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Old Fertilizer in New Bottles: Selling the Past as Innovation in Africa's Green Revolution

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Abstract

Rising global hunger in recent years has prompted calls for a broad reckoning over what is wrong with global food systems. Our changing climate has added urgency to the crisis. Many experts warn that our current agricultural practices are undermining the resource base – soil, water, seeds, climate – on which future food production depends. Now the global COVID-19 pandemic threatens to further exacerbate food insecurity for many of the world's poor. Africa is projected to overtake South Asia by 2030 as the region with the greatest number of hungry people. An alarming 250 million people in Africa now suffer from "undernourishment," the U.N. term for chronic hunger. If policies do not change, experts project that number to soar to 433 million in 2030. A growing number of farmers, scientists, and development experts now advocate a shift from high-input, chemical-intensive agriculture to low-input ecological farming. They are supported by an impressive array of new research documenting both the risks of continuing to follow our current practices and the potential benefits of a transition to more sustainable farming. The new initiatives have been met with a chorus of derision from an unsurprising group of commentators, many associated with agribusiness interests. They dismiss agroecology as backward, a nostalgic call for a return to traditional peasant production methods which they say have failed to feed growing populations in developing countries. For such critics, the future is innovation and innovation is technology: the kinds of commercial high-yield seeds and inorganic fertilizers associated with the Green Revolution.

This paper explores the ways in which this innovation narrative flips reality on its head, presenting Green Revolution practices of the past as if they were new innovations. It does so through the lens of the battle for Africa's food future, examining the disappointing results from the Alliance for a Green Revolution for Africa (AGRA). In contrast, the real innovations in Africa are coming from soil scientists, ecologists, nutritionists, and farmers themselves who actively seek alternatives to approaches that have been failing small-scale farmers for years. A wide range of farmer organizations, scientists, and advocates offer a broad and diverse array of ecologically-based initiatives based on sound science. These are proving far more innovative and effective, raising productivity, crop and nutritional diversity, and incomes while reducing farmers' costs and government outlays.

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Introduction

Rising global hunger in recent years has prompted calls for a broad reckoning over what is wrong with global food systems. Global agriculture produces an overabundance of food but leaves nearly one billion people chronically hungry, another one billion food insecure, and another billion overweight or obese. In total, nearly half the people on the planet suffer some food-related threat to their health.[2] Many more consume diets that fail to meet recommended nutritional diversity. Worldwide, noncommunicable diseases now cause more than 70% of all deaths.[3]

Our changing climate has added urgency to the deliberations. The U.N. Intergovernmental Panel on Climate Change in 2019 documented the contributions of industrialized agriculture to climate change, calling for profound changes to both mitigate and help farmers adapt to climate disruptions.[4] Many experts warn that our current agricultural practices are undermining the resource base – soil, water, seeds, climate – on which future food production depends.

Now the global COVID-19 pandemic threatens to further exacerbate food insecurity for many of the world's poor. According to the United Nations, for the fifth straight year undernourishment – or chronic hunger – increased in 2019 to 690 million worldwide, up 60 million since 2014. Those estimates were for 2019, before COVID-19. Experts say as many as 130 million more could be driven into hunger as a result of the virus. Some 2 billion people worldwide already experienced some regular form of food insecurity in 2019. Africa is projected to overtake South Asia by 2030 as the region with the greatest number of hungry people. An alarming 250 million people in Africa now suffer from "undernourishment," the U.N. term for chronic hunger. If policies do not change, experts project that number to soar to 433 million in 2030.[5]

One reckoning is scheduled for October 2021 when the United Nations will convene the U.N. Food Systems Summit. The initiative is part of the Decade of Action to achieve the Sustainable Development Goals (SDGs), one of which commits to ending hunger by 2030. By all accounts, the world is moving in the opposite direction, which prompted the U.N. Secretary General to call for the extraordinary summit.

Small-scale farmers in developing countries face multiple challenges. They represent the largest demographic group of chronically hungry people. They confront a relentlessly worsening climate, with rains growing erratic, droughts and severe storms threatening harvests, rising temperatures exacerbating pest infestations and rendering production of traditional crops more precarious.

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[2] FAO, "THE STATE OF FOOD SECURITY AND NUTRITION IN THE WORLD 2020" (Rome, Italy: FAO, July 2020), https://doi.org/10.4060/CA9692EN.

[3] World Health Organization, "Non Communicable Diseases." Accessed September 1, 2020. https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases.

[4] IPCC, "Special Report on Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems" (Intergovernmental Panel on Climate Change, 2019), https://www.ipcc.ch/srccl/.

[5] FAO, "THE STATE OF FOOD SECURITY AND NUTRITION IN THE WORLD 2020."

In response, a growing number of farmers, scientists, and development experts have advocated a shift from high-input, chemical-intensive agriculture to low-input ecological farming. They are supported by an impressive array of new research documenting both the risks of continuing to follow our current practices and the potential benefits of a transition to more sustainable farming.

The new initiatives have been met with a chorus of derision from an unsurprising group of commentators, many associated with agribusiness interests. They dismiss agroecology as backward, a nostalgic call for a return to traditional peasant production methods which they say have failed to feed growing populations in developing countries. For such critics, the future is innovation and innovation is technology associated with the Green Revolution: commercial high-yield and genetically modified seeds that respond to inorganic fertilizers. Under the banner of modernization, they prescribe the dissemination of high-input agriculture throughout the developing world.

This paper explores the ways in which this innovation narrative flips reality on its head, presenting Green Revolution practices of the past as if they were new innovations. It does so through the lens of the battle for Africa's food future, examining the disappointing results from the Alliance for a Green Revolution for Africa (AGRA). In Africa, the real innovations are coming from soil scientists, ecologists, nutritionists, and farmers themselves who actively seek alternatives to approaches that have been failing small-scale farmers for years.

Africa is considered the last frontier for industrial agriculture, and the Green Revolution for Africa has promised the continent its own well-funded transformation after the first Green Revolution failed to take hold in Africa. The new effort, spearheaded by the Bill and Melinda Gates Foundation's Alliance for a Green Revolution for Africa (AGRA), has thus far produced disappointing results, failing to significantly raise yields, incomes, or food security for Africa's small-scale farmers.

Meanwhile, a range of farmer organizations and advocates is challenging the Green Revolution campaign with a broad and diverse array of ecologically-based initiatives that are proving far more innovative than the Green Revolution's seeds and fertilizers. They are also proving more effective, raising productivity, crop and nutritional diversity, and incomes while reducing farmers' costs. In the process, they shrink the ecological footprint of agriculture and restore degraded soils while sequestering carbon and building climate-resilience for small-scale farmers. They also reduce government expenditures, which now heavily subsidize the purchase of commercial inputs.

The assault on agroecology

The adage widely attributed to Indian independence leader Mahatma Gandhi says, "First they ignore you, then they laugh at you, then they fight you, then you win." If those are the four stages of social change, the movement for agroecology seems to have reached Stage 3. Recent criticisms of agroecology have been well-orchestrated and scripted, invoking underdevelopment and backwardness and extolling the virtues of industrial-scale agriculture.

Then-U.S. Ambassador to the U.N. Food and Agriculture Organization (FAO), Kip Tom, is the most prominent of such critics. In an August 2020 commentary for a far-right media outlet, Tom repeated many of the claims he'd made in a controversial February speech at the U.S. Agricultural Outlook Forum, implying that a well-funded conspiracy by rich-country foundations, campaigners, and European governments is denying small-scale farmers in developing countries the technologies they need to feed their communities:

> "Under the previous Director General, Graziano da Silva (2012-2019), the FAO became increasingly politicized, transforming from a science-based development organization into a champion of agrarian 'peasant' movements supported by well-funded NGOs that condemn trade as neo-colonialism and equate property rights with oppression.
>
> "Advanced under the banner of 'agroecology,' this new approach rejects the 20th century agricultural technologies -- including advanced biotech seed varieties, modern pesticides and fertilizer -- that undergird food security in every developed and successfully developing nation. In their place, the FAO's agroecologists and their allies promote practices that are deemed more 'culturally sensitive' and hold up 'subsistence farming' as an ideal. But this endless cycle of back-breaking labor and low-yield production keeps so much of the world mired in underdevelopment."[6]

Paul Driessen, a senior policy advisor with the right-wing Committee for a Constructive Tomorrow (CFACT) and the Center for the Defense of Free Enterprise, detailed the conspiracy in a series of articles earlier this year. The inflammatory headlines drove home the argument that anyone opposing the advance of agricultural technologies in the name of agroecology was condemning poor farmers to backwardness and poverty: "Financiers of Poverty Malnutrition and Death," and "Luddite Eco-imperialists Claim to be Virtuous."[7] In "Keeping Africa on the Brink of Starvation," Driessen states:

> "For years now, the FAO, U.N. Development Programme and U.N. Environment Programme (UNEP) have been working in cahoots with some of the most radical environmentalist pressure groups on Earth to devise and impose 'agroecology' – a perverse combination of socialism, pseudo-ecology and primitive, anti-technology agriculture.
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> "Instead of transforming and modernizing African agriculture, the UN, FAO, UNEP, and radical groups like Food First, La Via Campesina, Greenpeace and IFOAM Organics International demand 'culturally appropriate' food produced through 'ecologically sound

[6] Kip Tom, "The UN Should Learn That Ideology Won't Stop a Plague of Locusts | RealClearWorld," August 5, 2020, https://www.realclearworld.com/articles/2020/08/05/the_un_should_learn_that_ideology_wont_stop_a_plague_of_locusts_501134.html.

[7] Paul Driessen, "Financiers Of Poverty, Malnutrition And Death (Part II) - OpEd," *Eurasia Review* (blog), April 23, 2020, https://www.eurasiareview.com/23042020-financiers-of-poverty-malnutrition-and-death-part-ii-oped/; Paul Driessen, "Luddite Eco-Imperialists Claim to Be Virtuous," The Heartland Institute, accessed December 15, 2020, https://www.heartland.org/news-opinion/news/luddite-eco-imperialists-claim-to-be-virtuous.

> and sustainable methods,' as only they can twist those terms to serve their sick determination to negate and roll back human progress."[8]

George Mason University economics professor Walter Williams amplified Driessen's message in his own set of columns, with their own inflammatory headlines, such as: "Blame Agroecology not Climate Change for this African Tragedy."[9]

Some African commentators have weighed in as well. Kenyan public relations consultant and journalist James Njoroge authored an October 28, 2020 article, "NGOs & Foundations Want to Dictate Africa's Agricultural Destiny," striking all the familiar chords:

> "Cloaking themselves in the woke environmental and pro-peasant farmer rhetoric of the organic-only agroecology movement, groups like the Alliance for Food Sovereignty in Africa (ASFA) (sic) and the anti-trade and anti-technology movement La Via Campesina work overtime to keep African farmers from using safe pesticides, fertilizers, hybrid seeds, and genetically modified crops (GMOs) and other advanced agricultural tools. It's a radical agenda that is the face of a 'green' neo-colonialism.
>
> "They advocate agroecology idealizing peasant labor and retrograde subsistence farming. In short, they reject the 'Green Revolution's' successes and dismiss the billions of lives saved from starvation…."[10]

Many African commentaries have been generated indirectly by the Cornell Alliance for Science (CAS), a controversial institute funded by the Bill and Melinda Gates Foundation to "depolarize the GMO debates" by training invited fellows in "advanced agricultural biotechnology communications." A recent report by the U.S. non-profit AGRA Watch analyzed the CAS Fellows Program, which trained 68 African fellows between 2015 and 2019. Among them was Ugandan Nassib Mugwanya, who authored the February 4, 2019 article, "After Agroecology: Why Traditional Agricultural Practices Can't Transform African Agriculture."

"Proponents of agroecological farming in Africa effectively advocate for the status quo, not transformation," writes Mugwanya. "They are proscribing technology and agricultural modernization in the name of social justice and working within the limits of nature, rather than giving African farmers a plausible pathway out of hunger and poverty."[11]

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[8] Paul Driessen, "Keeping Africa On the Brink of Starvation," Townhall, accessed November 10, 2020, https://townhall.com/columnists/pauldriessen/2020/02/22/draft-n2561715.

[9] Walter Williams, "Blame 'agroecology,' Not Climate Change, on This African Tragedy," TylerPaper.com, accessed December 15, 2020, https://tylerpaper.com/opinion/columnists/blame-agroecology-not-climate-change-on-this-african-tragedy/article_cc38ff08-5d0e-11ea-a46b-9b1beaa42c14.html.

[10] James Njoroge, "NGOs & Foundations Want to Dictate Africa's Agricultural Destiny," European Scientist, October 28, 2020, https://www.europeanscientist.com/en/features/ngos-foundations-want-to-dictate-africas-agricultural-destiny/.

[11] Nassib Mugwanya, "After Agroecology: Why Traditional Agricultural Practices Can't Transform African Agriculture," The Breakthrough Institute, February 4, 2019, https://thebreakthrough.org/journal/no-10-winter-2019/after-agroecology.

AGRA Watch analyzed Mugwanya's article and identified four "false narratives" common to these recent attacks on agroecology:

1. Agroecology can be characterized as a particular (limited) set of agricultural practices.
2. Agroecology involves a glorification of the past and a rejection of the modern.
3. Agroecology is being imposed upon African farmers from outside of Africa.
4. Agroecology will keep farmers locked into poverty and drudgery.

The report's authors demonstrated in each case why these narratives are false, citing a range of sources on agroecology and innovation and correcting biased characterizations. For example, La Via Campesina is not an "anti-trade and anti-technology movement," it is a multi-million-member global alliance of peasant and farmers' organizations. As AGRA Watch concludes, "The overall message left with readers of Mugwanya's article can be summed up as follows: Agroecology is being foisted upon unsuspecting African farmers from the outside – by wealthy NGOs that romanticize peasant lifestyles. Claims of the benefits of agroecology are not well grounded in science. What farmers really need is biotech and accompanying technological packages, and agroecology is dangerous and immoral for serving as an impediment to this."[12]

In my own analysis of Mugwanya's piece, I identified two persistent and related pieces of misinformation. First, he characterized agroecology in ways that failed to reflect the many scientific advances that have been made in relevant fields. In that sense, such commentaries are ill-informed and seem willfully ignorant of advances in science, all presented as a defense of science. Second, and perhaps less widely acknowledged, he characterized modern agricultural methods such as those promoted under the banner of Africa's Green Revolution as new innovations that are providing good results for farmers and food production. In fact, Green Revolution approaches are failing to meet the U.N. Sustainable Development Goals by sustainably increasing food production while reducing hunger and poverty. The interest in and acceptance of agroecology is growing, even at an FAO once characterized as the "temple of the Green Revolution," precisely in response to the failures of Green Revolution practices.

As I wrote in that response, "Agroecology brings much-needed innovations to prevailing smallholder practices. With a long track record of achievements in widely varying environments, the approach has been shown to improve soil fertility, increase crop and diet diversity, raise total food productivity, improve resilience to climate change, and increase farmers' food and income security while decreasing their dependence on costly inputs. The predominant input-intensive approach to agricultural development can hardly claim such successes, which is precisely why international institutions are actively seeking alternatives."[13]

We will examine first the evidence that the kinds of innovations associated with high-input, chemical-intensive agriculture have been successful in the past and that additional innovations make such Green Revolution programs well-suited for advancing sustainable agricultural

[12] AGRA Watch, "Messengers-of-Gates'-Agenda-A-Case-Study-of-the-Cornell-Alliance-for-Science-Global-Leadership-Fellows-Program.Pdf" (Community Alliance for Global Justice, August 7, 2020), https://cagj.org/wp-content/uploads/Messengers-of-Gates%E2%80%99-Agenda-A-Case-Study-of-the-Cornell-Alliance-for-Science-Global-Leadership-Fellows-Program.pdf.

[13] Timothy A. Wise, "Opinion | Agroecology as Innovation," *Food Tank* (blog), July 9, 2019, https://foodtank.com/news/2019/07/opinion-agroecology-as-innovation/.

development in Africa. As our research shows, the latest campaign to promote a Green Revolution for Africa relies on old technology and is failing on its own terms.

The Green Revolution isn't what it used to be…but maybe it never was

It is worthwhile to revisit the model on which Africa's Green Revolution is based, the widely hailed effort to improve food production in Asia and Latin America through the active promotion of new high-yield seed varieties supported by applications of inorganic fertilizer. U.S. crop breeder Norman Borlaug won a Nobel Prize for his development of a high-yield variety of wheat and his galvanizing effort to promote the adoption of improved varieties of wheat, rice, and maize – the world's three main staple grains – in India and other developing countries suffering widespread hunger and periodic famines. The effort, which transformed agriculture in much of India, was credited with saving millions of lives by allowing Indian farmers to grow more food.

This first Green Revolution, which had significant impacts in much of Asia and Latin America but not in Africa, has always had its critics. From the beginning, many warned that the technology package would prove unsustainable, leading to long-term declines in soil fertility, depletion and contamination of groundwater supplies, and impoverishment of many small-scale farmers who would not be able to sustain crop yields or profit from their sale as they took on the higher costs of such input-intensive farming practices.[14]

In hindsight, many of those warnings have proven accurate. Recently, historians have examined the myths and realities of the first Green Revolution.[15] Their accounts, grounded in empirical data, much of it from India, suggest that crop yields did not increase significantly faster after Green Revolution innovations than they were already rising. Agriculture was not stagnant and the new technologies did not appreciably increase yield growth. It only appeared that way because a severe drought had diminished harvests just before the Green Revolution arrived, making the recovery seem like a miracle. In that context, the claim of "millions of lives saved" has to be revised; some historians suggest that even in the short term the new technology package may have had only a negligible impact on hunger in India.

There is also evidence that high-yield seed genetics was not the most important input responsible for the yield increases Indian farmers observed, nor was inorganic fertilizer. The most important input was irrigation, according to recent studies. The Indian government and donors supported the widespread installation of tube wells, dramatically expanding the area under irrigation.[16]

These new detailed histories of the first Green Revolution (GR 1.0) explain why we should not now be surprised when Africa's Green Revolution (GR 2.0) fails to produce the promised results.

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[14] See, for example, Vandana Shiva, *The Violence of the Green Revolution: Third World Agriculture, Ecology, and Politics* (University Press of Kentucky, 2016).

[15] For a good overview, see Glenn Davis Stone, "Commentary: New Histories of the Indian Green Revolution," *The Geographical Journal* 185, no. 2 (June 2019): 243–50, https://doi.org/10.1111/geoj.12297.

[16] Kapil Subramanian, "Revisiting the Green Revolution: Irrigation and Food Production in Twentieth-Century India" (Ph.D., England, University of London, King's College (United Kingdom), 2015), https://search-proquest-com.ezproxy.library.tufts.edu/docview/1837038837?pq-origsite=primo.

If GR 2.0 relies mainly on the same technologies as its predecessor, there is little reason to believe the results will be any better. Consider:[17]

- There was no broad acceleration in yield growth in India for a range of food grains beyond wheat. Yields grew faster in the decade before GR 1.0 was launched with the introduction of so-called high-yield varieties of wheat and then rice in 1967-8.
- GR 1.0 promotion focused primarily on wheat, which was the only food grain to register higher productivity gains than the decade before.
- The area planted to wheat increased dramatically, accounting for nearly half of the increase in wheat production, thanks to all the incentives and subsidies for its adoption.
- India adopted a controversial policy to concentrate fertilizer use on GR 1.0 wheat varieties at maximum levels (up to 200 kg/ha) despite evidence that overall production would be higher if fertilizer was spread less intensively (40-80 kg/ha) on a wider range of varieties, including locally bred varieties.
- Contrary to Green Revolution myth, several locally bred wheat varieties did comparably well, particularly with moderate fertilizer; in fact, in field trials some showed higher yields than the GR 1.0 varieties. Such data was suppressed in the decisions to go all-in on promoting the new imported varieties.
- The Indian government was already expanding irrigation before the arrival of the Green Revolution, and most varieties showed accelerated yield growth with reliable water supplies. It would not surprise most farmers to learn that irrigation was deemed the most important input in India's Green Revolution.
- Irrigation rates were very high for priority crops such as wheat, particularly compared to Africa (just 4%). For all of India, 54% of wheat land was irrigated, with 86% irrigated in priority areas such as Punjab. The new GR 1.0 varieties of wheat, bred to respond to optimal water conditions and maximum applications of fertilizer, produced relatively high yields.
- All the attention to wheat took land and resources away from other priority food crops. Rice, a more important food grain in India, got its own GR 1.0 promotion but showed poor results, posting just 1.9% annual growth in production compared to 3.5% in the 15 years preceding GR 1.0.
- Unsupported crops such as pulses, a key source of protein in India, suffered declining yields with production growing very slowly; growth rates for sorghum and millet production also declined significantly.

These weak or even negative impacts presage some of our findings on Africa's Green Revolution, with maize rather than wheat as the chosen program crop, weak productivity even for maize, and negative impacts on non-target but important food crops such as sorghum, millet, cassava, and sweet potato. Even just from the standpoint of overall food crop productivity, GR 1.0's innovations appear to have failed to live up to expectations, and the results certainly do not justify the myths widely promulgated about the first Green Revolution.

Add to this the well-documented environmental toll on India's farms and landscapes and the negative impacts of GR 1.0 on the livelihoods of smallholder Indian farmers. Water tables have been depleted and contaminated with chemical runoff. Soil fertility has declined as monocultures of supported crops mine the nutrients from the land and excessive application of inorganic

[17] For a detailed presentation, see Subramanian, 37–57.

fertilizer acidifies the soil. Pest and weed resistance have rendered many common pesticides ineffective. The widespread adoption of genetically modified crops (GMOs), with their engineered pesticides and herbicide tolerance, have lost much of their effectiveness. Farmers have suffered the all-too-common experience of rising input costs and declining yields. The resulting economic strain has left many in debt and contributed to India's tragic levels of suicide among indebted farmers.[18] Some long-time advocates of the Green Revolution approach acknowledge the damage caused by many of the technologies and practices it promoted.[19]

It is perhaps unsurprising, then, that some of the strongest movements for agroecology are in India where farmers and public health advocates are struggling to recover from the social, economic, and environmental damage from decades of chemical-intensive agriculture. The state government of Andhra Pradesh, for example, has committed to so-called Zero Budget Natural Farming, one of many variations of ecological agriculture in practice around the world. Participating farmers saw declining costs, yield increases within two years of 9%-40% depending on the crop, and improvements in net incomes of 40%-80%. They expect to have six million farmers managing eight million hectares (about 20 million acres), challenging the common claim by critics that such systems cannot be scaled.[20]

GR 2.0: New, improved, and specially adapted for Africa?

The Alliance for a Green Revolution in Africa (AGRA), initiated in 2006, heralded a new campaign to bring the kind of input-intensive agriculture to Africa that had failed to take hold on the continent with the first Green Revolution. Now, argued Green Revolution promoters, science had developed the seed and other technologies to give Africa its own Green Revolution, one tailored to the specific ecological and climatic conditions across the continent.

With the Gates Foundation and other donors providing nearly $1 billion in contributions and disbursing $524 million in grants, AGRA initially focused its work in 18 countries, soon reduced to 13.[21] AGRA worked with governments to speed the development of high-yield commercial seeds designed for Africa's wide range of soils and climates and to facilitate the delivery to farmers of those seeds and the inorganic fertilizers that would make them grow.[22]

In Africa, as in India, governments provided subsidies to their farmers to purchase Green Revolution inputs, a support that has been far more important than AGRA's in this endeavor. Of

[18] Shiva, *The Violence of the Green Revolution*.
[19] See, for example, the chapter on India's Punjab in Joel K Bourne, *The End of Plenty: The Race to Feed a Crowded World* (W. W. Norton & Company: W. W. Norton & Company, 2015).
[20] Government of Andhra Pradesh, "Zero Budget Natural Farming," Zero Budget Natural Farming, accessed November 16, 2020, http://apzbnf.in/.
[21] AGRA, "AGRA Annual Progress Report, 2007-2016" (AGRA, March 2017), https://agra.org/AGRAOld/wp-content/uploads/2017/06/2016-AGRA-Progress-Report-Final.pdf; AGRA, "AGRA 2017 Annual Report" (Nairobi, Kenya: AGRA, 2018), https://agra.org/wp-content/uploads/2018/08/AGRA-2017-Annual-Report0708201802.pdf; Calculated from AGRA reports: AGRA, "AGRA 2018 Annual Report" (Nairobi, Kenya: AGRA, 2019), https://agra.org/ar-2018/wp-content/uploads/2019/07/AGRA-Annual-Report_v18_FINAL_Print-Ready_LR.pdf.
[22] Thus far, AGRA has not promoted genetically modified seeds, though nothing in the Green Revolution campaign excludes that possibility in the future.

AGRA's 13 focus countries, only three — Mozambique, Niger and Uganda — do not have significant input subsidy programs. The resources expended by national governments on such programs, often heavily supported with donor funds, generally dwarf those invested by AGRA. Where AGRA grants $40-$50 million per year in its supported countries, aggregate government expenditures on input subsidies approach $1 billion per year,[23] more than twenty times AGRA's funding.

These Green Revolution policies have always been controversial with Africa's farmer organizations. Many warned that AGRA was seeking to impose Western technologies inappropriate for the continent's soils, farmers, and food systems. Some decried the lack of consultation with African farmers on the nature of the interventions.[24] Many were well aware of the flaws in the first Green Revolution. African networks such as the Alliance for Food Sovereignty in Africa (AFSA) also warned of the loss of food sovereignty, the ability of communities and nations to freely choose how they wanted to feed themselves, as large commercial firms could come to dominate local markets backed by new government policies designed to ensure market access.

Critics also questioned whether there was anything particularly revolutionary in the African initiative; there was actually very little new in the design of GR 2.0. The technology package being promoted leaves out many of the features that supported productivity increases in Asia. For example, there is little investment by AGRA or other agencies in widespread development of localized irrigation for smallholder farmers. Only 4% of agricultural land in Sub-Saharan Africa is now irrigated,[25] compared to 37% in India.[26] Similar shares of land planted to rice and wheat, the two priority Green Revolution crops, were irrigated even before India's Green Revolution began, making all the new technology more effective.

It may not be surprising that an initiative launched by a technology magnate like Bill Gates would prove to be enamored of exciting new features while failing to appreciate the popularity – and importance – of some of the old ones. The history of GR 1.0 suggests that GR 2.0 may be an upgrade with similar design flaws.

GR 2.0 left out many other crucial features of India's GR 1.0, which was carried out by a post-colonial Indian government with well-developed capacities to promote economic development. Few African countries can boast of such a "developmental state," particularly after many saw state capacities reduced under structural adjustment programs mandated by the World Bank, International Monetary Fund, and donor governments. Consider that India's Green Revolution campaign was designed as the "Intensive Agricultural Development Programme," a ten-point program of not just inputs of fertilizers, seeds, and pesticides but credit, assured prices, improved

[23] Data are from 2010 and 2011 from T.S. Jayne and Shahidur Rashid, "Input Subsidy Programs in Sub-Saharan Africa: A Synthesis of Recent Evidence," *Agricultural Economics* 44, no. 6 (November 2013): 547–62, https://doi.org/10.1111/agec.12073.

[24] InterPares, "Coalition Pour La Protection Du Patrimoine Génétique Africain (COPAGEN)," Inter Pares, accessed March 23, 2020, https://interpares.ca/content/coalition-pour-la-protection-du-patrimoine-g%C3%A9n%C3%A9tique-africain-copagen.

[25] IFPRI, "Irrigating Africa," July 21, 2010, https://www.ifpri.org/blog/irrigating-africa.

[26] World Bank, "India: Issues and Priorities for Agriculture," Text/HTML, World Bank, May 2012, https://www.worldbank.org/en/news/feature/2012/05/17/india-agriculture-issues-priorities.

marketing, irrigation, extension services to improve farm management, and village-level planning, analysis, and evaluation.[27] GR 2.0 lacks most of these features critical to smallholder agricultural development.

Certainly the fertilizers have changed little, much the same blended compounds developed for U.S. industrial agriculture with their NPK formula of nitrogen, phosphorous, and potassium. On paper, AGRA claimed to promote a more complex approach to soil fertility. Integrated Soil Fertility Management (ISFM) relies on inorganic fertilizer as one supplement to other natural soil health measures: cover crops, mulching, applications of composted manure, etc. There is very little evidence such measures have been actively promoted in Africa's Green Revolution. Indeed, the subsidies have gone overwhelmingly to inorganic fertilizer and commercial seeds. One researcher documented the enormous benefits of true ISFM practices for farm productivity and showed that such measures were still the least adopted by farmers.[28] Evaluations of AGRA's ISFM trainings have found little impact on farming practices, and even where farmers have adopted recommended practices they have seen little improvement in yields or incomes.[29]

One technology that has evolved considerably since the first Green Revolution is crop-breeding. New methods allow more rapid development of new seed varieties and part of the GR 2.0 campaign has been the development of new seed varieties better adapted to a wider range of soils and ecosystems. The only Gates Foundation grantee in agriculture that has gotten more funding than AGRA is CGIAR, the international network of publicly funded crop research institutes that began with the first Green Revolution. CGIAR's "Drought-Tolerant Maize for Africa" (DTMA) initiative, for example, identified well-adapted local cultivars from different regions of Africa and bred them to produce higher yields with applications of inorganic fertilizers. Some of these varieties are now commercially available and some have produced good yields under "water stress," if not drought.[30]

There is little evidence that such varieties have been revolutionary, for a variety of reasons. First, as in India with wheat, GR 2.0's chosen crop is one widely bred in the developed world: maize. Wheat was only India's third most important food grain at the outset of GR 1.0. It was favored because U.S. crop-breeders had developed a variety that produced high yields with heavy doses of fertilizer. Maize is an important staple crop in many, but not all, African countries. The heavy promotion of maize by GR 2.0 proponents is driven not only by demand than by the extensive experience of U.S. breeders with the crop. The U.S. Corn Belt is blanketed with high-yield varieties of corn, giving breeders a shortcut to new varieties developed for Africa.

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[27] Subramanian, "Revisiting the Green Revolution," 49.

[28] Ephraim Nkonya, "The Unholy Cross: Profitability and Adoption of Soil Fertility Management Practices in Sub-Saharan Africa | IFPRI : International Food Policy Research Institute," accessed March 18, 2020, https://www.ifpri.org/publication/unholy-cross-profitability-and-adoption-soil-fertility-management-practices-sub-saharan.

[29] Kwaw Andam, Simrin Makhija, and David Spielman, "Evaluation Of The Impacts Of A Soil Fertility Training Project On Farm Productivity In The Volta Region Of Ghana," 2019, https://developmentevidence.3ieimpact.org/search-result-details/impact-evaluation-repository/evaluation-of-the-impacts-of-a-soil-fertility-training-project-on-farm-productivity-in-the-volta-region-of-ghana/7709.

[30] Monica Fisher et al., "Drought Tolerant Maize for Farmer Adaptation to Drought in Sub-Saharan Africa: Determinants of Adoption in Eastern and Southern Africa," *Climatic Change* 133, no. 2 (November 1, 2015): 283–99, https://doi.org/10.1007/s10584-015-1459-2.

Second, most of those new maize varieties are so-called hybrids, products of crop-breeding that creates "vigor" in the first generation of seeds but not their offspring. This means that for farmers such seeds have the disadvantage that they need to be purchased every year. That, of course, is a great advantage for the private seed companies that are so heavily involved in Green Revolution programs. But many African farmers save and exchange seeds from each year's harvest, so they are not accustomed to buying seeds every year. Nor do they have the cash to do so, which is why the input subsidies play such an important role in promoting adoption. Still, adoption rates are low and they often fall when subsidies are reduced or eliminated, as happened in Malawi. [31]

Third, many of the DTMA seeds are bred to require applications of inorganic nitrogen fertilizer. Even when such purchases are subsidized for farmers, they rarely have enough to carry out optimal dosing for high yields. Without the higher doses of fertilizer, many of the new seed varieties lose their yield advantages over locally bred varieties.[32]

While there may be gains from some of these new seeds, when GR 2.0 promoters talk about Africa getting its own Green Revolution, they are speaking mainly about the promise of genetically modified crops. Most African governments do not permit the cultivation of GMOs, especially food crops, citing health and environmental concerns. South Africa is the notable exception. GMOs are certainly the innovation consistently invoked by the many critics of agroecology cited earlier. The African market is coveted by the seed and chemical companies selling GM crops and their associated agrochemicals, largely because most other markets have already been tapped or closed. Global demand for GMOs is now quite flat.[33]

Many African farm groups warn that the new seed offerings are a way to open the door to GMOs. They point to the DTMA initiative, which was designed as a precursor to the Water Efficient Maize for Africa project. In that controversial effort, breeders took DTMA maize varieties and created GMO varieties with transgenes "donated" by Monsanto. Promoters claimed these would further enhance the crops' drought tolerance. There was little evidence they did. Many denounced the new project as creating "Trojan seeds" intended to break down resistance to GMOs in Africa.[34]

U.S. Ambassador Kip Tom, in his controversial speech, tipped his hand when it came to what technology he really meant when he decried African reluctance to embrace technology: GMOs. "But there is hope. Ethiopia has recently brought in Bt cotton, we know that they're looking at Bt cowpeas, we've seen Nigeria bring in Bt cotton, Kenya is a little bit more open today. We see

[31] For a detailed discussion of Malawi's FISP, see: Timothy A. Wise, *Eating Tomorrow: Agribusiness, Family Farmers, and the Battle for the Future of Food* (The New Press, 2019).
[32] For more on yield comparisons, see: Wise, *Eating Tomorrow*, 15–48.
[33] ISAAA, "Biotech Crops Continue to Help Meet the Challenges of Increased Population and Climate Change" (ISAAA, 2018), https://www.isaaa.org/resources/publications/briefs/54/executivesummary/default.asp.
[34] Gareth Jones, "Profiting from the Climate Crisis, Undermining Resilience in Africa: Gates and Monsanto's Water Efficient Maize for Africa (WEMA) Project" (Johannesburg, South Africa: African Centre for Biodiversity, April 2015), http://acbio.org.za/wp-content/uploads/2015/05/WEMA_report_may2015.pdf.

South Africa embracing all forms of GMOs, and using crop care products to protect their crops."[35]

Ambassador Tom was carrying on a long-standing commitment in the U.S. diplomatic corps to aggressively promoting GMOs. As one 2013 report documented, "The U.S. State Department has also lobbied foreign governments to adopt pro-agricultural biotechnology policies and laws, operated a rigorous public relations campaign to improve the image of biotechnology and challenged commonsense biotechnology safeguards and rules — even including opposing laws requiring the labeling of genetically engineered (GE) foods."[36]

If Africa's Green Revolution is primarily a campaign to open the continent to GMOs, that is a hidden, if poorly concealed, agenda. It is not the way AGRA has been presented to African governments and citizens. While AGRA's programs have not explicitly promoted the adoption of GMO seeds, the Gates Foundation and other donors have pressed hard for seed policy reforms that would allow GMOs.

It is beyond the scope of this paper to present the limited potential for GMOs to increase productivity in African agriculture. The U.S. National Academy of Sciences concluded that GMOs had not increased yields appreciably in the United States.[37] Many of the specific claims made for GMOs – such as to fight fall army worm or desert locust infestations – are largely unproven. As a recent FAO expert report concluded about GMOs, "There is no conclusive evidence that suggests that they need to be introduced into agroecosystems that currently do not rely on them."[38]

AGRA: Africa's failing Green Revolution

In any case, Africa's current Green Revolution can be evaluated on the basis of current permitted technologies, which do not include GMOs. AGRA was launched 14 years ago. In fact, AGRA was launched with a 2020 deadline to double yields and incomes for 30 million small-scale farming households while halving food insecurity.[39] How well are GR 2.0 innovations performing in achieving those goals?

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[35] Kip Tom, "Speech to Agricultural Outlook Forum" (text of speech, Agricultural Outlook Forum, Arlington, VA, February 27, 2020).

[36] Food and Water Watchg, "Biotech Ambassadors" (Washington DC: Food and Water Watch, August 27, 2013), https://www.foodandwaterwatch.org/insight/biotech-ambassadors.

[37] Committee on Genetically Engineered Crops: Past Experience and Future Prospects et al., *Genetically Engineered Crops: Experiences and Prospects* (Washington, D.C.: National Academies Press, 2016), https://doi.org/10.17226/23395.

[38] HLPE, "Agroecological and Other Innovative Approaches for Sustainable Agriculture and Food Systems That Enhance Food Security and Nutrition" (Rome, Italy: High Level Panel of Experts, FAO, 2019), 79, http://www.fao.org/3/ca5602en/ca5602en.pdf.

[39] AGRA web site, "What We Do: Grants," https://web.archive.org/web/20190406032154/https://agra.org/grants/, accessed May 18, 2020. AGRA is inconsistent in how it describes its goals, usually weakening them by saying it will "contribute to" doubling yields and incomes, or reducing them to just "increasing" yields and incomes. Some documents extend their timeline to

Neither AGRA nor the Gates Foundation has published an evaluation of the impacts of its programs on the number of smallholder households reached nor the improvements in their yields and household incomes.[40] Periodic reports simply highlight intermediate objectives — number of new seed varieties released, tons of seed produced in-country by domestic seed companies, number of farmers trained in new agronomic practices, and number of crop breeders trained.[41] This lack of accountability represents a serious oversight for a program that has consumed so much in the way of resources and driven the region's agricultural development policies with its narrative of technology-driven agricultural development.[42]

Our research team at Tufts University set out to fill that accountability gap using the best data and information to which we had access. AGRA declined our request to provide data from their own internal monitoring and evaluation of progress. In the absence of more specific data from AGRA, we used national-level data on productivity, poverty and food security as strong indicators of the impacts of Green Revolution policies. We found very little indication that GR 2.0 was coming at all close to achieving its objectives. Many of our findings, written up in an academic paper[43] and a policy report[44], mirror those of the first Green Revolution.[45]

Impact 1: Limited number of beneficiary farmers

From the available data, it is difficult to determine how many farmers are benefiting from AGRA and who those farmers are. AGRA's own reports suggest very limited reach in terms of "direct beneficiaries." Annual country reports refer to farmers "committed," without defining what that means. AGRA's most recent progress report, for the period 2007-16, is indicative of the reporting gap. Most detail focuses on seed varieties developed and commercialized or tons of fertilizer sold. Farmers are listed mainly as benefiting from training in ISFM techniques — Integrated Soil Fertility Management — AGRA's term for its technology package. The report lists "5.3 million farmers with knowledge of ISFM" and "1.86 million farmers using ISFM."[46] In a response our AGRA report, AGRA's Andrew Cox claimed that "AGRA through a network of partners and partnerships is already reaching 8.2 million farmers directly and about 12 million indirectly."[47] But there is no accounting for what technologies they are actually using and what benefit is accruing to those farmers.

2021, though many still refer to the original 2020 deadline. As of June 11, 2020, AGRA had taken the explicit goals statement off its grants web page.

[40] There are unconfirmed reports that the Gates Foundation conducted or commissioned an internal evaluation of AGRA in 2016. If so, the foundation has not released any information to the public.

[41] AGRA, "AGRA Annual Progress Report, 2007-2016."

[42] We could find only partial evaluations of individual programs or interventions, which are detailed in Footnote 13 of the background paper, "Failing Africa's Farmers."

[43] Timothy A Wise, "Failing Africa's Farmers: An Impact Assessment of the Alliance for a Green Revolution in Africa," *Global Development and Environment Institute Working Paper*, July 2020, 38.

[44] BIBA Kenya et. al., "False Promises: The Alliance for a Green Revolution in Africa (AGRA)," July 2020.

[45] The following section draws heavily on these publications.

[46] AGRA, "AGRA Annual Progress Report, 2007-2016."

[47] BIBA Kenya, "Correspondence-BIBA-and-AGRA-Accountability.Pdf," October 7, 2020, https://usrtk.org/wp-content/uploads/2020/10/Correspondence-BIBA-and-AGRA-accountability.pdf.

Although AGRA denies it, evidence would suggest that the main beneficiaries are likely not the poorest or most food-insecure farmers but rather a growing number of medium-scale farmers who have access to more land and are already integrated into commercial networks. Only a fraction of such farmers come up from the ranks of smallholders; many are new investors in farming from urban elites. One study showed that a tiny fraction of smallholders is likely to become commercial farmers.[48]

Impact 2: Limited productivity improvements

Table 1 shows the percentage growth in production, harvested area, and yield aggregated for the 13 AGRA countries over a 14-year period. Because three-year averages smooth some of the annual fluctuations common in agriculture due to weather and other variations, we used averages from 2004-6 as a pre-AGRA baseline, compared with the most recent available data, 2016-18 averages, to gauge progress. We treated the period under review as a 12-year span of time from a pre-AGRA baseline in 2006 to one that goes through 2018. We include production, area and yield because all are relevant to any evaluation of agricultural intensification, which is intended to increase production on existing lands by increasing productivity.

Table 1

AGRA: Limited Signs of Green Revolution
% Growth, selected crops, 13 AGRA Countries
2004-6 to 2016-18

	Production (MT/year)	Area (hectares)	Yield (MT/hectare)
Maize	87	45	29
Rice (paddy)	163	87	41
Wheat [1]	93	28	51
Millet	-24	-5	-21
Sorghum	17	13	3
All Cereals	55	22	27
Cassava	42	51	-6
Roots/tubers (all)	42	51	-7
Pulses (all)	80	19	51
Groundnuts	17	52	-23
Soybean [2]	58	35	18

Source: FAOSTAT for 13 Alliance for a Green Revolution in Africa countries: Burkina Faso, Ethiopia, Ghana, Kenya, Malawi, Mali, Mozambique, Niger, Nigeria, Rwanda, Tanzania, Uganda, Zambia.

[1]excluding Burkina Faso and Ghana

[2]excluding Ghana, Mozambique, and Niger

Over the 12-year period in which AGRA operated, from 2004-6 to 2016-18, maize production in the 13 countries increased 87%, but that production gain was due more to a 45% increase in area harvested than it was to yield increases, which improved only 29%. We highlight the yield column because that is the metric AGRA and related Green Revolution programs promised to double by 2020. (To be on track to achieve a 100% increase in yield by 2020 the growth through 2018 would need to be 85-90%.)

There is no sign of impressive productivity growth in any major food crops sufficient to meet AGRA's goal of doubling yields. Rice, a staple in only a minority of AGRA countries, showed large production increases, but as with maize this owed less to productivity improvements, which grew only 41%, than to bringing new land into rice production. Overall, cereals production grew 55%, but yields grew just 27%.

[48] T. S. Jayne et al., "Africa's Changing Farm Size Distribution Patterns: The Rise of Medium-Scale Farms," *Agricultural Economics* 47, no. S1 (2016): 197–214, https://doi.org/10.1111/agec.12308.

Weak productivity growth in maize is stunning given the support the crop has received from AGRA and input subsidies. As with wheat in India, the rate of productivity growth increased for maize in some countries, with all of the subsidies and support the crop received. Still, several of Africa's top maize producers have shown surprisingly weak productivity improvement:[49]

- Nigeria, the largest maize producer among AGRA countries, saw just a 7% increase in yields under AGRA, less than 0.5% per year, compared to 2.5% annual yield growth before AGRA.[50] Production increased significantly primarily because of an 81% increase in land planted to maize.
- Kenya, the fourth largest maize producer, saw yields actually decline under AGRA, after posting 1.7% average annual yield growth in the nine-year period before AGRA's arrival.
- Tanzania, the third largest maize producer, also showed tepid yield growth of just 15%, barely more than 1.0% per year.
- Zambia, AGRA's sixth largest maize producer, posted just a 27% increase in maize yields, an annual average of 2%; yield growth before AGRA was much higher, 4.2% per year.

This means that among AGRA's top six maize producers, only Ethiopia and Mali showed significant yield growth that surpassed pre-AGRA yield growth rates. The Green Revolution technology package often just doesn't pay for farmers. The African Center for Biodiversity estimated that in Malawi seeds and fertilizers cost three times the value farmers could gain from the small maize yield increase, assuming the farmer can afford to sell all the added production.[51] Many can't; their families need to eat. For many smallholders, the Green Revolution package is just too expensive. That is why input subsidies have been critical to achieving what limited adoption has been achieved, but it is striking that even with all those subsidies, yield improvements in maize have been so poor.

Impact 3: Decline or stagnation in nutritious food crops

One of the negative consequences of the Green Revolution's focus on maize and other commodity crops is the declining importance of nutritious and climate-resilient crops like millet and sorghum, which have been key components in healthy diets. These are rarely supported by African governments or AGRA; meanwhile, input subsidies and supports for maize and other favored crops provide incentives for farmers to decrease the cultivation of their own crop varieties. As Table 1 shows, millet production fell 24% in the AGRA period, with a 5% drop in area planted and a 21% decline in yields. Sorghum, an ancient grain that is a staple in many African countries, has also languished under the Green Revolution. Production grew just 17% as yields stagnated (3%) and area harvested increased only 13%.

Before AGRA nearly twice as much land was planted in both millet and sorghum than was planted in maize. Now, maize dwarfs both due to the many incentives to produce the crop despite

[49] Country-level data for all crops is available in the appendix of the background paper, "Failing Africa's Farmers."
[50] Pre-AGRA period compares three-year periods 1997-99 and 2004-6, calculating compound annual yield growth from FAOSTAT data.
[51] ACBio, "Running to Stand Still: Small-Scale Farmers and the Green Revolution in Malawi" (Melville, South Africa: African Centre for Biodiversity, September 2014), http://acbio.org.za/wp-content/uploads/2015/02/Malawi-running-to-stand-still.pdf.

the demonstrated climate-resilience of these crop varieties. In this sense, Green Revolution programs are undermining farmers' ability to adapt to climate change.

Other critical food security crops suffered as well. Cassava, a key staple in Nigeria, Mozambique, Uganda, Tanzania and many other AGRA countries, saw a 6% decline in yields. Overall, roots and tubers, which include nutritious crops such as sweet potatoes, experienced a 7% decline in yields. Groundnuts, another critical staple source of protein in many countries, saw an alarming 23% drop in yields.

These impacts again mirror those in India under the first Green Revolution, where the heavy promotion of wheat came at the expense of other important staple crops.

Impact 4: Measuring productivity gains comprehensively

Table 2

AGRA: Productivity & Undernourishment

	% Change 2004/6-2016/18	
	Staple Yields Index	Number Under-nourished
AGRA TOTAL	18	31
Burkina Faso	-10	15
Ethiopia	73	-29
Ghana	39	-20
Kenya	-7	43
Malawi	50	-3
Mali	19	-14
Mozambique	30	6
Niger	36	71
Nigeria	-8	181
Rwanda	24	13
Tanzania	22	29
Uganda	0	155
Zambia	20	29

Source: FAO; author's calculation of change in number undernourished between 3 year averages 2004/6 - 2016/18

Staple Yield Index: weighted yield increases for maize, millet, sorghum, roots/tubers. For AGRA total, Ethiopia, Nigeria, and Tanzania - cereals plus roots/tubers.

To better assess the overall impact of Green Revolution programs on the productivity of staple crops as a whole, not just the favored crops such as maize, we used national-level data to estimate the yield growth during the AGRA years for a basket of important staple crops. We included maize, millet, sorghum, and the broad category of "roots and tubers," which includes cassava, sweet potato and other key staples. For countries in which another grain is a key staple (e.g., teff in Ethiopia, rice in Nigeria and Tanzania), we used "cereals, total" with "roots and tubers." We created one index by weighting the yield growth for each crop based on area harvested (in 2017), a good measure of the prevalence of the crop. The resulting "Staple Yield Index" gives a more comprehensive picture of overall productivity growth for a range of key food crops over 12 years of Green Revolution programming.

No country is on track to reach the goal of doubling productivity. Only Ethiopia and Malawi show staple crop yield growth as high as 50% for the AGRA period. Three countries — Burkina Faso, Kenya and Nigeria — show declines in productivity for this basket of staple crops.

Rwanda, which AGRA touts as one of its greatest success stories, registers staple yield growth of just 24%, less than 2% per year. This is because Rwanda's relative success in raising maize yields (+66%) is offset by stagnant yields for sorghum (0%), which before AGRA was a more important staple than maize. Yields also declined for rice. Perhaps most significant, yields for "roots and tubers" increased only 6% over the 12-year AGRA period. The Staple Crop Index shows that Rwanda's

apparent success in maize has come at the expense of more comprehensive food crop productivity.

Again, the results mirror those in India, where productivity growth for food grains as a whole slowed in the Green Revolution years. In AGRA countries as a group, staple yields barely increased, from 17% to 18% in comparable 12-year periods.[52] These are poor productivity growth rates, well below population growth rates.

Impact 5: Production growth from extensification, not "sustainabie intensification"

The data in Table 1 suggest that Green Revolution programs have not produced a productivity boom through intensification but rather an *extensification* onto new lands. The promotion of extensification is a serious contradiction for Green Revolution proponents. The explicit goal of "sustainable intensification" is to minimize pressure on land and water resources while limiting further greenhouse gas emissions. To the extent Green Revolution programs are encouraging extensification, they are at odds with national and donor government commitments to mitigate climate change. Depending on individual countries' land endowments, extensification can be a serious problem. Rwanda, for example, is densely populated and does not have vast tracts of uncultivated arable land.

Impact 6: No evidence of doubling incomes or halving food insecurity

AGRA offers little evidence that beneficiary farmers' incomes are increasing, never mind whether they are doubling. There is no comprehensive measure of farmer or rural incomes, and data on rural poverty is spotty from country to country. Poverty data suggest slow and uneven reductions in extreme poverty at national levels; rural poverty tends to be higher and more persistent. The best available measure of farmer welfare is U.N. Food and Agriculture Organization (FAO) data on food insecurity. It indicates whether those yield increases are improving food security for the poor.

Table 2 shows the staple yield index and percentage change in the number of undernourished for AGRA countries. The hunger figures are alarming. The total number of undernourished in AGRA's 13 countries has increased from 100.5 million to 131.3 million, a 30% increase, from before AGRA to 2018. Only Ethiopia reports a significant decline in the absolute number of chronically hungry residents. Nigeria and Uganda account for a large share of the increase in undernourishment, with the number more than doubling in each country over the 12-year period. Several AGRA countries posted improvements in the shares of their populations suffering undernourishment, indicating progress in reducing the rate if not the number of hungry. But in four countries — Kenya, Niger, Nigeria and Uganda — the share as well as the number increased.[53] Many factors have contributed to rising food insecurity in recent years – civil conflict, climate change, poor infrastructure, and a history of disinvestment. There is little evidence the well-funded Green Revolution campaign in Africa has done much to help

[52] BIBA Kenya et. al., "False Promises."

[53] The full table of undernourishment and moderate food insecurity for AGRA countries is available in the background paper, "Failing Africa's Farmers."

governments address those issues. In any case, the data suggests AGRA is nowhere near achieving its goal of halving food insecurity by 2020.

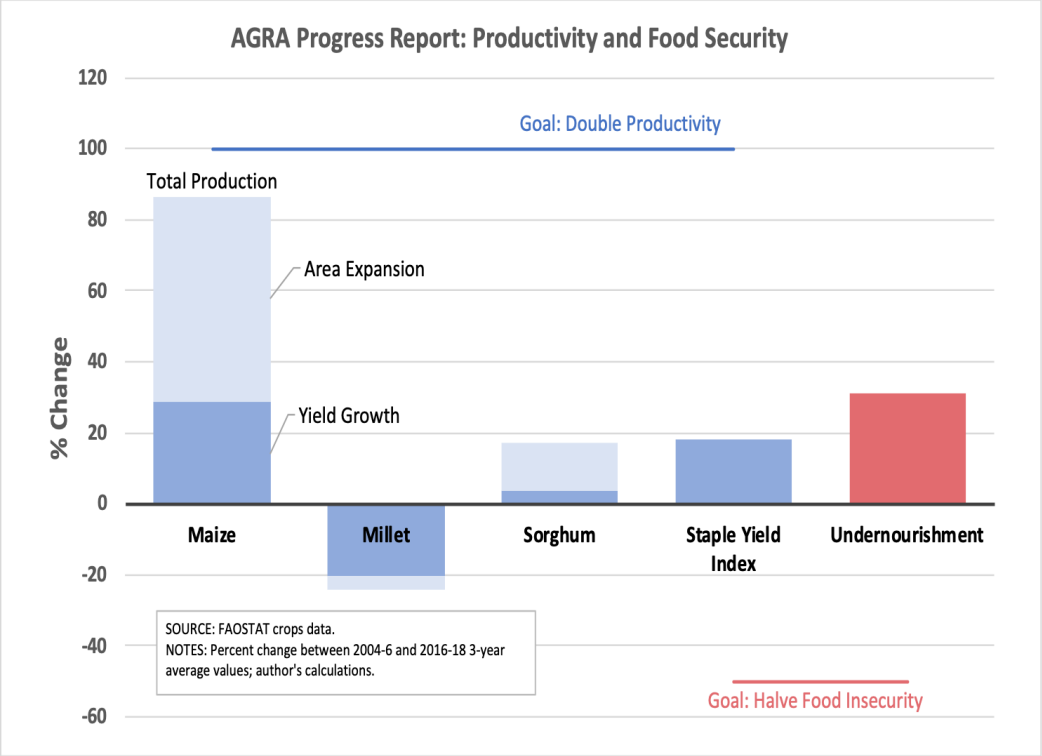
AGRA's Balance Sheet: Failure to yield, little benefit for small-scale farmers

On balance, as AGRA reaches its 2020 deadline for doubling the productivity and incomes of 30 million smallholder farm households while cutting hunger in half, the evidence shows that AGRA and the Green Revolution campaign of which it is a part are failing Africa's smallholder farmers.

Table 2 shows the two most revealing measures of productivity and welfare. Only one country, Ethiopia, shows anything resembling the combination of yield growth and hunger reduction Green Revolution proponents promised, with a 73% increase in productivity and a 29% decrease in the number of hungry. Note, however, that neither of these is on track to meet AGRA's goal of doubling productivity (100% increase) and halving the number of hungry (which would be a 50% decrease). Ghana and Mali are the only other AGRA countries that show decent productivity growth with some decrease in hunger. Malawi achieved relatively strong yield growth but only a small reduction in undernourishment.

For AGRA countries as a group, the picture is grim through 2018: small yield increases for staple crops (+18%) and rising levels of hunger (+30%). Nine of AGRA's 13 countries show rising hunger levels. In Rwanda, a supposed Green Revolution success story, the number of hungry increased 13% on weak productivity increases of 24%.

Figure 1



As Figure 1 illustrates, AGRA has failed to achieve food security through sustainable intensification. Maize yield growth has been well below the goal of doubling productivity, with production growth coming more from area expansion than productivity growth. Other key crops such as millet and sorghum have suffered, which we capture in the more comprehensive measure of "staple yield index." And instead of reducing food insecurity by half, the number of hungry in AGRA countries has increased by nearly one-third.

Selling the past as innovation

Africa's Green Revolution is presented as a specially tailored and bold set of interventions to bring rapid agricultural productivity growth to small-scale farmers. As the data shows, no such revolution is occurring. A recent article in the journal *Food Policy* surveyed the results from seven countries with input-subsidy programs and found little evidence of sustained — or sustainable — success. "The empirical record is increasingly clear that improved seed and fertilizer are not sufficient to achieve profitable, productive, and sustainable farming systems in most parts of Africa," wrote the authors in the conclusion.[54]

This should not be surprising because, in fact, there is very little new or innovative about GR 2.0. Indeed, Africa's campaign is failing even to bring farmers the innovations shown to have the greatest impacts in India's Green Revolution fifty years earlier, most notably irrigation. Green Revolution proponents who criticize agroecology initiatives as backward are in fact promoting old technologies and practices, many of which are now being rejected by farmers in India and elsewhere as they seek more economically and environmentally sustainable paths to inclusive agricultural development.

Consider the many ways in which Africa's Green Revolution is replicating the negative outcomes from India's experience:

- Overall staple crop productivity has not grown significantly faster, despite the costly investments in Green Revolution technologies.
- Moderate success in one priority crop (wheat in India, maize in Africa) has come at the expense of sustained productivity growth in other important staple crops.
- Subsidies and other incentives have drawn more land into priority crops and prompted extensification, not just intensification, with negative environmental impacts on land use.
- Soil fertility has suffered as a result of nutrient-mining from monocropping of priority crops fed by inorganic fertilizers with little attention to overall soil health.
- The high cost of inputs often exceeds the money a farmer can earn from the meager yield increases they get from the new seeds and fertilizer, leaving many in debt.[55]

The one innovation proponents claim can help Africa, GMOs, is one with which India already has experience. That came not in the first Green Revolution but starting in the 1990s when many of the farmers using Green Revolution practices adopted GMO varieties promoted by seed and

[54] Thomas S. Jayne et al., "Review: Taking Stock of Africa's Second-Generation Agricultural Input Subsidy Programs," *Food Policy* 75 (February 1, 2018): 1–14, https://doi.org/10.1016/j.foodpol.2018.01.003.
[55] For relevant case studies in Africa, see BIBA Kenya et. al., "False Promises," 13–14.

chemical companies. Over time, that experience has shown the high risks of such products. Yields did not significantly increase. Pests and weeds were easier to control at first but the crops and chemicals lost their effectiveness over time as pests and weeds evolved resistance. Farmers saw their costs of production rise while yields stagnated or fell, driving down incomes and increasing indebtedness.[56]

African farmers, consumers, and governments have many good reasons to be wary of GMOs. India's experience should make them more so. Selling Africa's Green Revolution as innovation is misleading. By comparison, the agroecology initiatives they decry as backward are bringing cutting-edge science into farmers' fields, and they have shown far more promising results. One University of Essex study surveyed nearly 300 large ecological agriculture projects across more than 50 poor countries and documented an average 79% increase in productivity with decreasing costs and rising incomes.[57] Such results far surpass those of Africa's Green Revolution.

Agroecology as true innovation

The recent wave of articles criticizing agroecology as backward and as a rejection of innovation in agriculture come just as the U.N. FAO has formally adopted its "Scaling Up Agroecology" initiative[58] and as the Committee on World Food Security (CFS) is debating related policy measures to recommend to member states. Those policy options are drawn from a commissioned report from the CFS's High Level Panel of Experts, "Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition."[59]

The critiques, many of which target FAO and related agencies, are clearly hoping to undermine the emerging consensus that, as former FAO Director General Graziano da Silva put it, "We need to promote a transformative change in the way that we produce and consume food. We need to put forward sustainable food systems that offer healthy and nutritious food, and also preserve the environment. Agroecology can offer several contributions to this process." [60]

The 160-page expert report, finalized in 2019, defines agroecology as innovation, presents an exhaustive review of the literature, and identifies a range of agroecological practices that contribute to their defined goals of resource efficiency, resilience, and social equity. These include the overlapping categories of agroecology, organic agriculture, agroforestry, permaculture, and food sovereignty. The first four of these are science-based approaches that draw on ecology, agronomy, hydrology, soil science, microbiology, and a range of other

[56] "The Failure of GMO Cotton In India," Resilience, September 9, 2020, https://www.resilience.org/stories/2020-09-09/the-failure-of-gmo-cotton-in-india/; Jacob Koshy, "M.S. Swaminathan Calls GM Crops a Failure; Centre's Adviser Faults Paper," *The Hindu*, December 7, 2018, sec. Agriculture, https://www.thehindu.com/sci-tech/agriculture/ms-swaminathan-calls-gm-crops-a-failure-centres-adviser-faults-paper/article25693009.ece.
[57] J. N. Pretty et al., "Resource-Conserving Agriculture Increases Yields in Developing Countries," *Environmental Science & Technology* 40, no. 4 (February 2006): 1114–19, https://doi.org/10.1021/es051670d.
[58] FAO, "Agroecology Can Help Change the World's Food Production for the Better," April 3, 2018, http://www.fao.org/news/story/en/item/1113475/icode/.
[59] HLPE, "Agroecological and Other Innovative Approaches for Sustainable Agriculture and Food Systems That Enhance Food Security and Nutrition."
[60] FAO, "Agroecology Can Help Change the World's Food Production for the Better."

disciplines. They can involve the incorporation of new technologies but they overwhelmingly involve low-input interventions to improve the management of natural resources for long-term productivity, sustainability, and profitability. Most rely on close collaboration between small-scale farmers and scientists to determine appropriate innovations in local farming practices.

The report's authors also examine ongoing controversies, including over whether GMOs have any role to play under a broad definition of sustainable food systems. After reviewing the evidence on GMO safety and environmental impacts, they acknowledge many questions as yet unresolved by the evidence. But in relation to the adoption of GMOs in developing countries, they are clear that developing countries that do not currently use them have no need to introduce them.[61]

That has not stopped critics of agroecology from citing GMO technologies as the only viable solution to the challenges faced by Africa's farmers. Those promoters have recently won approval in Kenya for the experimental cultivation of a new GM variety of cassava engineered to resist a virus currently threatening harvests of this important staple crop. Ironically, Africa's cassava is the crop perhaps most widely recognized as having previously been saved by agroecology.

Entomologist and ecologist Hans Herren was awarded the World Food Prize in 1995 for his multi-year effort to save Africa's cassava harvest from an infestation of mealybugs, an effort that saved an estimated 20 million lives. As I recounted in a published interview with Herren,[62] he found a natural predator from Paraguay that preyed on young mealybugs. These "beneficial predator" wasps killed the mealybugs before they could reproduce. The campaign involved detailed scientific research into the such predators and which one would be safe to release in African tropical landscapes. They were produced at scale and released by land and in air drops over cassava-growing regions of Africa. They brought the infestation under control.

As the World Food Prize committee noted in the 1995 award, "Within ten years, Dr. Herren had almost single-handedly developed a chemical-free biological control for the mealybug, eliminated the threat to cassava production, averted disastrous famine, and saved upward of 20 million lives."

The 2020 World Food Prize was awarded to soil scientists Rattan Lal, another scientist who understands the complex nature of soil fertility and would prefer to, as Herren has said, treat causes rather than symptoms by taking an ecological approach. Lal has recommended a more comprehensive range of practices than just inorganic fertilizer to restore degraded soils and rebuild soil fertility.[63]

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[61] HLPE, "Agroecological and Other Innovative Approaches for Sustainable Agriculture and Food Systems That Enhance Food Security and Nutrition," 79.

[62] Timothy A. Wise, "Does Kenya Need GMO Cassava?," *Food Tank* (blog), October 14, 2020, https://foodtank.com/news/2020/10/does-kenya-need-gmo-cassava-ask-the-world-food-prize-winner-who-saved-africas-cassava/.

[63] World Food Prize, "2020 Lal - The World Food Prize - Improving the Quality, Quantity and Availability of Food in the World," October 2020, https://www.worldfoodprize.org/en/laureates/2020_lal/.

Such innovations are far too numerous to summarize here. But many focus on ecological methods of restoring soil fertility, which can increase productivity without increasing costs, producing the sorts of results that have largely eluded AGRA and related Green Revolution initiatives. They give small-scale farmers increasing quantities of a wide range of foods while raising net incomes and food security. Two examples highlight the value of such innovations.

In the drylands of West Africa, farmers in Burkina Faso, Senegal, Ghana and Niger are leading "another kind of green revolution."[64] With the help of scientists and government extension officers, they are regenerating tree growth and diversifying production as part of agro-forestry initiatives[65] increasingly supported by national governments. The renewed tree growth restores soil fertility, reduces temperatures in fields heated by a changing climate, increases water retention, and has been shown to increase yields 40%-100% within five years while increasing farmer incomes and food security.

Another is the practice of cover-cropping, widely recommended in the United States as a means of reducing soil erosion, increasing soil carbon sequestration, and improving soil organic content. In Africa and other developing countries, the practice is being used more effectively by some 15 million small-scale farmers. They interplant so-called green-manure cover-crops alongside their food crops to fix nitrogen in the soil, reduce weeding, add another food or forage crop to their fields, and increase carbon sequestered in the soil. Scientists recommend appropriate cultivars from a range of more than 100 proven cover crops. The Lablab bean native to East Africa, for example, has been shown to fix very high levels of nitrogen in the soil through its roots, improving soil fertility and water retention. The added nitrogen can raise maize yields in those same fields threefold, eliminating the need for inorganic fertilizer. While some farmers have been practicing green-manure cover-cropping for generations, scientists have helped by optimizing the particular crop used and training farmers in optimal farm management for both food security and farm productivity.[66]

Scientists are key to the success of such initiatives. They have also advanced innovations in biological pest control. For example, so-called push-pull methods teach farmers how to plant varieties alongside their maize that push away common pests and plants outside their maize fields that attract them. In the words of the scientists, they identify "companion plants delivering semiochemicals, as plant secondary metabolites." Such practices are now widely practiced in parts of Africa, reducing the need for chemical pesticides.[67] Push-pull and other biological control measures have proved particularly effective in controlling recent infestations of fall armyworms, which have devastated maize crops in southern and eastern Africa.[68]

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[64] Chris Reu, Gary Tappan, and Melinda Smale, "Agroenvironmental Transformation in the Sahel: Another Kind of 'Green Revolution,'" *IFPRI Discussion Paper*, 2009, https://www.ifpri.org/publication/agroenvironmental-transformation-sahel.

[65] Oxfam, "Regreening the Sahel: A Quiet Agroecological Evolution - Burkina Faso," ReliefWeb, accessed November 6, 2020, https://reliefweb.int/report/burkina-faso/regreening-sahel-quiet-agroecological-evolution.

[66] Roland Bunch, *Restoring the Soil - Second Edition* (ECHO Incorporated, 2019), https://www.echocommunity.org/resources/aba0ef91-ceea-4f06-8ca7-e9518288345e.

[67] John A Pickett et al., "Push–Pull Farming Systems," *Current Opinion in Biotechnology*, Food biotechnology ● Plant biotechnology, 26 (April 1, 2014): 125–32, https://doi.org/10.1016/j.copbio.2013.12.006.

[68] Zeyaur R. Khan et al., "Push-Pull Farming System Controls Fall Armyworm: Lessons from Africa," *Outlooks on Pest Management* 29, no. 5 (October 1, 2018): 220–24, https://doi.org/10.1564/v29_oct_09; Komivi Senyo Akutse et

Selling chemicals, not science, to control pests

The fall armyworm has been a favorite talking point for critics of agroecology as they decried "primitive" techniques and touted the application of chemical pesticides, and the use of genetically modified Bt maize even though there is no evidence it would control that particular pest. The African Centre for Biodiversity analyzed the dangers of relying only on chemical pesticides rather than employing less damaging biopesticides and control measures while restoring the kind of ecosystem balance that can reduce future infestations.[69] They cite the recent science on the most effective control measures.[70]

A current target for critics is the ongoing infestation of desert locusts in East Africa, claimed by commentators to be caused by agroecology, which presumably keeps farmers using antiquated methods such as banging on pots instead of controlling the destructive swarms with aerial spraying of chemical pesticides. As some of these commentators are confirmed climate-deniers, some laugh off the clear evidence that the current outbreak is as severe as it is because of warmer, wetter weather and the rising intensity of storms.[71] They evoke archaic practices in language that borders on racism. And they caricature critics as anti-progress while ignoring the range of short and long-term prevention measures and the many biological pesticides proven to be more effective than chemical agents, most developed by scientists at institutes such as the Nairobi-based International Centre of Insect Physiology and Ecology (ICIPE).[72]

There and elsewhere, entomologists and other scientists study the breeding and life cycles of such pests, the causes of infestations, and the biological and neurochemical features of their behavior. While they do not on principle eschew the use of chemical pesticides, they have documented the damage such agents can cause to the environment and to non-target species, including the pests' natural predators. As alternatives, they develop biopesticides and preventive treatments and practices, and they work with farmers to test and then disseminate such control methods.

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al., "Ovicidal Effects of Entomopathogenic Fungal Isolates on the Invasive Fall Armyworm Spodoptera Frugiperda (Lepidoptera: Noctuidae)," *Journal of Applied Entomology* 143, no. 6 (2019): 626–34, https://doi.org/10.1111/jen.12634.

[69] ACBio, "SHOCK AFTER SHOCK IN AFRICA: A TALE OF ECOLOGICAL IMBALANCE, THE FALL ARMYWORM INFESTATION AND FALSE SOLUTIONS," African Centre for Biodiversity, December 2020, https://www.acbio.org.za/en/shock-after-shock-africa-tale-ecological-imbalance-fall-armyworm-infestation-and-false-solutions.

[70] Rhett D. Harrison et al., "Agro-Ecological Options for Fall Armyworm (Spodoptera Frugiperda JE Smith) Management: Providing Low-Cost, Smallholder Friendly Solutions to an Invasive Pest," *Journal of Environmental Management*, 2019, https://agris.fao.org/agris-search/search.do?recordID=US201900296715.

[71] Abubakr A. M. Salih et al., "Climate Change and Locust Outbreak in East Africa," *Nature Climate Change* 10, no. 7 (July 2020): 584–85, https://doi.org/10.1038/s41558-020-0835-8.

[72] E.M. Badr et al., "Novel Control Tactics as Alternatives to Chemical Insecticides Against the Desert Locust to Reduce Environmental Risks.," *International Journal of the Environment and Water* 4, no. 4 (2015), https://ijew.ewdr.org/component/k2/item/402-novel-control-tactics-as-alternatives-to-chemical-insecticides-against-the-desert-locust-to-reduce-environmental-risks.html.

In the case of the desert locust, ICIPE scientists have found that monitoring and treating breeding grounds in so-called recession areas is the most effective and environmentally sound method. The early warning system set up by international agencies was underfunded and poorly maintained, failing to spot the intense breeding activity set off by recent warmer, wetter weather triggered by climate change. ICIPE recently introduced a more comprehensive model for predicting the location of locust breeding areas.[73] The spread of agricultural lands can contribute to wider infestations once the locusts have exited the recession areas, creating habitats more hospitable to locusts. Vast tracts of staple and horticultural crops are particularly vulnerable, offering locusts the diets they require to multiply and swarm. ICIPE researchers have developed control measures to combat the attacks, including a pheromone that can limit their transformation into the swarms that devastate crops, which can be effective early in the pests' development.[74] The International Institute of Tropical Agriculture (IITA) has found and developed a fungus, marketed as "green muscle," which kills the locusts more safely than chemical pesticides.[75] Both products can be combined for greater impact and can be produced and applied in large quantities.

These are examples of the science and innovation being discounted by critics of agroecology. A common thread in those critiques is the specious notion that innovation equals technology, and that technology is only something a farmer can buy from the companies that promote such narratives.

Conclusion: Old fertilizer in new bottles

Critics of agroecology, with the narrative that their Green Revolution inputs are needed innovations and that agroecology is rejecting innovation, are distorting reality in two important ways. First, they are overstating both the levels of innovation that initiatives such as Africa's Green Revolution offer small-scale farmers and the effectiveness of such programs. As we have demonstrated, with initiatives such as AGRA they are selling old fertilizer in new bottles, repackaging old and questionable technologies from the first Green Revolution as if they were cutting-edge innovations.

Second, in doing so they seem willfully ignorant of a wide range of recent research that documents why such failing policies need to be replaced with innovations in sustainable food systems. Since the launch of Africa's new Green Revolution in 2006, scientists and world leaders have gained growing awareness of the limitations of input-intensive agricultural systems,

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[73] Emily Kimathi et al., "Prediction of Breeding Regions for the Desert Locust Schistocerca Gregaria in East Africa," *Scientific Reports* 10, no. 1 (July 20, 2020): 11937, https://doi.org/10.1038/s41598-020-68895-2.

[74] Marion Le Gall, Rick Overson, and Arianne Cease, "A Global Review on Locusts (Orthoptera: Acrididae) and Their Interactions With Livestock Grazing Practices," *Frontiers in Ecology and Evolution* 7 (2019), https://doi.org/10.3389/fevo.2019.00263; Long Zhang et al., "Locust and Grasshopper Management," *Annual Review of Entomology* 64 (January 10, 2019): 15–34, https://doi.org/10.1146/annurev-ento-011118-112500; Uwe Homberg, "Sky Compass Orientation in Desert Locusts—Evidence from Field and Laboratory Studies," *Frontiers in Behavioral Neuroscience* 9 (2015), https://doi.org/10.3389/fnbeh.2015.00346.

[75] CABI, "Green Muscle Providing Strength against Devastating Locusts in the Horn of Africa," *CABI News* (blog), accessed December 9, 2020, https://www.cabi.org/news-article/green-muscle-providing-strength-against-devastating-locusts-in-the-horn-of-africa/; CABI, "More than 5 Million Farmers Helped in Bid to Battle Scourge of Locust Swarms in Kenya and Ethiopia," *CABI News* (blog), accessed December 9, 2020, https://www.cabi.org/news-article/more-than-5-million-farmers-helped-in-bid-to-battle-scourge-of-locust-swarms-in-kenya-and-ethiopia/.

particularly to mitigate and adapt to climate change. A 2009 interagency report by a range of world scientists showed that industrial agricultural practices were ill-suited to the climate, soils, and needs in developing countries, arguing forcefully that "business as usual is no longer an option."[76] A ten-year review and update, "Transformation of Our Food Systems," was published in 2020.[77] The U.N. Intergovernmental Panel on Climate Change in 2019 documented the contributions of industrialized agriculture to climate change, calling for profound changes to both mitigate and help farmers adapt to climate disruptions. The authors consider agroecology a key potential contributor to mitigation and adaptation.[78]

Much of the recent literature was summarized and analyzed well in the report, "From Uniformity to Diversity," by the International Panel of Experts on Sustainable Food Systems, founded by former U.N. Special Rapporteur on the Right to Food Olivier De Schutter.[79] As the expert report makes clear, a range of sustainable agricultural practices that move away from chemical-intensive monoculture cropping can grow all the food the world needs to feed a growing population. They warn of "lock-ins" that are preventing the changes called for by a wide range of experts, from the IPCC to the FAO. They identify eight key lock-ins, including "path dependency," the tendency of economic systems to follow prescribed development paths which then become difficult to change.

The vast majority of smallholders in Africa are not yet heavily reliant on such inputs, nor are they locked into production for value chains that require the large-scale production of uniform commodities. Unlike industrial-scale farmers in developed countries, their path has not yet been determined; there remain opportunities to chart paths different from the high-input agriculture model promoted by AGRA and other Green Revolution proponents.

The graphic below maps the eight lock-ins identified by IPES-Food. Note that the lock-in that sits at the center, the one around which the others revolve, is "Concentration of Power," which the authors define as concentrated economic power from a decreasing number of multinational corporations gaining increasing control over key parts of global food systems. That economic power translates into political power, of course, and it has its powerful allies in philanthropy as well.

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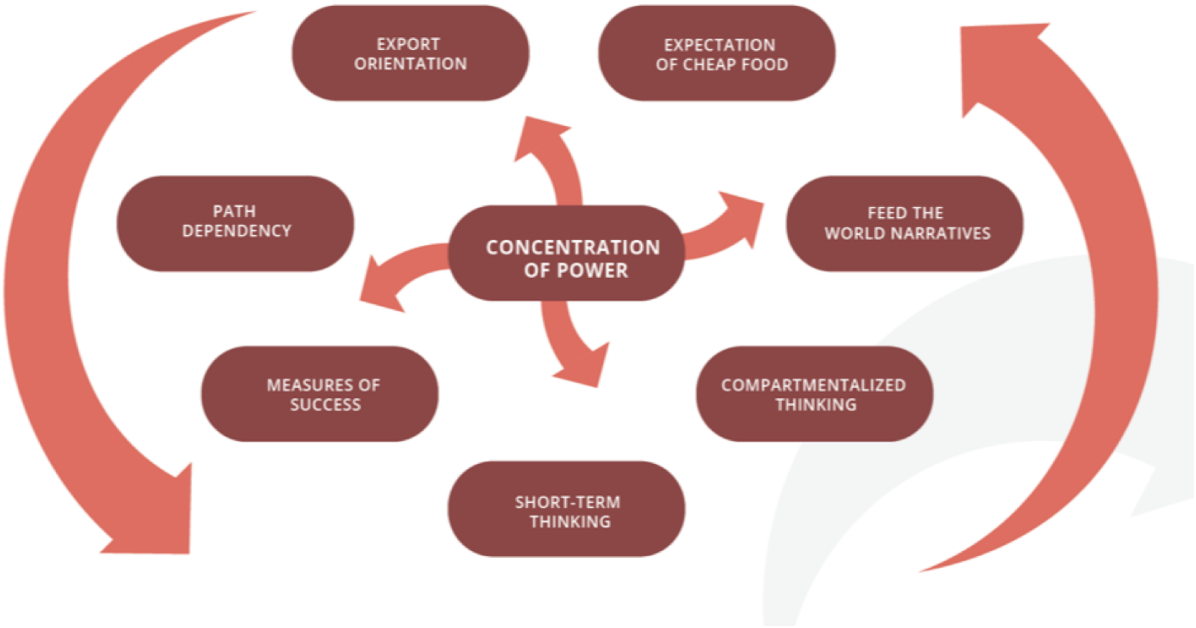
[76] IAASTD, "International Assessment of Agricultural Knowledge, Science and Technology for Development: Global Summary for Decision Makers," 2009, http://agassessment.org/.

[77] Hans Herren, Benedikt Haerlin, and IAASTD+10 Advisory Group, eds., *Transformation of Our Food Systems: The Making of a Paradigm Shift* (Berlin: Biovision and Zukunftsstiftung Landwirtschaft, 2020), https://www.weltagrarbericht.de/fileadmin/files/weltagrarbericht/IAASTD-Buch/PDFBuch/BuchWebTransformationFoodSystems.pdf.

[78] IPCC, "Special Report on Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems."

[79] IPES-Food, "From Uniformity to Diversity: A Paradigm Shift from Industrial Agriculture to Diversified Agroecological Systems" (International Panel of Experts on Sustainable Food systems, 2016), http://www.ipes-food.org/_img/upload/files/UniformityToDiversity_FULL.pdf.

FIGURE 12 - THE EIGHT KEY LOCK-INS OF INDUSTRIAL AGRICULTURE



It is not surprising, then, that many of the recent attacks on agroecology are associated with individuals or institutions with strong ties to industry, especially the agrochemical sector. These are the interests served by opening Africa to Green Revolution inputs and, eventually, GMOs. The recent spate of attacks on agroecology may well be coming now because global leaders are finally taking steps to move away from policies that have proven inadequate to the challenges of reducing poverty and food insecurity while increasing the provision of healthy diets.

Among such bold leaders are those within the government of Senegal, which has cut the incidence of severe hunger from 17% to 9% since 2006. Senegal is one of Africa's leaders in agroecology, supported by the FAO's Scaling Up Agroecology Program. Papa Abdoulaye Seck, Senegal's Ambassador to the FAO, summarized the reasons the government is so committed to the agroecological transition in a recent report on agroecology in West Africa: [80]

> "We have seen agroecological practices improve the fertility of soils degraded by drought and chemical input use. We have seen producers' incomes increase thanks to the diversification of their crop production and the establishment of new distribution channels. We have seen local knowledge enriched by modern science to develop techniques inspired by lived experience, with the capacity to reduce the impacts of climate change. And we have seen these results increase tenfold when they are supported by favorable policy frameworks, which place the protection of natural resources, customary land rights, and family farms at the heart of their action."

[80] IPES-Food, "The Added Value(s) of Agroecology: Unlocking the Potential for Transition in West Africa" (IPES-Food, July 2020), http://www.ipes-food.org/pages/AgroecologyWestAfrica.

The promotion of "local knowledge enriched by modern science" is the innovation African farmers need. It is the kind of low-input innovation that critics of agroecology so fear will displace their profitable but failing model of agriculture for Africa.

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