If not GM and factory agriculture, what and who will nourish the world?

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GM does not produce more food. By contrast, many studies reveal that small-holder farmers often have higher productivity than large farms on a per hectare basis without using transgenic crops. The problem of producing food for a growing and more demanding world population lies in improving soil fertility, closing of the yield gap between low-productivity and high-productivity farmers, improving water access and conservation, and protecting biodiversity. These issues can be addressed with agronomic practices that improve climate-change adaption on the one hand, while also providing much needed climate-change mitigation. Modeling of the sustainable farming methods recommended by the widely-supported IAASTD study demonstrates that agriculture can be transformed so that all major sustainability indicators are improved, as well as productivity. This type of agriculture, which relies on fewer expensive, scarce, and often harmful purchased inputs, including genetic engineering, also results in higher income and more jobs. Key points on this are outlined below.

Productivity of Smallholder Farmers without GM seeds

For an overview from the FAO on *smallholders and family farmers and their relationship to sustainability and high productivity*, see FAO (2012). Drawing on Pretty et al., smallholders adopting sustainable agriculture have increased their crop yields on average by 79 percent.

Sub-saharan Africa

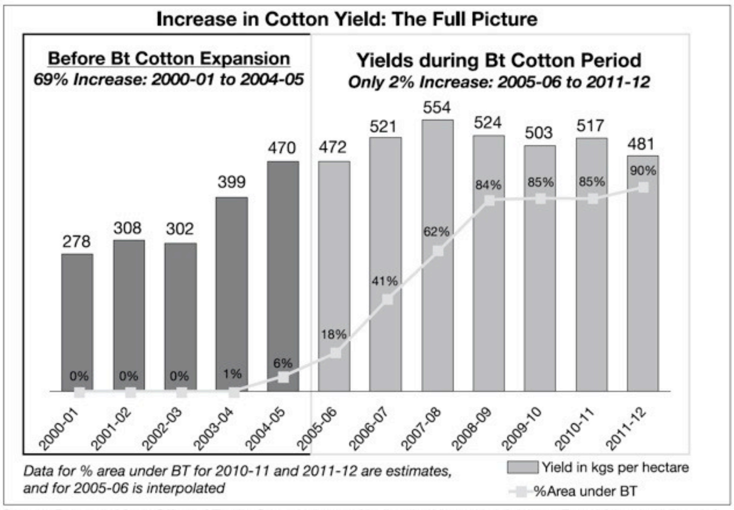
In line with *the Green Revolution approach to achieve agricultural growth in Africa*, the genetic modification of crops, hand in hand with synthetic fertilizer applications, has risen to the forefront as a viable alternative –technological solution – to the current traditional agriculture methods. While some of its most vocal proponents (Paarlberg and Collier) contend that biotechnology is currently kept out of African countries at the cost of starving and poor farmers, I argue that numerous and scientifically backed-up agro-ecological alternatives exist to increase productivity – sustainably and with a proven track record – to the benefit of these small-scale farmers, as well as the local consumers in sub-Saharan Africa and beyond. In addition to the traditional herbicide- and pest-tolerant varieties, GM technologies developed for African farmers include newer generation varieties. One example is a drought-tolerant variety "Water Efficient Maize for Africa (WEMA)" - managed by the African Agricultural Technology Foundation (AATF). Although it has stimulated high hopes, to this date, however, AATF has yet to release to the public the yield results from its ongoing trials. Since yield increases from similar genetic modifications were limited in the US (around 10 percent), it is very likely that existing local and improved (CGIAR and National Research Institutes) drought-tolerant varieties might yield better results.

Singe approaches to increasing yields through genetic improvement do not address the need to consider the farming system as a whole, in which any improvements need to "take root". While I support advancements in seed technologies, sustainable agricultural methods promoted by the Biovision Foundation in Africa and implemented by thousands of East African farmers are effective in not only substantially increasing yields, but at the same time improving soil fertility, increasing soils' abilities to retain moisture, prevent soil erosion, reduce carbon emission, and increase biodiversity among other benefits (see for example Niggli et al. 2009; UNEP 2011; Khan et al. 2008a, b). In an African low-input environment, sustainable agricultural practices cannot only reduce costs of synthetic inputs (i.e. pesticides replaced by push-pull methods), but also increase yields, enhance economic diversification and strengthen household self-sufficiencies and food securities (UNEP and UNCTAD 2008, FAO 2007). Furthermore, smallholder farmers can take advantage of both domestic and international markets for organic and other products derived from such productions.

These multipronged efforts aim at improving the livelihoods of farmers across the scales: moving from soil and the seed to the crop and animals, and finally to the household and the social, economic and ecological sustainability of the region as a whole. While genetically modified seeds have the potential to save input costs (such as labor) or under optimal conditions increase yields, these solutions do not pay off for the smallholder farmer, as they often demand additional fertilizer use, access to irrigation and access to credit and the needed complementary insurances, none of these readily available nor affordable.

On India

In regards to genetic modification, studies have found sustained yield increases for Bt cotton compared to conventional cotton. For example, Kathage and Qaim (2011) compared data of over 500 farmers between 2002 and 2008. They estimated that Bt cotton farmers had a net yield gain of 24 percent. Over the last five years, Bt yields however are described as stagnating, with improper pest management and an overall decrease in soil fertility mentioned as two main culprits (DownToEarth 2011). When focusing on smaller, more marginal farmers who were using intercropping strategies (i.e. sorghum and mungbeans; Swaminathan and Rawal 2011) and focusing on rain-fed, as opposed to irrigated cotton (i.e. Greenpeace 2010), benefits for growing Bt cotton diminish, are non-existent or as new evidence suggests, negative. In contrast, a previous study by Eyhorn et al. (2007) showed significant increases in income at the farm-level for organic farmers compared to Bt cotton farmers in India. Fair comparisons between Bt cotton and best practices conventional and organic are missing. These would be long term comparisons that have all the same agronomic practices, soil fertility levels at the tart of the experiment, irrigation levels as well as equivalent varieties. Environmental and social data need also be considered in such studies. Until such data exist it will be meaningless to draw definitive conclusions.



Source: Data used from Office of Textile Commissioner of India, cited by cotton Advisory Board (www.txindia.com) and Cotton Corporation of India (cotcorp.gov.in/state-operations.aspx)

A recent publication reviewing a decade of Bt cotton in Madhya Pradesh (where Bt adoption has risen from 6 % in 2004–5 to 90 % by 2011–12 measured in percentage of area under production) by Hamara Beej Abhiyan and Beej Swaraj Abhiyan (2012) highlights how yield increased by nearly 70 percent from 2000 till 2005 prior to the expansion of Bt cotton. After 2005 and with the expansion of Bt cotton, yield increases were only 2 percent (Figure 1).

Due to the very widespread adoption of Bt cotton (90+ percent), it has become nearly impossible for organic cotton contractors - India produces up to 80 % of the world's organic cotton - to obtain non-GM seeds. Current efforts are underway to establish a long-term participatory plant breeding program to develop locally adapted cultivars and maintain and increase genetic diversity (Roner et al. 2012). These efforts - led by FiBL, bioRe an organic cotton producer in Central India and the University of Agricultural Sciences (UAS) Dharwad - are focusing on safeguarding the heritage of Desi cotton for the benefit of organic farmers. Given the high costs associated with these initiatives (and the lack of private seed company interest given the importance of the Bt seed market) this type of initiative clearly would offer a great opportunity for government involvement to strengthen public research for the benefit of rain-fed small-scale farmers, sustainable agriculture and maintaining biodiversity.

Challenge of soil fertility

Fertile land is the precondition for successful agricultural production. However, land is becoming scarce, with increasing degradation due to unsustainable practices and growing global competition for productive agricultural land. Land degradation, and poor soil fertility in particular, is widely accepted as the most critical limiting factor in constraining agricultural production in sub-Saharan Africa (IAASTD 2008; 2009). There are some 5 billion hectares of land presently available for the global food supply: 1.5 billion hectares of farmland and permanent crops and 3.5 billion hectares of grassland, grazing land and extensively used steppe (Harder 2008). Of this land, 1.9 billion hectares have already been degraded to a greater or lesser extent due to intensive and improper use (IAASTD 2008; i.e. UNEP 1999; Eswaran et al. 2006). Additionally, 10 million hectares are lost to erosion every year. The need to stop the loss of farmland is urgent, and this includes regenerating depleted soils so they can be uses in the future with sustainable production methods (Herren 2012). Fertile soils are also crucial to mitigating climate change and building resilience for adaptation as discussed below. There is a need to consider the feedback system from agriculture to CC and CC to agriculture. Clearly, a continuation of present farming practices contributing some 50 % of the GHG need a major change in direction. In particular any practice, such as the ones promoted and underscoring the Green Revolution need to be dumped in favor of ecologically based practices that are regenerative.

Challenge of Yield Gap

"The challenge is to find ways to close this yield gap by overcoming the constraints to innovation and improving farming systems in ways that are appropriate to the environ- mental, economic, social and cultural situations of resource- poor small-scale farmers. An additional requirement is for farm products to be fairly and appropriately priced so that farmers can spend money on the necessary inputs." (IAASTD 2009, p.223)

Proposed methods from IAASTD (2009, p. 382–383) include:

- improve practices for root health management
- conventional breeding/rDNA assisted
- transgenics
- improve the performance of livestock in pastoral and semi-pastoral subsistence communities
- rain water harvesting, supplemental and small scale irrigation for rainfed systems
- integrate soil water and soil fertility management
- multiple water use systems, domestic and productive uses, crops/livestock/fisheries

Closing the gender gap in agriculture would have a substantial impact on increasing yield. According to the FAO's State of Food and Agriculture 2010–11 report on the topic: "If women had the same access to productive resources as men, they could increase yields on their farms by 20–30 percent. This could raise total agricultural output in developing countries by 2.5 to 4 percent, which could in turn reduce the number of hungry people in the world by 12–17 percent." (FAO 2011, p.5f)

Challenge of improving water access and conservation

Sustainable use of natural resources is also especially relevant when we look at the use of water in agriculture. Agriculture accounts for 70 per cent of global freshwater consumption today – yet it is possible to limit water use while still meeting global food and nutritional needs. In various regions such as India, China, North Africa and the Middle East, depletion of water resources is already a serious problem. Groundwater levels are falling rapidly. Further, groundwater resources are only renewable over the very long term, if at all. Climate change will exacerbate water shortages in drier parts of the world. Sustainable small-scale farming exhibits a great deal of potential with regard to reducing water consumption. Efficient irrigation systems – such as drip irrigation – could reduce consumption by several degrees of magnitude. Case studies in developing countries have demonstrated that water consumption can be reduced by 40–80 per cent yet increase yields by up to 100 percent (i.e. for drip irrigation see Burneya et al. 2009; Sivanappan 1994, Belder et al. 2007). In 2011 the United Nations Environment Programme (UNEP) Green Economy report confirmed that production with sustainable methods, which is adequate to cover humanity's food needs in the year 2050 with limited use of water, is now feasible (UNEP 2011) and should be implemented without delay in order to avert a catastrophic temperature rise beyond 2 degree Celsius (N Stern Review, 2010).

Challenge of protecting biodiversity

Biological diversity is crucial for sustainable food production, but it is currently under considerable threat. Over centuries, humanity has used over 10,000 edible plants: today we use only 150 and just 12 species make up 80 per cent of plant-based food production (FAO 2008). The edible plants being grown are becoming increasingly similar to one another. The enormous wealth of cultivars that the world's farmers have created through cultivation under a variety of conditions has shrunk in parallel with the rapid rise to dominance of a few globally grown high-yield cultivars. An estimated 75 per cent of all economically useful plant cultivars have vanished from the world's farms (Forum Biodiversität Schweiz, 2005, p.18). With every species that disappears, valuable genes are lost. Considering that 90 per cent of pest species have natural antagonists – predatory or parasitic insects – and over thousands of species of pollinating insects provide their services to the agriculture sector, this matters a great deal. This is why diversity in the animal kingdom and plant species is an insurance against pest problems, and key to ensuring food and nutrition for all allowing higher productivity, adaptation, and maintenance of ecosystem functions (see also FAO and Platform on Agrobiodiversity Research 2011). The conservation of agricultural biodiversity is unique, in that it depends on the use and practices of farming communities, in their fields. Diverse smallholder farming systems with farmer-selected seeds not only foster genetic diversity and adaptation to climate change, but provide an environment that is very beneficial to natural enemies and pollinators. These beneficial insects may be far more diverse in farmer's fields even than in natural habitat (Gikungu 2011). The contrary is also true, however, that the uniformity of industrial farming and use of pesticides, whether sprayed or coated on seeds, is highly damaging to agrobiodiversity in all forms.

Agroecology fosters climate-change adapation and mitigation

Intensive industrial farming is one of the causes of climate change, and we need to switch to ecological methods to provide relief. Agriculture accounts for 47–55% per cent of man-made greenhouse gas emissions. Livestock contributes 18 percent of the global warming effect, which is even more than the total from global transport. Agriculture accounts for 50–60 per cent of emissions of nitrous oxide (N_2O) and methane (CH_4), which are both potent greenhouse gases: 1 kilogram of methane has the same impact as 21 kilograms of carbon dioxide (CO_2), and nitrous oxide has 310 times the impact. Animal factory farms have the highest greenhouse gas emissions in the agriculture sector. Moreover, the potential impact of climate change on agricultural production is huge (see IAASTD 2008, 2009; Steinfeld et al. 2006). On the other hand, some methods of sustainable and organic farming can reduce climate change impact while increasing resilience (Niggli et al. 2009). One example is the sequestration of CO_2 in fertile soils where the humus content is higher. CO_2 from the atmosphere ends up in dead plant materials in the soil, where it is mineralized before being released again as CO_2, but some of it is also stored in the humus for a long time. If the humus content increases, more CO_2 will be stored in the soil than will escape. Studies have shown that soils on organic farms are richer in humus than soils on conventional farms. Furthermore, ploughless farming techniques can further increase CO_2 capture in soils, because ploughs promote the breakdown of humus.

Modeling of sustainable agriculture demonstrates how productivity and sustainability can be improved

There are a number of recent studies that provide evidence from both experiments and computer simulation models to justify a change in course in agriculture and the wider food system, as both are closely connected. Maeder et al. (2002) reported on soil fertility and biodiversity. The Rodale Institute (2011) published extensively on yield and profitability under sustainable production systems and also FiBL (2011) on farming system comparisons in the tropics. Some of these and many other studies have provided the needed input into the agriculture chapter supported by a system dynamics model of agriculture and related sectors (UNEP. 2011). The UNEP study shows how an investment in a global change from brown to green agriculture would result in benefits on all key social, environmental and economic sustainability indicators (Figure 2).

Green Agriculture can......(UNEP GER Report - 2011)
Investing 0.1% or 0.16% of total GDP ($83-$141 Billion) / year

Year		2011	2050		
Scenario	***Unit***	***Baseline***	***Green***		***BAU***
Ag production	Bn US$/Yr	1,921	2,852	↑	2,559
Crops	Bn US$/Yr	629	996	↑	913
Employment	M People	1,075	1,703	↑	1,656
Soil quality	Dmnl	0.92	1.03	↑	0.73
Ag water use	KM3/Yr	3,389	3,207	↓	4,878
Harvested land	***Bn ha***	***1.20***	***1.26***	↓	***1.31***
Deforestation	***M ha/Yr***	***16***	***7***	↓	***15***
Calories p/c/day for consumption	Kcal/C/D	2,081	2.524	↑	2.476

Figure 2. Summary of results from the Green Economy Agriculture chapter

Benefits of a revolution based on sustainable agriculture: knowledge- and labor-intensive, vs capital-intensive

Public investments in sustainable agricultural productivity will result in clear pro-poor growth. Improving productivity of small-scale agriculture in sub-Saharan Africa by 10 percent can lift almost 7 million people above the dollar-a-day poverty line (McIntyre, B., Herren, H. R., Wakhungu, J., & Watson, R. T., 2009, p.2) The benefit of agro-ecological agriculture is its focus on knowledge-intensive nature, which means that the technologies can be adapted and disseminated amongst farmers, including their own innovations. Depending on the agro-ecological technology, higher labor-intensiveness in agriculture - coupled with increased productivity - can also result in improved employment opportunities and wages for rural, landless poor classes. This stands in stark contrast to previous experiences of the Green Revolution, where the introduction of high-input agriculture resulted in increases in inequalities as the poorest farming households or regions were unable to benefit from such capital-intensive technologies. Even proponents of the Green Revolution are beginning to moderate their assessments of its success: “The direct benefits to the poor through their own on-farm adoption, greater agricultural employment, and empowerment have been more mixed and depend heavily on local socioeconomic conditions. In many cases inequalities between regions and communities that adopted Green Revolution technologies and those that did not also worsened. At the same time, the Green Revolution had many negative environmental impacts that have still to be adequately redressed.” IFPRI (2003), p. 4.

The way forward

In order to change the way food is produced, there will be a need to change the ways food is being processed, marketed and consumed. In particular, consumption patterns will have to change drastically, as in no way can the planet sustainably produce food at the rate it is being consumed and wasted in the western world today. Consumers have the ultimate decision power over their preferences, and information needs to be given to them in order that they can make informed choices. This is not the case today in most instances. But there is also a trend in the right direction on the horizon, despite the fact that agri business is trying hard to thwart any effort in that direction. Scare tactics such as the specter of additional costs, or the “impossibility “ to label foods that contain GMOs for example are being widely circulated. The IAASTD report “Agriculture at a Crossroads” could not have delivered a stronger message than “business as usual is not an option”; the world needs a paradigm shift if it wants to reach the goal of food security for all for the long term. Simple solutions for complex problems - as they are being proposed with GMOs as the solutions to production problems of today and climate change impacts of tomorrow - are not credible. Scientists and policy makers need to start to think in system, and see the agriculture and food as an integrated system that is interconnected across all the dimensions of development. System tools and scenario models, allowing people to play out options for the future and inform sustainable development policies that take into account the worlds boundaries are urgently needed. We can’t afford to keep our heads in the sand and hope for the crises to pass, or throw some reductionist solution(s) at them, in the hope that they will miraculously disappear. Time for realism and above all courage to make the tough decisions today has come, for the sake of our children and theirs too.

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