global population growth. The continued expansion is mostly due to population growth in Africa, whose projected 2100 median population size will be 4.2 billion, from 1 billion today.

It is important to note that Asia and Africa are predicted to follow very distinct population growth scenarios. East Asia’s population will stabilize by 2030, as Africa’s population bypasses it at 1.6 billion. South Asia will stabilize by 2050, with Africa reaching 2.3 billion by then. Despite some encouraging progress on addressing climate change, population growth will be the dominant determinant factor in causing food insecurity in Africa.

Stabilizing the global population can be achieved by reducing the mean global total fertility rate (TFR) from 2.527 nearer the replacement rate of 2. At present, TFR in developing countries is 2.65, and 1.67 in the so-called developed world. Given that the one-child policy has been implemented in China since 1979 and is so widely known, it is interesting to note that at present TFR in China is 1.60. Even now that the one-child policy measure has been eased, many couples decide not to further expand their families, due to perceived additional costs and time constraints. It seems that the one-child policy has created a new enduring norm in China, with a continuing long-term impact even in its absence. Are there lessons to be learned

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7. United Nations, Department of Economic and Social Affairs, Population Division, op. cit.
from these observations on changing mindsets, short of implementing and then abandoning a limited family-size policy? The optimistic viewpoint argues that burgeoning population growth can be put to good use if new jobs are created, which would be both intellectually challenging and financially rewarding, especially for youth. This raises a sensitive point, however: along with continued efforts to curb population growth, should we also encourage those with less interest and ability to succeed in agriculture, but with the potential to excel in other salaried activities, to explore finding personal fulfillment out of agriculture? Unmotivated and half-hearted farmers tend to be less productive and less eager to modernize farm production, thus delaying food security goals. Should presently farm-bound dreamers, who would rather occupy other positions, be encouraged to work off-farm to fulfill their personal potential and happiness, and thus contribute to society, leaving those most passionate and capable to run the farms?

ROLE OF FAMILY FARMS

There are about 560 million farms in the world. More than 90% of all farms in the world are run by individual families, 85% of all farms are less than 2 ha in size, but all together these small farms occupy only 12% of global arable land. Most of the arable land is home to the 3% of farmers with 5-10 ha, to the 1% with farms of 10-20 ha, and to the remaining farmers with large to very large farms. Most of the arable land area is farmed in large to very large units, even reaching several thousand ha each, and are owned by what are still mostly individual families; e.g., in the United States of America, Canada, Argentina, Australia. Therefore, as a whole, family farms cultivate about 75% of global farmland, producing 80% of the world’s food. These family farms, small and large, are home to about 2.5 billion people, which is about a third of the total global population.

Most small family farms in the developing world suffer from poor infrastructure, lacking efficient access to markets for inputs or outputs. For the more isolated of these farms, modern agricultural technologies, such as improved seed, fertilizers, small machineries, and reliable storage facilities are hardly accessible. At present, labor productivity on small family farms is less than that of larger family farms, while land productivity may or may not show a positive relationship.

10. Shenggen Fan, Joanna Bazarova and Tidjane Olofinbiyi, op. cit.
SUSTAINABLE INTENSIFICATION OF AGRICULTURE

Significant investment in agricultural development in the developing world has been paying off. Since the 1960s, agricultural production has, on average, more than doubled in low- and middle-income countries. The number of hungry people in the developing world, according to the 2016 Global Hunger Index, has dropped by 29% since 2000.

But was this achieved in a sustainable fashion? This a very serious question, with very serious long-term implications. To make substantial progress towards sustainable intensification, we need to replace non-specific outcome and impact statements, which have crossed over from the political arena to many a development arena, with tangible, concrete steps to be taken. Development projects and policies need to adopt quantifiable, verifiable milestones and pursue solid final objectives and goals, with independent accountability evaluations, even if it will sometimes lead to difficult course corrections. In the overseas development aid arena, excessive time seems to be increasingly invested in fine-tuning the "process", rather than in ensuring the joint achievement of development, adoption and impact of new technologies on farmers’ fields that measurably increase food security.

Even seemingly hard figures on goals can prove requiring updating. For example, the widely cited projections that we will need 60-100% more food in 2050 compared to that produced in the second decade of this century may be exaggerated. Hunter et al.’s analysis argues that 25-70% more food would be sufficient, if coinciding with reductions in greenhouse gases and nutrient losses. If this is correct, then plans need to be adjusted. Such hard numbers and positive concepts are sorely needed to achieve tangible on-farm progress, including regular verification of those targets by knowledgeable third parties.

For almost a century, the “inverse productivity” argument has held that small farms have higher labor and land productivity than larger farms. Scandizzo and Savastano recently further dissected the “inverse productivity” dilemma, questioning whether the relationship between farm size and farm / land output efficiency is influenced by crop yields being either low or high. They studied surveys from five African countries. At the lower yield levels, smaller farms indeed tended to have a higher farm / land productivity. However, interestingly, at the higher yield levels, the relationship between farm size and productivity tended to be positively correlated. In other words, larger farms produced not just more food per unit area, but did so more efficiently due to higher land productivity. Clearly, national food security needs higher crop yields to close the food gap sooner. Therefore, if larger farms yield more produce per unit area and more efficiently so, then their continued growth and expansion should be encouraged, including through policy reforms. Larger

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farms also provide more sustainable options for crop diversification and soil-health enhancing crop rotations, with nutritional implications. A diverse, balanced diet starts with a diverse, balanced production system.

In a scenario where the vast multitude of farms is – very – small, and if high yields are indeed fueled by high land and labor productivity, then farm / land consolidation is desirable. History is rife with land reform gone wrong, and lessons should be drawn from such past experiences. In Asia, farm-consolidation has started to gain traction.\(^{15}\)

In Eastern Asia, larger farms are gaining comparative advantage over smallholders, as rising salaries in other sectors of the economy result in farm labor leaving, and then being replaced by agricultural machinery. This then leads to further farm consolidation, because of economies of scale associated with mechanization, Studies like these are highly needed, not in the least to draw lessons from Asia relevant to SSA, where field or farm consolidations are still few and far between.

To benefit from the economies of scale of increased land size per holding, simple consolidation of fields across various farms, but retaining individual farm ownership, can be a first step. This is very effectively happening in Ethiopia in some fairly large farm-based seed production schemes, where GPS technology ensures that everyone still knows very well where his or her farm begins and ends.

Operating larger farm units allows easier experimentation with new technologies, which claim to promote increased production, on just a small section of the farm’s land. Such relatively small trialing areas will hardly affect a larger farm’s overall productivity, but this lower overall risk of experimentation allows farmers on larger farms to see firsthand what new technologies can achieve, and hopefully be convinced. On the other hand, farmers who have small areas to cultivate can ill-afford to sacrifice some land to experimentation and follow a more risk-averse strategy, subsequently learning less.\(^{16}\)

Efficiency-enhancing land transfers beyond immediate family members to more productive producers increase farm and labor productivity, but involve farm sales, and likely some very sensitive family decisions. During such transitions to larger modes of sustainably intensified production involving land ownership transfers, policy support is crucial to guarantee fair sale / purchase agreements. Likewise, safety-nets are needed for those leaving their farms, seeking gainful employment in other parts of the economy, thus contributing to society as a whole.\(^{17}\)

The transition to sustainable intensification by land consolidation would benefit from a concurrently implemented integrated agroecosystems approach. In such an integrated approach, all on the value chain benefit, whether from high-quality and high productivity, environmental goods, or social outcomes.\(^{18}\)

The call for action is growing, warning that over-emphasis on just smallholders could derail attempts to achieve national food security and improved livelihoods for the

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15. Shengen Fan, Joanna Brzaska and Tolulope Olofinjade, op. cit.
17. Shengen Fan, Joanna Brzaska and Tolulope Olofinjade, op. cit.
majority by 2050, including growing urban populations. This is not to say that smallholders should be forgotten, but that a balance should be struck that benefits all within society, while achieving food security. The growing proof of increased land and labor productivity on larger farms with higher yields, should motivate us to advocate for sustainable land consolidation supported by equitable policies.

**CONSERVATION AGRICULTURE**

Four millennia of plow-based agriculture have increased collapse of soil structure, loss of soil organic matter, and soil erosion. At the same time, climate change has raised the urgency to find long-lived natural sinks and perennial green biomass to store excess atmospheric CO₂-carbon. Soils are an excellent candidate, and conservation agriculture (CA) is an effective way to achieve this, with its three-pronged approach that includes zero-tillage, crop residue retention and rotation. Agroecosystems-based CA can come with added advantages, such as substantially increased yields, especially in dry, rainfed regions where it reduces rain water run-off, increases infiltration into the soil, and hence provides more for food production. Recently, nitrogen (N) concentrations in topsoil proved significantly higher under a zero-tillage, permanent broad-bed, maize-wheat system in Northern India than those under conventional tillage. Besides storing more N, this CA package also increased maize and wheat yields by 36% and 8%, respectively, while simultaneously raising soil microbial activity, which released nutrients to the crop. In another maize-wheat rotation trial in Northern India, higher water-use efficiency and soil organic carbon (SOC) storage were obtained with zero-tillage and crop residue retention, as maize yields increased. In a rice-wheat rotation in India’s eastern Indo-Gangetic Plains, combinations of zero-tillage, raised beds, direct seeding, and residue retention, raised SOC levels to 3.0-4.7 t/ha, while conventional tillage actually reduced SOC by 0.9 t/ha. Interestingly, the inclusion of one cycle of conventional tillage, after zero-tillage in the previous crop, resulted in zero increase in SOC in the next crop: apparently just one round of conventional tillage can obliterate past success due to CA in carbon sequestration.

There remains some debate as to whether CA significantly increases carbon storage under increasingly tropical conditions, both in SSA and Asia. Overall the conclusion is that even if the effects are small, CA as a package is recommended. CA trials in tropical East and Southern Africa under heat and drought conditions increased maize yields under either stress. However, in very wet seasons and on high-clay soils, CA performed less than conventional tillage. In an impressively lengthy study of 12 years of CA in the humid tropics of Western Kenya, SOC decreased by 0.11-0.37 t/ha, but did avoid more significant losses of SOC in the absence of CA.¹⁹

Most reported trials on “CA” focus on production systems that just rotate cereal

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crops, and do not include legumes, and thereby do not take into account the third principle in CA’s three-pronged approach, that is “appropriate rotational crops”. Hence, despite successes, there is room for further improvement. In a rare legume-after-legume, pigeonpea-soybean intercropping study, all permutations of CA increased SOC by up to 0.64%, and sequestered up to 15.39 t/ha. Mustard grown under semi-arid CA conditions in India, using appropriate alternative legume and fallow rotations, increased SOC by up to 50%. At the same time, the improved SOC increased yields up to 26.3% over conventional tillage.

Regarding major- (N, P, K) and micro-nutrients (Zn, Fe, and Mn), CA practiced in North-West India in cereal-based cropping systems increased all their levels. This means that investments in fertilizer for the subsequent crop can be reduced without losing productivity.

A recent literature study of 157 publications on CA showed that the best results in SOC storage rates were indeed obtained if all three principles of CA were applied: zero tillage, crop residue retention, and appropriate rotation.

**FOOD WASTE AND LOSS**

Global food waste and loss are around one third of all food produced and stood at 1.3 billion tons annually in 2014.20 One needs to analyze this figure considering all the effort invested, under often difficult circumstances, to produce that food in the first place.

In SSA and South / Southeast Asia, food waste is 120-170 kilograms per capita per year (kg/cap/year), and in Europe and North America about double that, 280-300 kg/cap/year. In 10 SSA countries, representing almost 30% of the SSA population, food loss and waste was equivalent to 22% of daily energy needs.

In the developing world, most food waste is due to production and post-harvest losses, while in the so-called “developed world”, distribution and consumption issues are more important.21 The causes include biochemical, biological, chemical, logistical, mechanical, microbial, organizational, physical, physiological, psychological, technological, and behavioral factors.22 Food loss in the “developing world” includes lack of sanitary storage and transport facilities. Few wholesale supermarket and retail facilities have the economies of scale to invest in such appropriate equipment. Small country food outlets cannot at all afford investment in such relatively expensive facilities. Despite remedial approaches often being well known, reducing food waste and loss in the developing world is one area where little if any progress is visible.

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20. HLPE op. cit.
21. ibid
22. ibid
AGRICULTURAL BIOTECHNOLOGY AND HARNESSING HYBRID VIGOR

Various biotechnology contributions to plant breeding are having a positive impact, such as marker-assisted selection for trait-specific genes and transformation of genetically modified plants, including in developing countries. In 2016, 185.1 million ha of “biotech crops” were grown worldwide, an increase of 3% over the year before. These were planted by a record 18 million farmers in 26 countries, 90% of whom were smallholders. Developing countries planted the majority of the area (54%). Most of this hectarage is situated, in declining order, in the United States of America, Brazil, Argentina, Canada, India, Paraguay, Pakistan, China, South Africa, and Uruguay. Eight of these ten are developing countries. Almost exclusively, the introduced genes provide herbicide or insect resistance, and are restricted to non-food crops. The large-scale provision of genetically modified food crops with climate-smart stress tolerances and health-enhancing qualities are projected to lead to a further quantum leap in genetically modified organism (GMO) adoption, and needs active encouragement from the research and policy communities.

Recent gene-editing approaches (e.g., CRISPR-Cas9) allow a wider choice of species-own genes to be modified or introduced into a plant with high genome site-specificity. These have the potential to contribute to food security through gene transfers that provide drought tolerance, heat tolerance, and other climate-smart attributes. Unlike in traditional cross-breeding, the modern genetically engineered plant is a much more defined and precise product with just the targeted trait and genes improved. These are not “genetically modified organisms” in the commonly used sense of containing introduced genes from outside the plant kingdom, but involve genes from the crop itself or very related crop species, and hence should not be classified as “GMOs”.

In the past 100 years, some first-cross generation F1 hybrids were shown able to hugely out-yield their parents, a phenomenon called hybrid vigor or heterosis. Such hybrids, from the intercrossing of two parents, are most easily achieved in naturally cross-fertilizing crops, such as maize. While these quantum leaps in yield were obtained in these outcrossing crops, breeders of self-fertilizing crops looked with envy at the huge progress made. It proved difficult to coach selfing crops to outcross on a scale needed for commercial hybrid seed production. Recently a newly integrated breeding approach for selfing crops has been developed, which allows the genetic components of the heterosis-fueled, increased yield potential to be bred into superior new varieties of self-fertilizing crops. These varieties breed pure, and require no new seed to be bought for every crop season, as farmers can save their own. Two-thirds of the 30-some major crops we globally eat are

self-fertilizing. This newly integrated “hybrid-enabled line profiling” (HELP) concept and technology should help considerably in lifting yields and obtaining food security for the crops involved.

AGRICULTURAL POLICIES

The “agriculture as the main engine of growth” paradigm needs to be re-examined, including in terms of a primary focus on return-on-investment. While agricultural products stimulate growth in other sectors, its growth itself also depends significantly on demands from elsewhere in the economy, and increasingly so in a globally connected and trading world.

As farm / land consolidation takes place, policies need to be enacted to guarantee fair sales/purchase agreements. Commercializing farms need policy support for effective partnerships with local, regional or international private companies along the value chain in other sectors of the economy, prioritizing sustainable growth. National food and nutrition security will benefit from policies to invest in research and development, to unlock innovations and expand adoption of new technologies. Especially, attracting youth to such careers will require intellectually challenging and financially rewarding positions in science and its applications, supported by empowering policies.

As an example of re-thinking policies, historically, policies on pricing water have been met with opposition by farmers and the larger community, as they are considered to be exclusively negative to farming. However, globally the conviction is growing that some form of water pricing must become part of a climate-smart package for agriculture; it is no longer a question of whether, but of how. In Syria, empirical research involving the International center for agriculture research in the dry areas (ICARDA) has shown that a penalty imposed on water over-use (such as in over-irrigation beyond a crop’s needs), as opposed to a price on just water use, can be effective and is readily accepted. This is a good example of creatively rethinking policy interventions to achieve user adoption.

Agricultural insurance options are often lacking in the developing world. However, in the so-called “developed world”, insurance as a safety-net in commercial agriculture is nothing new, and amounts to a total global business of more than US$20 billion annually. Commercialization of a modernized agricultural sector in developing countries can be encouraged in many ways, if insurance safety-net policies are in place. For example, index-based livestock insurance in Kenya, initiated by the International Livestock Research Institute (ILRI) together with the Kenyan government, which protects rural livestock investments, was recently awarded the World Food Prize Award for Field Research and Application. As another example, Seed Co, one

of the largest private sector seed companies in Africa, has a 21-day money-back index-based insurance on new maize seed in Kenya, using GPS. If it doesn’t rain on your farm within three weeks of the seed purchase, the period in which the seed would have successfully germinated if it did rain, you get your money back, and very efficiently so, via real-time mobile / cell transfer. Customer satisfaction makes customers return.

“Resilience building” as a criterion to evaluate development programs facilitates measuring progress in complex dynamic agro-ecosystem processes, including non-linear dynamics, thresholds, and tipping points, and their response to policies.

THE GOOD NEWS

Past and ongoing implementation of proven and new approaches has resulted in a significant reduction in hunger since the Green Revolution. Some of the current trends in food insecurity and hungry people are among the lowest seen in decades, and very encouraging.

Based on the view that food prices are relatively low, and incomes are increasing in many low-to-middle income countries, the United States Department of Agriculture International Food Security Assessment 2017-2027 predicts that, “over the next decade, the number of food-insecure people is projected to fall from 646 million to 372 million.” This represents a dramatic 42% reduction.

One reason is that the bulk of consumption is focused on grain crops, whose price over the next 10 years is expected to remain relatively low. Global grain production is expected to increase by 9% in the next 10 years. Nevertheless, in the case of SSA, this is not enough to make it independent of imports to fill its deficit. On the nutritional front, fruit, vegetable and meat consumption is also growing in the developing world, thus diversifying and enriching diets, and contributing to food quality security.

In the next decade, the food insecure population in Asia will drop from 13.5% to 4.6%, partly due to Gross Domestic Product (GDP) growth of 6.3%, which is two-thirds above the global average. While on a very different scale, projections for SSA are that the percentage of food insecure people will drop from 31.7% to 19.5%. Nevertheless, the absolute number of food-insecure people in SSA will increase due to large population growth. In terms of absolute numbers, by 2027, Asia, with more than double the number of people than SSA, is predicted to have less food insecure people than SSA.

Food is obtained in a multi-dimensional environment. This multi-dimensional space is a daily reality for those in the food value chain, from the individual farmers standing

28. ibid.
29. ibid.
in their countryside field to the consumers sitting in their urban home, and requires an integrated agroecosystems approach. Some of the key concepts for the latter were created more than 25 years ago, the ideas were then further conceptualized, 30 and examples of implementation were presented. 31 An integrated agroecosystems food security approach that involves all relevant elements, including rural development, food supply chains, agri-business, and urbanization, which are all linked in mutually causal directions, is critical to establishing a sustainable way forward. This integrated agroecosystems approach was briefly considered part of the new framework for future planning international agricultural research during the relatively recent reform of the Consultative Group for International Agriculture (CGIAR). But in mid-2015 the integrated agroecosystems concept, as a guiding principle, and although as worthy of research and development in its own right, was dropped, following significant pressure from a few of the world’s largest governmental and philanthropic overseas development aid investors / funders / donors. The CGIAR then reverted to its original, mostly reductionist, 1960s model of organizing its work as “breeding, agronomy and economics,” many observers arguing that such a model is “reductionist”. However, the realization that this approach is a “reductionist” and “dated”, and can no longer address the modern needs and constraints of farmers in a continuously and increasingly interconnected world, is gaining wider recognition. 32 Moreover, since the 1960s, a significant number of the concepts and technologies developed by CGIAR in partnership with national agricultural research programs, the locally emerging private sector (with / without links to the international private sector) and policy-makers, are very successfully being adopted by farmers. However, after more than 50 years of this CGIAR approach, including training of thousands of developing country scientists and other stakeholders, it is important that the national and local, public and private sector partners in the developing world further develop and optimize such innovative technologies. This will allow the CGIAR to free up its limited budget and outstanding staff to re-invent the organization and its mission, looking forward rather than backward, and acting again as a partner and less as an emerging competitor with national programs. It needs to develop the concepts and methodologies needed to address the future challenges of food insecurity, climate change, and other influences yet unknown.

31. Maarten van Ginkel, Jeff Sayer, Fergus Simkar et al., op. cit.
32. Jiaruo Liu et al., op. cit.
and deteriorating natural and environmental resources — e.g., soil degradation, compromised water quality — and declining public sector investments in agriculture, the issue of food security has resurfaced as a major concern in the global debate in the last 10-15 years. It is generally accepted that the benefits of original Green Revolution technologies included large increases in wheat and rice grain production in many countries. Many of those concepts and approaches have also successfully spilled over into other production systems, including that of food legumes, agro-forestry and livestock, and been adopted by national, public and private sectors. However, many relevant agricultural innovations did not reach those farmers with holdings less than two hectares, and situated in remote areas removed from access roads, markets and empowering infrastructures. As we noted, 80% of all farms (475 million) are — much — less than two ha in size. Increased focus on their plight will likely also result in the realization that totally new concepts and technologies need to be developed.

We strongly believe that sustainable, integrated agro-ecosystems, based on optimized farm size, advanced scientific methods — e.g., conservation agriculture, stress tolerant and high-quality GM food crops, harnessing hybrid vigor in selfing crops — and participatory technology transfer and policies — e.g., pricing water over-use —, must be developed, studied and optimized to jointly achieve food security also for these presently left-out small family-farm communities.

With more than half the world population already living in national cities, food security for those urban areas would specifically benefit from rigorously addressing waste and loss of food products grown in their own rural areas. Apart from a needed change of mind in managing food sustainably along its value chain so that little is lost, developing and building a range of cheap, small-to-large, sanitary storage facilities for use along the value chain will already go a long way to limiting food waste and losses.

Accomplishing local and global food security through implementing technical innovations on small farms, while preserving natural and biological resources, and sequestering pollutants such as CO₂, Carbon and other harmful elements, need strong governmental commitment and policy support. We often find out, indeed, that few of the promises and decisions made in high-profile conferences and fora, are actually implemented on the ground, such as e.g. agreements to curb global deforestation. Although Africa has some catching up to do, signs indicate that great strides can be made towards food security for the majority of the developing world, including certainly Asia, by 2050. However, in order to reach such a food security level, public and private sector world leaders would need to quickly take actions to implement the promises made in conferences and fora.

33. Shenggen Fan, Joanna Braziers and Tolulope Ofohunbi, op cit.