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Saved by the Soil?
Africa's Frontier for Conservation-Based Agriculture

Executive Summary

Following dramatic topsoil loss during the US Dust Bowl crisis of the 1930s and 1940s, no-till farming emerged in the 1960s as a technique to prevent soil erosion. Over time, it has evolved into a key element in what has become known as the "conservation agriculture" movement, contributing to both improved soils, and potentially mitigating green house gas emissions. With support of US government subsidies and the introduction of new tools and techniques, "mechanized no-till" has expanded to over 25 percent of US farmlands.

A key question for many observers is whether this "no-till revolution" can be adapted to nations in the developing world that are currently mechanizing their agricultural sectors. What factors led to the growth of "no-till" in the US, and can developing countries in Africa and elsewhere follow this model?

This audiovisual case study explores the history of no-till farming in the US and the West African country of Ghana. It includes original interviews with leading actors in the no-till community including Ghanaian Deputy Minister of Agriculture Dr. Ahmed Yakubu Alhassan, Dr. Kofi Boa of the Center for No-Till Agriculture in Ghana, Howard G. Buffett of the Howard G. Buffett Foundation, Dr. Edwin Price of Texas A&M, Dr. Johannes Lehmann of Cornell University, Dr. Lloyd Murdock of the University of Kentucky, and Howard W. Buffett of Columbia University.

This case includes the following elements:

a) Video Intro (available online)

b) Written Case Study (this document)

c) Additional Materials and Interviews (available online)

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Tilling the Soil

No-till farming is a concept that turns on its head one of the key principles of agriculture — plowing the land. Plowing dates to prehistoric times, when our ancestors used sticks to dig furrows for seeds. The Roman Empire saw the creation of the ox-drawn plow, which many credited for the initial success and later decline of farming areas in the Middle East and Mediterranean.

The basic science behind plowing remained the same for millennia—by turning over topsoil, plows cover and kill unwanted weeds, while also releasing carbon dioxide into the atmosphere. Horse-drawn plowing took a leap forward in productivity in 1837 when an Ohio blacksmith named John Deere invented the first steel plow. It quickly became a best seller and allowed settlers to till the nutrient-rich soils of the American plains. As territory from Ohio to Nebraska opened to agriculture, plows helped produce grain surpluses that fueled the growth of American cities and the broader economy.

In 1917, Henry Ford introduced the Fordson, the first commercial mechanized tractor, which soon won popularity in the US and Europe. As pressure from World War I drove up grain prices, mechanized agriculture was born, and new fields were brought under cultivation. But by the 1930s, the limits of the new mechanized model became apparent, as drought and unusually high winds led to the so-called Dust Bowl. Bone-dry topsoil, loosened by heavy and often repeated plowing, simply blew away.

Nonetheless, after World War II the United States led the world in agricultural productivity. The lessons of the Dust Bowl—that annual mechanized plowing led to degraded topsoil vulnerable to wind and drought—seemed less important in a new world of increased production driven by chemical fertilizers, pesticides, farmers' easy access to loans, and cheap fuel to run farm equipment. But by the 1990s, the negative impacts of constant tilling had once again come into clear focus. Run-off from chemical pesticides and fertilizer contaminated some water sources, many farmers could no longer pay their debts, and fuel prices rose.[1] Worse, soil degradation had spread.

One of the chief culprits was plowing. With the growth of fertilizer use, farmers could plant the same crop on the same field year after year. As plows dug, they bit deep—six to 10 inches. The upturned soil looked fresh and rich. But plowing destroyed a crucial ecosystem of earthworms, insects and microorganisms that promoted the decomposition of organic matter. Plowing meant soil lost crucial nutrients, and it disrupted the production of nitrogen necessary for soil and crop health. In some areas, topsoil over time simply vanished, washed away along with fertilizer by rainfall into rivers and bays, often contributing to algal blooms in coastal waterways. Or blown away causing damaging dust storms.

Some agricultural researchers warned against the dangers of intensive mechanized farming. A few farmers turned to other methods known as sustainable agriculture or conservation agriculture, and one favored approach emerged in the 1960s—no-till agriculture.

[1] John Reganold, Robert Papendick and James Parr, "Sustainable Agriculture," *Scientific American*, June 1990. See: http://oregonstate.edu/instruct/bi430-fs430/Documents-2004/7B-MIN%20TILL%20AG/Sustainable%20Agr%C3%89hn%20Reganold.pdf

Advent of no-till

At that time, no-till was hardly new. In 1911, a book chronicled East Asian no-till farmers who, over 4,000 years, maintained the fertility of their fields.[2] But the method was little known—and not practiced— in the US. In 1961, third-generation Kentucky farmer Harry Young Jr. visited the Dixon Springs Agricultural Experiment Station in Illinois.[3] There he heard about a new approach to agriculture known as no-till, advanced by field crops specialist Shirley Phillips. Young had also read the 1943 best-seller *Plowman's Folly* by agronomist Edward H. Faulkner, which blamed plowing for the ruinous Dust Bowl.[4]

Young decided to try it, and in 1962 planted the first US commercial no-till crop—less than an acre of corn. No-till had several components, but the most important was that existing vegetation was not plowed under but left in place to rot and form a mulch. Seeds for a new crop were drilled into the soil beneath the mulch. Young used herbicides (2, 4-D and atrazine) for weed control, and planted using a jerry-rigged machine seeder he pulled behind a small tractor. The results were sufficiently encouraging that Young switched exclusively to no-till. Others soon followed.

No-till farmers discovered that while in the short run yields sometimes fell somewhat compared to conventional farmers, their costs were also lower. No-till farmers saved on fuel because they had to "pass" over their fields only four times (apply herbicide, plant, apply herbicide, harvest), compared to seven-plus for conventional till users.[5] Over time, they also needed less fertilizer as the mulch decomposed, releasing nutrients (although they used herbicides to control weeds). The environment benefited, too. Because mulched soil absorbed water, while compacted soil shed it, the run-off from no-till fields into streams and rivers was reduced significantly. Best of all, the soil was healthy. A 1993 University of Kentucky study showed that no-till methods decreased soil erosion by 98 percent.[6]

There were drawbacks. It was not appropriate for all crops (potatoes, for example, disrupted soil at harvest). Different pests as well as diseases, such as fungus, sometimes afflicted no-till crops. Some farmers experienced a drop in yield during the first couple of years after the transition from plow to no-till as the soil adjusted. To compensate, experts advised farmers to transition only 10-15 percent of land at first. Some crops planted in sandy soil did poorly with no-till. Seeds could take longer to germinate, and no-till often required extra nitrogen fertilizer in the early years for crop health.

Equipment. But the method increased steadily in popularity. Before long, manufacturers such as Allis Chalmers developed specially-designed no-till seeders, which carved a 1⁄2 to 3-inch

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[2] The book was by Franklin King, *Farmers of Forty Centuries: Permanent Agriculture in China, Korea and Japan,* first published in Madison, Wisconsin, by Mrs. F.H. King, 1911. See: https://books.google.com/books?id=FYkVAAAAYAAJ&printsec=frontcover#v=onepage&q&f=false

[3] Katie Pratt, "Kentucky celebrates 50 years of no-till agriculture," *Southeast Farm Press*, October 24, 2012. See: http://www.southeastfarmpress.com/grains/kentucky-celebrates-50-years-no-till-agriculture

[4] Edward H. Faulkner, *Plowman's Folly* [Norman, OK; University of Oklahoma Press], 1943. See: https://books.google.com/books?id=7uwVBgAAQBAJ&printsec=frontcover&dq=plowman%27s+folly&hl=en&sa=X&ved=0ahUKEwiwtuLZtKHRAhVIbSYKHVsPBxIQ6AEIHDAA#v=onepage&q=plowman%27s%20folly&f= false

[5] Huggins and Reganold, "No-Till." The authors report that no-till required 50-80 percent less fuel and 30-50 percent less labor than conventional methods.

[6] David R. Montgomery, "Pay Dirt," *Scientific American*, July 2008. See: http://oregonstate.edu/instruct/bi430-fs430/Documents-2004/7B-MIN%20TILL%20AG/Sustainable%20Agr%C3%89hn%20Reganold.pdf

groove in the earth for seeds.[7] As for creating the mulch, US farmers at first used herbicides to kill existing vegetation. But as early as the 1980s, companies in Brazil developed what were known as roller-crimpers. These machines did not overturn soil but used a smooth roller to flatten plants and "crimp" (bend) their stems just above the roots. The bent plants did not germinate but decomposed, and the roots held the mulch in place.

US growers, however, felt the Brazilian machine suffered from excessive vibration, and it gained little attention until the early 21st century. In 2002, the Rodale Institute (Pennsylvania) designed and built a prototype; commercial manufacturers soon improved on and marketed it. The roller was a water-filled heavy round drum with protruding blunt metal blades arranged in horizontal, angled, or spiral patterns. Usually, a tractor pulled the roller, but it could also be mounted on the front of a tractor.[8]

Expansion of no-till in the US gained force with passage of the 1985 Food Security Act, which subsidized farmers engaged in conservation agriculture. Combined with an increased supply of specifically designed no-till tools and equipment, no-till became a "best practice." By 2010, more than 25 percent of US farmland used no-till techniques.[9] A USDA database recorded that soil erosion on US cropland had decreased 43 percent from 1982 to 2003.[10] Wildlife, especially birds, increased in no-till fields.

Carbon's role. No-till methods also drew the attention of climate scientists. Increasing carbon dioxide in the atmosphere has been a leading cause of global warming. Left to themselves, crop residue and roots post-harvest convert to soil organic matter, which is 58 percent carbon. With plowing, some of that carbon is released into the atmosphere as CO_2, contributing to global warming. With no-till, the bulk of the residue remains on the field, keeping the carbon trapped in the soil (part of the process known as carbon sequestration).[11]

In the late 1990s and early 2000s, a "carbon farming" movement emerged, led by farmers and scientists who advocated no-till as a climate mitigation practice, and carbon markets to compensate farmers who adopted the practice. The 1992 Kyoto climate agreement established carbon trading markets, but they were later derailed. Nonetheless, local markets developed in places such as California and Australia. Many climate scientists continue to see carbon farming to promote conservation agriculture worldwide, and at the same time assist the global effort to mitigate climate change.

A model? To many observers, the development and consolidation of no-till in the US demonstrated that, with adequate government support and good equipment, conservation agriculture could become mainstream. Countries that had "missed out" on previous agricultural booms had an opportunity to learn from experience in Asia, the United States and other regions. One battleground for the ongoing debate is the continent of Africa. Much of Africa did not enjoy many of the productivity gains that had benefited Asian countries during the Green Revolution, which raised crop productivity through high yielding varieties and increased fertilizer use.

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[7] Huggins and Reganold, "No-Till." Harry Young in Kentucky used a six-row Allis Chalmers planter, which could cover 30-50 acres a day. Source: Ruy Casao Junion, Augusto Guilherme de Araujo and Rafael Fuentes Llanillo, *No-Till Agriculture in Southern Brazil*, UN Food and Agriculture Organization and Instituto Agronomico do Parana, 2012. See: http://www.fao.org/docrep/016/ap289e/ap289e00.pdf

[8] Source: National Sustainable Agriculture Information Service (ATTRA). See: https://attra.ncat.org/calendar/question.php/what-information-can-you-give-me-on-building-and-using-a-roller- crimper-for-cover-crops

[9] Huggins and Reganold, "No-Till."

[10] The data came from the USDA's National Resources Inventory database. Source: Huggins and Reganold

[11] Huggins and Reganold, "No-Till."

Could "mechanized" no-till become a central part of agricultural development in the fast-developing countries of Africa, such as Ghana?

Ghana—Agricultural Nation

Once a British colony known as the Gold Coast, Ghana gained independence in 1957, and by the 21st century was one of the continent's most prosperous countries. From 2006-2016, annual GDP grew 4-8 percent a year, while the poverty rate fell from 52 to 28 percent.[12] The number of undernourished among its 27 million population fell from 5.4 million in 1990-1992 to 1.9 million in 2003-2005.[13]

Nonetheless, as of 2015 some five percent (1.2 million) of the population remained food insecure, and another two million were vulnerable to food insecurity.[14] Although the economy was heavily agricultural, Ghana produced only a portion of the foodstuffs its population required: 51 percent of cereals; 60 percent of fish; 50 percent of meat; and some 30 percent of raw materials for agriculture. It imported the rest. In 2014, Ghana spent $1.5 billion on rice, sugar, fish, tomato and cooking oil imports alone.[15] It also imported 15 percent of maize supplies. Food was relatively expensive; most citizens spent 60-80 percent of their income on food.[16]

Legally, the government owns all land in Ghana's 10 administrative regions. But customary (as opposed to statutory) laws govern its use. Two-thirds of Ghana is communally owned, with a family head or chief as custodian. Specifics differ from region to region on the possibility of individual ownership, the ability to sell or lease land, allocation of farming rights and so forth. Sharecropping is also common, with a variety of arrangements on sharing the harvest.

Still, agriculture constitutes 21 percent of GDP as of 2015.[17] As of 2010, agricultural products like cocoa accounted for 30 percent of total export earnings.[18] Of the country's 24 million hectares, 69 percent is agricultural land.[19] 30 percent of the population farms. But the vast majority of farmers are smallholders, operating barely above subsistence level. Despite a colonial heritage of extensive oil palm, rubber, rice, maize, cocoa, coconut and pineapple farms, 90 percent of Ghanaian farms are two hectares or less.[20] Most depend exclusively on rainfall for irrigation. Much of Ghana (it has four ecological zones) has two rainy seasons: end of March to July, and September to November. Farmers can plant twice a year—in February and in August.

Slash-and-burn. By the late 20th century, most farmers used slash-and-burn to clear land for planting. Under this approach, farmers cleared vegetation with a machete, left it to dry, then burned the residue. That left the land ready to plant, required less time and labor than plowing

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[12] Bernard Darfour and Kurt Rosentrater, "Agriculture and Food Security in Ghana," *Agricultural and Biosystems Engineering Conference Proceedings and Presentations*. 478. July 20, 2016. See: http://lib.dr.iastate.edu/abe_eng_conf/478.

[13] Paul-Florent Montfort, "Ghana between food insecurity and the financial crisis," *Momagri*. See: http://www.momagri.org/UK/focus-on-issues/Ghana-Between-Food-Insecurity-and-the-Financial-Crisis_484.html

[14] Darfour and Rosentrater, "Agriculture and Food Security." The following statistics are also from this report.

[15] Ghana Ministry of Foreign Affairs and Regional Integration, "Ghana spent $1.5 bn on importation of basic food such as rice in 2014." See: http://mfa.gov.gh/?id=273 Also Darfur and Rosentrater.

[16] Montfort.

[17] World Bank Data. See: http://data.worldbank.org/indicator/NV.AGR.TOTL.ZS?locations=GH

[18] Food and Agricultural Organization, *Analysis of Incentives and Disincentives for Cocoa in Ghana* .. 2013 See: http://www.fao.org/3/a-at551e.pdf

[19] World Bank Data. See: http://data.worldbank.org/indicator/AG.LND.AGRI.ZS?locations=GH

[20] Darfour and Rosentrater.

by hand, destroyed weeds, wiped out plant diseases, and made seeding easier. Seeds were planted with a dibbling stick.

Historically, farmers cultivated "slash and burn" fields for two to three years, then left it fallow for 5-10 years to rejuvenate. But to meet needs and build exports, Ghana's per capita food production rose 55 percent from 1990-1992 to 2008-2010.[21] Farmers achieved this by using land more intensively, with fields left fallow for shorter or no time. The result: erosion, reduced soil fertility, lower yields—and lower income. In 2015, farmers across Ghana reported poor water infiltration of soil, crusting and hardening in drought, and the soil's low ability to hold water.[22]

Farmers typically sold production to middlemen at the farm or sent it to market centers.[23] Especially during dry years or between harvests, farmers too often proved unable to feed their families, unable to pay children's school fees or afford much beyond basics. At least one Ghanaian, a researcher who spent his entire professional career promoting no-till farming, was sure he had a solution to offer.

Kofi Boa

Kofi Boa was an agronomist, born in 1955 in Amanchia, a village in the Ashanti region of central Ghana, the country's most populous. The youngest of four boys, his father died when Boa was six. At 12, his family's cocoa farm was wiped out by a brush fire. Boa saw his mother reduced to near-penury, forced to work as a caretaker for other landowners. The experience gave him a strong hatred for fire, including the slash-and-burn method of farming.

Boa studied agriculture in high school and continued with agricultural science at the Kwame Nkrumah University of Science and Technology, in Ashanti's capital, Kumasi. He graduated in 1980 and found a job as an agronomist at the Ashanti Cocoa Project. Boa already had a career focus, although he had not yet heard the global term for it: no-till farming.

Proka. As a teenager, Boa had learned from elderly cocoa farmers that at one time, Ghanaian farmers did not burn their fields to prepare for planting. Rather, they used a system called *proka*, which he translated as no-till with mulch.[24] Under *proka*, farmers cleared land (often forested), left it alone for a year to rot, and then planted cocoa seedlings through the resulting mulch. With his dislike of fire, this farming system appealed strongly to Boa.

But Boa felt a year's wait was too long, and on his family farm he developed a method to accelerate mulch production. His approach: use a machete to clear a field. Chop the vegetative remains into small pieces. Plant in rows below the mulch using a machete to clear a small area, slit open a hole, drop in seed and close the soil.[25] The mulch served to trap moisture in the soil, and to also shade out weeds. He used glyphosate (Round-Up, Chemosate or Helosate), a common organophosphorus herbicide, to treat the weeds that did emerge. Sometimes, he intercropped smaller vegetables like tomatoes and peppers until the main crop grew too high and shady.

When Boa learned about no-till, he recognized it as essentially the same as *proka.* At the Ashanti Cocoa Project, he tried repeatedly to persuade farmers to stop burning their crop residue

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[21] Ibid.

[22] Dykstra.

[23] Ibid.

[24] *Proka*, or *oprowka*, literally means "add to by rotting" in the Akan-Twi language. Source: Edwin A. Gyasi, *Integrated Final report of PLEC work in Ghana August 1992-February 2002*, University of Ghana, Legon, March 2002, Section 3.3.4. See: archive.unu.edu/env/plec/country/ghana/Ghana.do

[25] Mike Wilson, "Africa's no-till revolution," Farm *Futures*, February 4, 2015. See: http://www.farmfutures.com/blogs-africas-till-revolution-9442

and instead try no-till, but he got little encouragement. So in 1985, he quit to join the Ghana Green Development Project at the Crops Research Institute (CRI) of the Council for Scientific and Industrial Research. His work gained him such notoriety that he was dubbed "Mr. Mulch."

In 1991, Boa won a scholarship from CRI to pursue a master's degree. He had noticed that numerous farms in Nebraska embraced no-till, so he attended the University of Nebraska (Lincoln) for an MSc in agronomy (1993). While there, he studied American-style no-till, and recalled:

> I came back from Nebraska very much enriched, in the sense that I had been exposed to the very advanced no-tillage system, as well as the smallholder system that I knew here.[26]

The difference was that farmers in Ghana had little access to machinery, financing, or expensive chemicals. New degree in hand, Boa returned to CRI as an on-farm research scientist, determined to do what he could to encourage no-till in Ghana.

Ghana and No-Till

His timing was fortuitous. Ghanaian scientists had researched no-till as early as the 1960s. But in the 1990s, the Ministry of Food and Agriculture (MoFA) was actively exploring alternatives to slash-and-burn. Nationwide brushfires in 1983 had destroyed a majority of cocoa and palm oil plantations, which had forced many farmers to abandon their farms but also opened the door to experimentation. [27]

The government launched a series of initiatives to research and document whether and how no-till worked. CRI in 1990 started a Ghana Grain Development Project (GGDP) with initial funding from Canada. GGDP piloted no-till at five research stations. The Sedentary Farming Systems Project (1996, funding from Ghana and Germany) examined residue management, equipment, pest control, cover crops, and crop rotation.[28] The Cover Crop Program, a collaboration between the International Institute of Tropical Agriculture and CRI, tested various plants for suitability as cover crops.[29]

At CRI, Boa was asked to be a researcher on yet another project: educating farmers in three of Ghana's eco-zones (Forest, Guinea Savannah, and Transition) about no-till.[30] The initiative was launched in 1993 as a partnership among CRI, GGDP, Sasakawa Global 2000, the global chemical giant Monsanto, and MoFA. Project officers worked directly with farmers, meeting as often as weekly to identify problems, craft solutions and launch on-farm trials on a portion of a farmer's land. They offered farmers pre-season training, field days, field tours,

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[26] Adam Stepan interview with Kofi Boa in Amanchia, Ghana, on May 21, 2016. All further quotes from Boa, unless otherwise attributed, are from this interview.
[27] Ibid
[28] R.J. Carsky et all, eds, *Cover Crops for Natural Resource Management in Africa*, International Institute of Tropical Agriculture, 2000, p.120. See:
https://books.google.com/books?id=bECU0b5iGkQC&pg=PA120&lpg=PA120&dq=Sedentary+Farming+System+
project++ghana&source=bl&ots=0aLey_nJ4u&sig=51vWp54KfYGFI4mWpHuImHbg5qE&hl=en&sa=X&ved=0a
hUKEwij98SU4KbRAhXOxyYKHZvfDPwQ6AEIHDAA#v=onepage&q=Sedentary%20Farming%20System%20 project%20%20ghana&f=false
[29] Dykstra.
[30] Ekboir, Boa, and Dankyi.

workshops and seminars, fact sheets, and production guidelines.[31] They helped farmers obtain credit and provided access to suppliers of seed, fertilizer, and pesticides. By 2000, some 100,000 Ghanaian farmers were using no-till on 45,000 hectares of farmland.[32]

In 2002, Boa and two co-authors published a study of no-till results in Ghana, documenting that in normal rainfall years, no-till famers obtained maize yields 45 percent higher than their slash-and-burn peers. In dry years, the no-till advantage was even better—48 percent. In addition, no-till reduced family labor by 31 percent—both in preparing/planting fields, and in weed control. It increased the soil's water retention, permitted farmers to plant a second, edible crop as cover, and encouraged beneficial insects that fed on pests.[33] The study noted that rotating crops also promoted soil health.

The researchers identified two groups of good cover crops for Ghana: grain legumes (groundnut, cowpea, or beans) and green manure legumes (mucuna, dolichos or canavalia). The green manure created a nitrogen-rich biomass.[34] Once a cover crop was established, local crops included plantains, cocoa, maize, cassava, vegetables, and okra.

But in 2003, the Grain Development Project ended, and Boa quit CRI to devote himself fulltime to no-till farming research and practice. Many of his peers were confused by this and questioned his decision. "I had friends coming to tell my wife to sit me down because they thought I was getting crazy," he recalls. "At the prime age of my research career, I was quitting and nobody understood that." But he wanted to return to his own farm to see what he could do—and invite others to witness it.

A Nebraska Connection

Boa established several research priorities: explore better planting processes, identify promising crop rotations adapted to farmers' objectives and resources, test how to better integrate cover crops in no-till, and introduce low-labor slash practices.[35] In 2007, Boa met Howard G. Buffett. Buffett was a US farmer and philanthropist keenly interested in no-till (he used it on his own 1,500 acres in central Illinois) and eager to promote its use in the developing world. "We always say that plow is a four-letter word," he quips.[36] The son of investor Warren E. Buffett, Howard and the family established the Howard G. Buffett Foundation (HGBF) in 1999.[37] The foundation supported and researched conservation agriculture techniques and practices through grants and research farms it operated in the US and South Africa.

The foundation first supported wildlife conservation but, in 2004, added global hunger and poverty, with an interest in smallholder farming in the developing world. Buffett saw his mission as teaching soil preservation. "Farmers need to understand how important it is not to lose their soil, how important it is to take care of that soil," he says. "But it's really, really hard to change anybody's behavior." Technology was not always the answer. "Technology cannot put soil back where it's been eroded. Technology can't do things that Mother Nature does," he observes.

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[31] Dykstra.
[32] Ekboir, Boa, and Dankyi. Additional data in this paragraph results from this study.
[33] Ekboir, Boa and Dankyi.
[34] The biomass boasted a high nitrogen fixation rate of 150 kg N/ha.
[35] Ekboir, Boa, and Dankyi.
[36] Adam Stepan interview with Howard G. Buffett in Omaha, Nebraska on November 21, 2016. All further quotes from Buffett, unless otherwise attributed, are from this interview.
[37] For more details on the foundation, see http://www.thehowardgbuffettfoundation.org/

As HGBF CEO, Buffett traveled widely to see for himself the causes and manifestations of hunger. In 2007, his odyssey brought him to Ghana. He flew to Kumasi for a meeting, but his contacts were late. A stranger approached because Buffett was wearing a University of Nebraska shirt. It was Boa. When it turned out Buffett was a disciple of no-till, a relationship was inevitable. They talked for two hours. "Kofi was like a soulmate," says Buffett. He was impressed that Boa used no-till on his own cocoa and citrus farm. "I could sense his deep connection to the issues smallholder farmers faced," he wrote later. "Perhaps more importantly, he was as fixated on helping farmers take care of and improve their soil."[38]

Boa showed him his demonstration fields, which Buffett viewed as real-time experiments vividly illustrating for farmers that "taking care of the soil pays off in better yields for less labor."[39] On the plots, each about 1,000 square meters, workers first slashed the vegetation with machetes and left it to dry and rot.[40] After weeds grew to 30-40 cm, they were treated with glyphosate using a backpack sprayer. The weeds decomposed into mulch for 7-10 days before seeds were planted with a dibbling stick. Further weed control was done either by hand (hoe or machete) or with an herbicide. The longer a field experienced no-till, the less herbicide was necessary because mulched weeds did not sprout. For comparison, Boa placed conventional tillage fields next to no-till.

From that point, Buffett's foundation began to support Boa's ongoing research, such as a five-year study called Sustainable Soil Management for Improved Food Security. The study evaluated the effects of tillage, cropping systems, and soil changes on the chemical and physical properties of soil, yield, and nutrients. It also looked at the sustainability of various crop production systems, and the project resulted in a comprehensive data set on carbon dynamics and conservation systems applicable to West Africa.[41]

Buffett appreciated that Boa's research yielded practical results. "People forget farmers in Ghana are... farming to survive. They're farming to feed their family... Kofi was this guy who I met by accident that turned out to be one of our best investments." For Boa, had more in mind than research. In 2012, with Buffett's support, he founded Africa's first Center for No-Till Agriculture with six employees and a handful of demonstration fields in his home village of Amanchia. As he wrote, his goal was "to permanently illustrate the evidence and benefits of no-till farming and to teach other farmers the processes."[42]

No-Till Center

The new non-profit center operated a host of programs, many a continuation of Boa's long-time activities: training, workshops and seminars. A five-week "Sunday school" on conservation agriculture ran every Sunday from 2-5 pm. "The three elements we talk about are: minimal disturbance to the soil—just opening it up enough to put in the seed; a diversified cropping system, through mechanisms like crop rotation; and maintaining soil cover," Boa elaborated.[43] Field days took researchers, farmers and others to a no-till demonstration plot to discuss benefits and problems. Field tours took participants to no-till farms where they could see

[38] Howard G. Buffett, *40 Chances: Finding Hope in a Hungry World* [New York, London; Simon & Schuster], 2013, p.359.
[39] Buffett, *40 Chances*, p.359.
[40] Ekboir, Boa,and Dankyi.
[41] Buffett, *40 Chances*, p.361.
[42] Source: No-Till on the Plains website. See: http://www.notill.org/kofi-boa
[43] Buffett, *40 Chances*, p.360.

the method applied on a larger scale and interview the farmers. NGOs sent technical staff, as did the Ministry of Food and Agriculture. In 2016, the center added a one-year fellowship program.

The center supplied concrete guidelines for farmers eager to try no-till. For example, with one cover crop safely established, plant maize. Six to eight weeks later, replant a second cover crop.[44] Harvest the maize, and then the second cover crop. Sell what you can of both. This drew on the principles of cover crops, crop rotation, and intercropping. The center also encouraged farmers to band together into cooperatives to rent or buy expensive equipment like herbicide sprayers and share the cost.

The center developed a fine reputation among its constituents. But Boa wanted to use no-till to address a large societal problem: bringing youth back to the land. To them, farming was too much work. It also carried little prestige. Young Ghanaians think that "a farmer is somebody who could not learn any trade and therefore had to stay in the village to farm, to produce food as a way of life," Boa observes. To motivate young people to return to the farms, Boa knew he needed strong arguments. For cost reasons, Ghana used little agricultural machinery. Maybe, thought Boa, labor-saving equipment specially designed for no-till would persuade young people to return to their small family farms. He approached Howard Buffett.

Coalition support. In October 2013, Boa received additional commitments from Buffett and other partners to support the No-Till Center. [45] One was John Deere, the international agricultural equipment company. Its President in late 2011 had approached Buffett to discuss how the company might improve its product suite, sales, and marketing in Africa, especially for smallholders. Buffett's answer: develop a no-till planter suited to small fields.

No-till planters had existed for decades; the Dixon Springs Agricultural Experiment Station in Illinois had first developed one in 1966. But large machines designed for the US market were of no use to smallholder farmers in Africa. Buffett and Deere agreed that the foundation would fund, and Deere would develop, a prototype no-till planter for smallholders. Buffett also enlisted the DuPont Pioneer chemical company to experiment with seeds, fertilizer, and herbicides suitable for no-till.

Meanwhile, Boa set out to research the best machinery available for the other heavy-labor aspect of no-till: preparing fields for planting. He and his partners were able to import the first roller-crimper in 2014. Made by I&J Manufacturing (Pennsylvania), it made an immediate and impressive difference. "The roller crimper takes away the drudgery of using the machete," says Boa. "Also, it takes away the dangers associated with the use of the herbicides, both for humans and for the soil." A roller came in standard widths of eight feet (3-row), 10½ feet (4-row) and 15½ feet (6-row), meaning it could work for farms of varying sizes.

In early 2016, as part of its contribution to the partnership with the Buffett Foundation, John Deere began rolling out the first commercially available no-till planter for smallholders. Small by design, it seeded only two rows at once. The center understood that at $7,000 each, the planter was too expensive for a single farmer. So as with sprayers, it encouraged farmers to use cooperatives to purchase and share a single machine and helped them secure credit.

By early 2017, Boa had plenty of success stories to tell. For example, in 2015 poor weather had affected farming, "especially in the second season, and several fields were lost. But in and around the Center for No-till Agriculture, farmers harvested so much," he says. "What we stress

[44] Dykstra.

[45] For the announcement of the partnership, go to: http://www.prnewswire.com/news-releases/ag-leaders-announce- partnership-to-promote-conservation-agriculture-adoption-228166511.html

on is, the soil comes first. We always get the farmer to appreciate that you need to take care of the soil, and the soil will take care of the plants." In its first five years, the center had trained over 5,000 people. Its full-time staff were up to 10.

Ghana's North and Future of No-Till

As of early 2017, the Center for No-Till's partnership with HGBF and John Deere was in full implementation, with satellite offices and an additional eight demonstration plots established throughout the country so that far-flung farmers would not have to travel to the center for instruction. The center took special interest in the north, an area of rich water resources and flat plains considered Ghana's agricultural frontier. Many international development groups, as well as commercial agricultural investors, had already invested in the area, consolidating smaller holdings into larger farms that could be served by irrigation systems. The center worked both with private landowners and farm collectives to purchase no-till planters and tractors communally.

For Boa, the no-till message seemed to be gaining traction. "We call it the brown revolution," expands Boa. "The brown giving rise to the green, and it becomes so perfect that you have a nice carpet of mulch very well laid on the ground, and then you have your crops right through the mulch." Boa hoped that by reducing labor, the new equipment for no-till would help lure young people back to the farm, not only in Ghana but across Africa. He also saw potential for no-till to help the planet turn the tide on carbon sequestration. But his focus was Ghana. In his lifetime, says the agronomist, "I will surely see Ghana becoming a no-till country."

Whether Ghana will be able to mechanize on the no-till model remains to be seen. Unlike in the US, there were not, in 2017, significant government tax incentives in place to support farmers making the transition to no-till. The idea that one day a new international system of "carbon credits" may provide financial incentives to no-till and other conservation techniques has been debated but is not currently part of the equation.

For now, no-till must win new converts based on the short and long-term benefits it provides farmers. For Howard G. Buffett, this may be enough. "I'm not no-tilling to sequester carbon. I'm no-tilling because it's the smartest thing I can do in terms of profitability. It's the best thing I can do for my soil. It's the right...long term strategy for my biggest investment, which is my farmland."

For Boa and his team, his job will be to be show Ghanaian farmers that this equation makes sense. He believes the timing is right; "We have a very unique opportunity for us to show the right way, right from be beginning, especially in areas that have not been touched yet...The farmers themselves are seeing the value, so it's a matter of time."

From Project to Sustainable Model

The coming years will be crucial for the roll out of Dr. Boa's plans. The challenges he faces include successfully replicating the model he developed in Kumasi to the satellite training farms he has established elsewhere.

He also must continue and expand his advocacy work with the government and the local financial sector, so that official support and financing can be put in place. The example from the US shows that while no-till farming generally "pays for itself" in terms of increased soil fertility, it was a huge boon to the movement when "conservation agriculture" was recognized as a set of official practices, and when certain government subsidies were put in place to support farmers who adopted the practices. Having lenders who understand that purchasing no-till equipment is a solid investment will also be crucial in allowing more Ghanaian farmers to make the transition.

For the HGBF, one question is how the Ghanaian model might replicate and expand to other countries, and how to leverage investments with matching funds from other local partners in various regions. It has as one of its goals for 2016-2017 the development of plan that allows to No-Till Center in Ghana develop other local revenue streams through local and regional trainings. It is also exploring the creation of a no-till center in Central America that would serve as a regional training center based on the Ghanaian model.

For Buffett, the key is to try to find local leaders who can energize and drive such efforts:

> You have to have a champion. You have to have a person that is so committed to it that it's going to work because of that person. You can't just take an idea and move it somewhere and expect it to work. It works because of the people that are engaged in, the people that believe in it.