The Criticality of the Agricultural Distributor for Poverty Reduction in Least Developed Countries

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Abstract. *Agricultural production in the poorest countries of the world has remained stagnant over the past ten years while poverty and undernourishment have increased. In order to maintain minimum caloric intake for the projected tripling of population in sub-Saharan Africa, production must increase by 100% by 2050. Agricultural methodologies must employ sustainable agricultural practices in order to achieve two major objectives: because agriculture is the major cause of global greenhouse gas emissions, and, climate variability is the primary determinant of agricultural productivity agricultural regimes must be adaptive and provide means of mitigating environmental damage; and, as evidence has shown, and will be explicated below, sustainable agricultural practices utilize few inputs and provide greater yields and profitability for the grower. This paper cites evidence that the current paradigm of providing Development Assistance does not significantly increase growers' producer supply curves and does not reduce poverty or undernourishment in Least Developed Countries. This paper posits that analyses centered on Market Failure to explain lack of production and the eventual prescription of government interventions overlooks an important paradigm for improved agricultural production that has been successful in other, developed, communities. This paper posits that to improve production within the context of global environmental change an effective model must integrate agro-economic institutions and provide epistemic space for sustainable agriculture irrigation regimens. This paper posits that the critical agro-economic institution for smallholders in Least Developed Countries is the irrigation distributor network and provides four models of irrigation distribution in Africa*.

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Keywords. Agriculture in the Anthropocene, Sustainable Agricultural Production irrigation distributors, irrigation distributors, poverty reduction, agro-economic institutions

Introduction

This paper asks that, given the positive and significant correlation between sustainable agricultural practices and socio-ecological improvement, why is it that agricultural production in the Least Developed Countries (LDCs) has not significantly increased over the past decade? Or, to quote an oft-asked question: "If economists are so smart, why is Africa so poor?" (Haber, North, & Weingast, 2003). The question is of serious concern but becomes a much more urgent problem when taking into account the massive increase in population that is projected to occur over the next thirty years which will demand a 70 percent increase in global production. Of further concern is evidence that water and land management have the greatest and most significant anthropogenic impacts on greenhouse gas emissions (Wollenberg, Nihart, Tapio-Bistrom, & Grieg-Gran, 2012; Hayashi, Akimoto, Tomoda, & Kii, 2012; Ospina & Heeks, 2012; Adams, Hurd, Lenhart, & Leary, 1998; Maeda, Pellikka, Siljander, & Clark, 2010; Folke, et al., 2004; Bellarby, Foereid, Hastings, & Smith, 2008). "The earth's largest terrestrial store of carbon is soil (and), since the Industrial Revolution, soil carbon emissions from land-use change and agricultural activities have accounted for about 19% of total atmospheric carbon emissions" (Tennigkeit, Kahrl, Wölcke, & Newcombe, 2012, p. 302) while indirect total emissions caused by agricultural production account for about one-third of all greenhouse gas emissions (Wollenberg, Tapio-Biström, & Grieg-Gran, 2012).

Conway has called for a new "Doubly Green Revolution" (Conway, 1999, p. 17) to significantly increase crop production in LDCs while '"conserving natural resources and the environment" (Conway, 1999, p. 29). The process of sustainable agricultural production (SAP), also called climate-smart agriculture (Grainger-Jones, 2011), or smallholder systems innovations (Bossio, Jewitt, & van der Zaag, 2011) has been shown to act as a positive and significant independent variable that explains decreases in poverty and malnutrition and mitigation of global environmental change. SAP represents a win-win for smallholder farmers and the Earth's system in that it provides smallholders greater profitability while reducing the impacts of global enironmental chan (Pretty, Noble, Bossio, Dixon, Hine, & Penning de Vries, 2006, p. 1114).

This paper posits that the investigation into the paucity of increased agricultural production starts with an understanding of private, agro-economic institutions that have not been allowed to function to their maximum efficiency because of epistemically-poor government and NGO interventions. In other words, government programs and NGO funding and programs ignore the critical relationship between the irrigation manufacturer, distributor, and grower. The critical gap in current paradigms is institutional.

The structure of the paper is divided into eight brief sections: The next, or, second section will provide a background summary of the socio-economic status and projections of the LDC populations who make up the central level of analysis of this study. The third section explicates the state of agricultural production in LDCs which remains stagnant over the past decade. The fourth section describes the state of water security in LDCs, the nature of the Anthropocene, and the impacts of global environmental change on the most vulnerable countries. The fifth section describes in detail the processes of SAP and a detailed literature review of case studies where SAP has been implemented. The sixth section provides an overview and critical analysis of current Development models that are designed to increase agricultural production and reduce poverty. The seventh section describes the distributor model that is posited as the critical element for agricultural production increases within the context of global environmental change. The final section is a conclusion of the paper followed by references.

Background

Socio-Economic Status and Projections in LDCs

Between 2011 and 2100, the population of high-fertility countries, which include the majority of Least Developed Countries (LDCs) in sub-Saharan Africa, is projected to triple, passing from 1.2 billion to 4.2 billion (UNFPA). LDCs constitute the poorst 48 countries of the world. In LDCs, the number of extremely poor people (living on less than $1/day) increased by over 3 million from 2002-2007 to 1.3 billion, the distribution of people in the adult population earning less than $1.25/day doubled from 18 percent to 36 percent, and 2.6 billion people live on less than $2/day (UN, 2012) . The total number of people in LDCs who are undernourished (living on less than 3000 kcal/day/capita) increased by over 5 million from 2002-2007 (UNCTD, 2010) . Fully 95 percent of all undernourished people live in the developing countries (UN, 2012).

One particularly insidious and revealing indicator of undernourishment in LDCs is the incidence and severity of childhood stunting. Stunting is defined as "the height (or length)-for-age more than 2 Standard Deviations (SD) below the median of the National Center on Health Statistics and World Health Organization (NCHS/WHO) international reference" (WHO). "Even though the prevalence of stunting in all developing countries declined from 47% in 1980 to 33% in 2000...progress was uneven across regions...Stunting had increased in Eastern Africa...had modest improvements in Northern Africa and had presented very little progress in Western Africa" (de Onis, Frongillo, & Blossner, 2000, p. 1). Table 1, below, illustrates that stunting has not been significantly reduced, particularly in Eastern and Western Africa, since 1980 (de Onis, Frongillo, & Blossner, 2000).

Table 1. The Prevalence of childhood stunting in Africa 1980-2005 (pct)

Region	1980	1985	1990	1995	2000	2005
Africa	40.5	39.2	37.8	36.5	35.2	33.8
Eastern Africa	46.5	46.9	47.3	47.7	48.1	48.5
Northern Africa	32.7	29.6	26.5	23.3	20.2	17.0
Western Africa	36.2	35.8	35.5	35.2	34.9	34.6

Agricultural Production in LDCs

The Food and Agricultual Organization (FAO) of the UN has determined that agricultural production needs to increase by 70 percent overall (Pretty, Noble, Bossio, Dixon, Hine, & Penning de Vries), and by 100 percent in developing countries by 2050, to cope with an overall increase from 6.5 to 9.0 billion people (Bruinsma, 2009). Evidence is abundant that agricultural growth is key to poverty reduction in countries that depend largely on agriculture for their livelohoods (ADB, FAO, IFAD, IWMI, World Bank, 2006). Moreover, a great deal of evidence-based studies show that there is a direct and positive correlation between the growth of irrigation and reduction of poverty. Hussain and Wijerathna shows that "on average, a 1-percent increase in agricultural productivity level will reduce incidence of poverty by 0.31 percent" (Hussain & Wijerathna, 2004). Case studies establishing the linkage between efficient irrigation systems and poverty reduction are many— in Kenya (Ngigi, Thome, Waweru, & Blank, 2010); Pakistan (Hussain, Z, & Ashfaq, 2006); Ethiopia (Gebregziabher & Namara, 2009); and, Burkina Faso (Dembele, Yacouba, Keita, & Sally, 2011), for example— and report direct and indirect benefits of irrigation, including increased farmer consumption and assets. Additionally, farmers that have irrigation systems tend to informally share more with their communities than non-irrigators (Dillon, 2011). However, over the past decade, growth in agricultural production in LDCs has been virtually stagnant (UNDP, 2011; Bruinsma, 2009; World Bank, 2012). In addition, projections imply that agricultural production will decline in many parts of the developing world. Reports indicate that per capita food production is already declining in parts of sub-Saharan Africa (Grainger-Jones, 2011) and new data suggests that rainfed crop yields in some African countries are projected to decline by 50 per cent by 2010 due to climate change (IFAD, 2012). World Bank data illustrate the stagnation of agricultural growth in LDCs (World Bank, 2012).

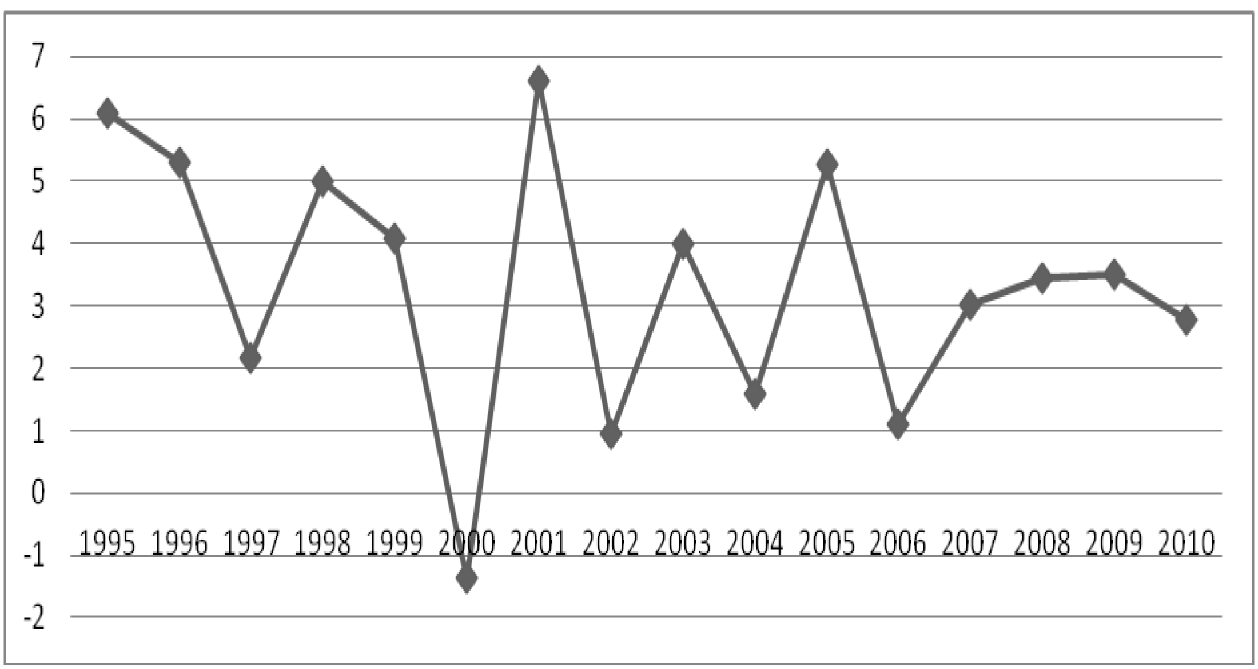

Figure 1 LDC annual growth from agriculture 1995-2010 (percentage) (World Bank, 2012)

Grain production in sub-Saharan Africa is often cited as an indicator of agricultural production. From 1960-2010 the average grain production has averaged at or below 1 ton/hectare (Makurira, Savenije, Uhlenbrook, Rockstrom, & Senzanje, 2011, p. 1697) and is illustrated below in the graph. There has been an approximate 5 percent growth in grain production from 2000-2010 but only a 3 percent growth from 1970-2010. In order to cope with the overall 40 percent increase in world population, grain production has to increase by an additional billion tons of cereals by 2050, as compared with production in 2005/07 (Bruinsma, 2009, p. 2).

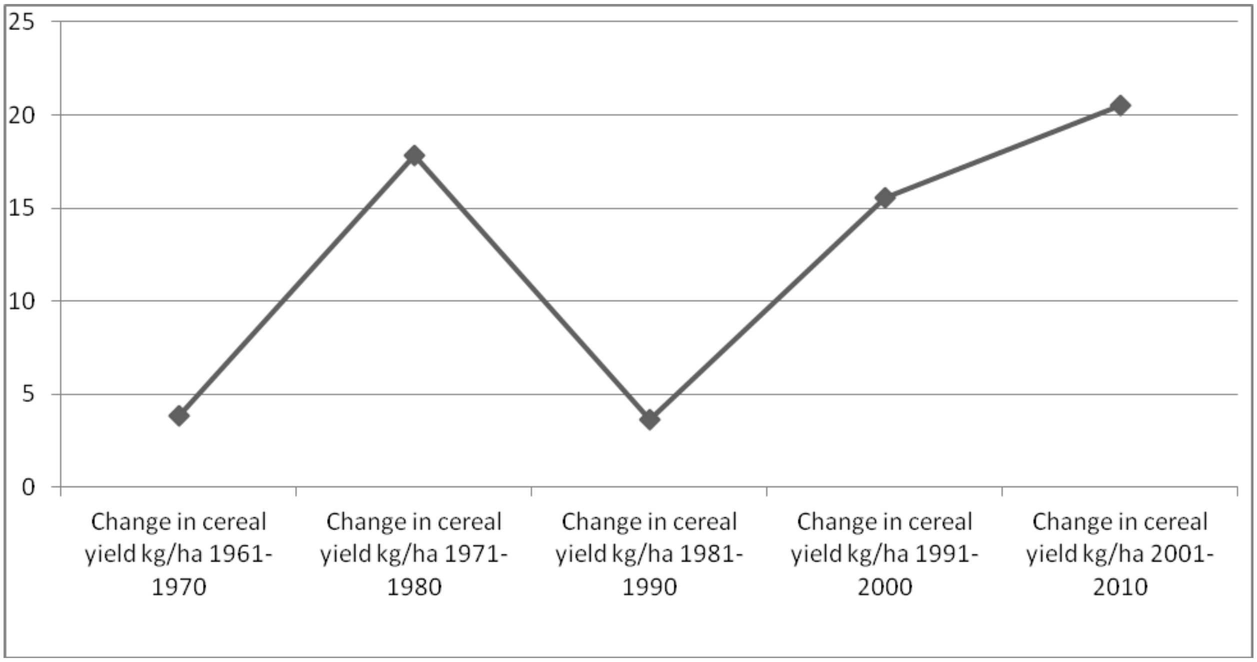

Figure 2 Grain production growth in LDCs from 1960-2010 (percentage) (Makurira, Savenije, Uhlenbrook, Rockstrom, & Senzanje, 2011)

Water Scarcity, the Anthropocene, and Impacts of Environmental Change

In addition to the socio-economic challenges faced in LDCs over the next generation, it is also important to note that those most in need of poverty and undernourishment reduction live in the most water-scarce and environmentally vulnerable environments. Currently, about 700 million people in 43 countries suffer from water scarcity. A region experiences water stress when annual water supplies drop below 1,700 m^3/capita. When annual supplies drop below 1000 $m^{3/}$capita the population faces water scarcity, and when annual supplies drop below 500 m^3/capita, the population faces absolute water scarcity (UN, 2005) . "By 2025, 1.8 billion people will be living in countries or regions with absolute wter scarcity, and two-thirds of the world's population could be living under water-stressed conditions (FAO, 2007).

Water scarcity is likely to increase over the next 30 years in vulnerable communities because agriculture is the major cause of global greenhouse gas emissions and "climate variability is the primary determinant of agricultural productivity" (Adams R. , Hurd, Lenhart, & Leary, 1998, p. 19). The majority of agricultural emissions, approximately 74 percent, originate in low and middle-income countries, where smallholder farmers predominate (Wollenberg, Tapio-Bistrom, & Grieg-Gran, 2012, p. 4). A central reason for the increase in greenhouse gas emissions in LDCs, is the propensity for farmers to increase crop production by expanding cultivated areas rather than increasing yields on current agricultural lands. Typically, the expansion of land involves cutting forested areas. In sub-Saharan Africa about 95 percent of the total agricultural land is rainfed agriculture so increasing yields on established agricultural land is challenging (Bossio, Jewitt, & van der Zaag, 2011, p. 1683).

The Anthropocene

The Anthropocene is the new epoch in Earth history (Steffen, Grinevald, Crutzen, & McNeill, 2011) that is distinguished by the sizeable and siginficant impact of the human imprint on the global environment. The anthropogenic impacts of humankind on the global enviornment have been quantified by Rockstrom, et al, and codified into Planetary Boundary Theory. Climate change is only one of a number of planetary boundaries that make up the Earth-system processes and associated thresholds that, of crossed, could generate unacceptable enviornmental changes (Rockstrom, et al., 2009). Of particular salience for this paper is that land and water management is key to mitigating the seven, currently quantifiable, planetary boundaries. "Water and land management are the primary media through which climate change will impact people, ecosystems and economics" (Sadoff & Muller, 2009).

Sustainable Agricultural Production; the Process and Literature Review

Sustainable agricultural production methods are instruments and regimes that growers draw from a tool kit in order to increase production . A key study elegantly illustrates the "synergies and tradeoffs between productivity, climate change adaptation, and greenhouse gas mitigation" (Bryan, Ringler, Okoba, Koo, Herrero, & Silvestri, 2011, p. 3). Bryan, et al, list the activities of sustainable agriculture (productivity impacts) and corresponding climate adaptation benefits and greenhouse gas mitigation potential and finds that improved crop varieties; changing plant dates; improved crop rotation with legumes; appropriate use of fertilizer and manure; incorporation of crop residues; reduced tillage; agroforestry; irrigation and water harvesting; bunds; terraces; mulching; grass strips; ridge and furrow, and; diversion ditches, all increase yields (with the excepted impact of reduced likelihood of crop failure for the 'changing plant date' activity) and all have positive mitigation potential. Reganold, et al, point out that "sustainable agriculture does not represent a return to pre-industrial revolution methods; rather it combines traditional conservation-minded farming techniques with modern technologies. Sustainable systems use modern equipment, certified seed, soil and water conservation practices and (the)...emphasis is placed on rotating crops...and controlling pests, naturally" (Reganold, Papendick, & Parr, 1990, p. 115). Makurira, et al, compared a combination of three methods of sustainable agriculture which he terms "farming system innovations" ((Makurira, Savenije, Uhlenbrook, Rockstrom, & Senzanje, 2011, p. 1696). His Tanzania project looked at the effects of runoff diversion (RD), on-site water harvesting (WH), conservation tillage (CT) at four sites using traditional hand-hoe methods and found an increase of maize yields of up to 4.8 tha^{-1} over the current average of less than 1tha^{-1} (Makurira, Savenije, Uhlenbrook, Rockstrom, & Senzanje, 2011, p. 1696). .

"The idea of agricultural sustainability centers on food production that makes the best use of nature's goods and services while not damaging these assets" (Pretty, Noble, Bossio, Dixon, Hine, & Penning de Vries, 2006). Even more succinctly, "Sustainable agriculture is concerned with the ability of agroecosystems to remain productive in the long term" (van der Werf & Petit, 2002, p. 131). The two keys to mitigating any deleterious impacts of irrigated agriculture are: (1) to provide scientifically-derived evidence that the adoption of sustainable agricultural practices leads to profitable increases in production and (2) to make those methods available and accessible to smallholder farmers. Evidence shows that interventions to increase agricultural sustainability reduces pesticide use, increases yields and improves soil (Pretty, Noble, Bossio, Dixon, Hine, & Penning de Vries, 2006). Pretty, et al. showed "the extent to which 286 interventions in 57 poor countries covering 37 million ha (about 3% of the cultivated area in developing countries) have increased productivity on 12.6 million farms while improving the supply of critical environmental services" (Pretty, Noble, Bossio, Dixon, Hine, & Penning de Vries, 2006, p. 1114). Sustainable agricultural practices such as minimum crop tillage and integrated pest and nutrient management regimes helped increase "average yields by 79% (geometric mean 64%). Potential carbon sequestered amounted to an average of 0.35Gt/Cy (gross tons per calendar year). One of the parameters of sustainable agriculture is integrated pest management. Of projects in Pretty's study with pesticide data, 77% resulted in a decline in pesticide use by 71% while yields grew by 42%" (Pretty, Noble, Bossio, Dixon, Hine, & Penning de Vries, Resource-Conserving Agriculture Increases Yields in Developing Countries, 2006, p. 1114).

Lin suggests that building resilience through crop diversification is a rational and cost-effective way for agriculture to adapt to changing climatic conditions (Lin, 2011, p. 183). The specific benefit of crop diversification is to reduce the outbreak and intensity of pathogenic transmission which is a typical phenomenon of monoculture agriculture (Lin, 2011). Salient to this paper is Lin's emphasis on the importance of the ability to communicate adaptation options to farmers and the local community (Lin, 2011, p. 190). Lin stresses the need for partnerships among stakeholders and, in particular, farmers and scientists. While Lin overlooks the role of the irrigation distributor it is implicit in his.

According to Bellarby, et al, "the total global contribution of agriculture, considering all direct and indirect emissions, is between 8.5-16.5 Pg CO_2, which represents between 17 and 32% of all global human-induced GHG emissions, including land use changes" (Bellarby, Foereid, Hastings, & Smith, 2008, p. 5). Bellarby, et al, suggest that agriculture provides a wide range of mitigation options including: cropland management, restoration of organic soils, improved water and rice management, increasing the efficiency of fertilizers, etc (Bellarby, Foereid, Hastings, & Smith, 2008, p. 9).

Similarly, other studies show significant and positive economic benefits from practicing sustainable agricultural practices (Smith, et al., 2008) and McCarthy in (Branca, McCarthy, Lipper, & Jolejole, 2011) (CCAG 1.33).

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Silvestri, 2011, p. 3). Bryan, et al, list the activities of sustainable agriculture (productivity impacts) and corresponding climate adaptation benefits and greenhouse gas mitigation potential and finds that improved crop varieties; changing plant dates; improved crop rotation with legumes; appropriate use of fertilizer and manure; incorporation of crop residues; reduced tillage; agroforestry; irrigation and water harvesting; bunds; terraces; mulching; grass strips; ridge and furrow, and; diversion ditches, all increase yields (with the excepted impact of reduced likelihood of crop failure for the 'changing plant date' activity) and all have positive mitigation potential. The overall climate adaptation benefits were reduced yield variability and improved soil fertility (Bryan, Ringler, Okoba, Koo, Herrero, & Silvestri, 2011, pp. 3-4). Salient to this study is the conclusion that Bryan, et al, reach in their study. Namely, that farmers (in Kenya) "do not fully recognize the interlinkages between agricultural productivity, climate change adaptation, and GHG mitigation. Rather farm decisions depend largely on productivity considerations" (Bryan, Ringler, Okoba, Koo, Herrero, & Silvestri, 2011, p. 35). They continue, "This is a significant gap that the government, NGOs, and extension agents will need to address in Kenya and elsewhere in the developing world for agricultural GHG mitigation to become an effective development strategy" (Bryan, Ringler, Okoba, Koo, Herrero, & Silvestri, 2011, p. 35).

Current Models for Development

In a word, the model for development of agriculture in LDCs has had two broad elements: funding; and, research and development of new technologies. To a lesser degree, the Development community has also tried to provide incentives, or subsidies, to encourage sustainable growth.

Market Failure Interventions

The rationale for funding and interventions of NGOs in African agriculture are based on analyses of market failure in African agriculture. The reasons for market failure often cited in the literature are several. "Inefficient allocation of resources (and), the breakdown of transmission mechanisms when people are socially excluded from markets" (Dorward, Farrington, & Deshingkar, 2004) are often cited. Other reasons for the lack of production within the context of market failure that precipitated government interventions are "inefficiencies created by incomplete institutional and physical infrastructure and imperfect competition" (Barrett & Emelly, 2005). The objectives of the interventions are to "get prices right (and) get institutions right" (Barrett & Emelly, 2005).

A later intervention to correct market failure was to introduce new and better technology. The constraints to widespread adoption of new technology were discussed by the United Nations Ministerial Conference of the Least Developed Countries in 2007. The internal and external difficulties to the adoption of technology to increase agricultural development were cited as, "low productivity; inflexible production and trade structures; low skill capacity; low life expectancy; low educational attainments; poor infrastructure; and, deficient institutional policy frameworks" (United Nations Ministerial Conference of the Least Developed Countries, 2007, p. 1).

Other constraints that are often cited and serve as attract intervention strategies are: the tension between customary and statutory laws (Gebregziabher & Namara, 2009; Maganga, 2003); unpredictable and variant rainfall (Bossio, Jewitt, & van der Zaag, 2011); the imbalance of gender in the agricultural sector (Phillip, Nkonya, & Oni, 2008).

Funding

Funding to correct market failures, from 1995 to 2009, by the mechanism of Net Official Development Assistance (ODA) to LDCs rose from $17 billion to $40 billion (in current US$) (UNDP, 2010). In 2010 net ODA flows from members of the Development Assistance Committee (DAC) of the OECD reached $128.7 billion, which is the highest level of aid in the history of OECD (OECD, 2013). The FAO suggests that in order to feed the developing world in 2005 it will be necessary to annually invest in developing country agriculture $83 billion (FAO).

Funding for R&D

One central model for agricultural development from the middle of the 20th century onward has been to invest in agricultural research and development (R&D). The assumption by Development is that "the world's agricultural economy underwent a remarkable transformation during the 20th century as the result of agricultural productivity growth, which was primarily generated by agricultural R&D financed and conducted by a small group of rich countries—especially the United States, but also Japan, the United Kingdom, France, and Germany" (Pardey, Alston, & Piggott, 2006, p. 3). Approximately $37 billion in total R&D was generated, worldwide, in agriculture in 2000 but has dwindled somewhat since.

Incentives and subsidies

Another type of intervention that the Development community has attempted to encourage the adoption of sustainable agricultural practices (considered a public good) are subsidies. The typical incentive-based intervention program to financially stimulate sustainable production has been to subsidize programs to reduce carbon footprints. Direct incentives for smallholder farmers to adopt mitigation practices are not particularly effective for a number of reasons: uncertainties and high transaction costs of identifying carbon sequestration practices (De Pinto, Ringler, & Magalhaes, 2012, p. 61); lack of standards, particularly in developing countries, to measure GHG emissions (Wollenberg, Tapio-Biström, & Grieg-Gran, 2012, p. 21), and; carbon payments available to smallholders are generally several factors lower than potential profits from higher yields (Tennigkeit, Kahrl, Wölcke, & Newcombe, 2012, p. 152).

Indirect incentives are derived when the same sustainable agricultural practices that mitigate greenhouse gas emissions are implemented that result in higher agricultural yields and profit. While agriculture has the greatest economic potential contribution to greenhouse gas reductions, it is the farmer's perspective that increased soil fertility, for example, is of greater emphasis than are potential payments for mitigation, which are considered as bonuses (Lee & Newman, 2012, p. 98). Smith and Wollenberg point out that the agriculture has the potential to reduce somewhere between 25-78% of all CO_2 gases {as cited in (Smith & Olesen, 2010; Smith, et al., Agriculture, 2007)}. "The annual economic mitigation potential is estimated to be worth between $32 billion and $420 billion. About 70% of the potential arises from developing countries" (Smith & Wollenberg, 2012, p. 50). Mitigation, adaptation and sustainable agricultural practices represent a synergistic model that can serve to incentivize smallholders in LDCs. (Smith & Wollenberg, 2012, pp. 50-51).

However, growers are rational decision-makers. "...a farmer will adopt mitigation practices when the net present value of farming with these practices is greater than that of the alternatives" (De Pinto, Ringler, & Magalhaes, 2012, p. 62).

A key reason why interventions to correct markets are not effective is because "the 2 billion smallholder farmers produce 70% of the world's food crop which never enters the market" (Noble, 2013).

The grapha and table below illustrate the growth in ODA funding and the stagnation of agricultural production. This data is important but the implications for the continuation of this trend in light of impending population growth in the next thirty years are significant and negative. As is clearly indicated in the figure below, there is an insignificant relationship between total funding and changes in agricultural production. This analysis does not include an examination of the potential counterfactual circumstances. It may be that were there not funding at the levels indicated, production may be much lower than were no funding available. Nonetheless, the level of funding does not encourage increased production to the levels required.

Figure 3 Financial Input, Agricultural Growth, and Population in LDCs

The Distributor Model

The distributor/grower/manufacturer model, diagrammed below, is the successful paradigm for increases in agricultural production in developed countries.

The function of the irrigation distributor is to enable growers to achieve greater efficiencies, higher yields, cost-effective methodologies for their farming operations, regardless of scale, within the context of good environmental stewardship. The distributor interfaces, on an exclusive basis, with manufacturers of irrigation, agricultural tool and implement, nutrient, and chemical manufacturers. The distributor serves as the wholesale procurer and distributor of equipment. It is the responsibility and commitment of the distributor to represent the products he/she sells honestly, at a fair market price, and provide support services for those products and their applications.

It is has been established above that sustainable agricultural production leads to optimal yields, greater efficiencies, higher profits, and mitigates environmental damage. It is incumbent upon the manufacturers, NGOs, academic institutions, economists, environmentalists, climatologists, social scientists, to ensure that the agricultural and irrigation distributor is educated in this process. The distributor is not only the agent of the manufacturer and the grower. The distributor is the indispensable dissemination source for agricultural information for two reasons: 1) the task of informing individual smallholders about methodologies or technology by an academic institution or NGO is virtually impossible. In order for the distributor to become successful he/she must reach out to the smallholder community to develop a consistent customer base. One distributor will have direct access to hundreds or thousands of smallholder farmers; 2) the smallholder, like any farmer in the world, looks first to the distributor for support and information, on a regular basis. Irrigation is a dynamic process. As the great Nigerian writer, Chinua Achebe, wrote, "Things Fall Apart" (Achebe). All irrigation system components: pumps; valves; emitters; conveyance pipes; fittings, etc, need regular repair and maintenance. The critical actor for any farmer is the agent who stocks spare parts.

The critical distinction between the distributor model and the development model, is the interlinked and interdependent financial relationship that exists between the three key actors: grower; distributor; and, manufacturer. As illustrated below, these three actors are tied together.

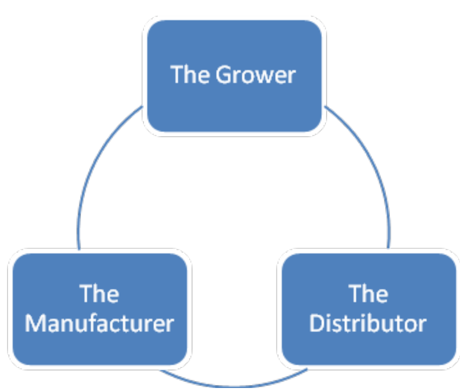

Figure 4 The Distributor Model

The financial success of all three are dependent on each other. The manufacturer's lifeline depends upon purchases of his/her equipment by the distributor; the distributor's lifeblood depends upon the successful performance of the manufacturer's product and the purchases of the grower; the grower is dependent upon the reliability of the manufacturer's products and the support and service, including availability of spare parts, of the distributor. Training is provided by the manufacturer to the grower through the good offices of the distributor. The key to the sustainable success of this model is the relationships that are built by all three actors and the formal commitment of the manufacturer to only sell products to the distribution network, never directly to the grower.

The Distributor Models

There are four typical distributor models: the private entrepreneur; collective; partnership; and, NGO Farm Center.

Entrepreneur

The entrepreneur model is the most common in developed countries. This model stipulates that a private agent owns and operates a dealership, employs a full staff and stocks equipment. In essence, the entrepreneur runs a full service store for his/her clients which, for the most part, are privately held farming operations. A typical irrigation dealer in the United States will stock upward of 14,000 parts to serve all the irrigation components in the field (Davis, 2013). For example, in California, irrigation dealers in the agricultural sector provide design and engineering services, installation of irrigation systems, service work for components and systems, and maintenance. They sell individual components and spare parts and provide full system sales and rentals. The designers are "certified irrigation designers", and "Certified Agricultural Irrigation Specialists" (Agri-Valley, Inc.). Installations "include mechanical sprinklers, drip irrigation systems, sub surface systems, PVC transport systems, solid set sprinklers and all aspects of aluminum pipe" (Agri-Valley, Inc.).

Agricultural dealers typically sell irrigation, chemical, pest control, fertilizer, injection equipment, mulch and row covers, spray gear, hardware and safety equipment (Water Tech Ag Supply). Within the irrigation category typical sub-categories are: drip tape; filters; PVC pipe; layflat hose and fittings; Schedule 40 PVC fittings; Schedule 80 PVC fittings; fabricated fittings; pumps, parts and accessories, hose and tubing and fittings, drain pipe, accessories and fittings, irrigation valves; emitters and sprinklers, aluminum pipe; pivots, linears and travelers, furrow and flood irrigation components, and; tools (Water Tech Ag Supply).

Dealers are formally trained in agricultural engineering or production. Many dealers (and all irrigation manufacturers) belong to The Irrigation Association which "offers a number of certification programs for professionals specializing in agriculture" (Irrigation Association). The Certified Agricultural irrigation Specialist (CAIS) is trained to manage and operate on-farm irrigation systems. The CAIS "understands surface irrigation methods and pressurized systems, including micro-irrigation and sprinklers; evaluates crops and determines water availability and use requirements; understands soil-plant-water relationships and how salinity affects irrigation; selects the most effective irrigation methods and equipment for the application, and develops efficient and cost-effective irrigation schedules that meet the crop's water requirement" (Irrigation Association).

The business model of the irrigation distribution network consists of an exclusive arrangement between manufacturer and distributor such that all products are sold only to the distributor and never to the end-user or grower. Product is sold at a discounted price to the dealer who serves as the wholesaler.

Partnership

The partnership model stipulates that a single irrigation manufacturer identifies a business partner in a particular region and reaches a contractual agreement whereby he/she uses the manufacturers products as the preferential product for irrigation purposes when appropriate. In return, the manufacturer limits distribution of the products within a specific region thereby protecting the interests of the dealer. Typically, the manufacturer supplies in-situ training for the dealer and his/her customers and provides other sales and training tools. This is the model employed by Amiran in Kenya. The Amiran model has increased its scope, now operates in 22 African countries (Kedar, 2013). In the case of Amiran Kenya, a partnership relationship exists with Netafim, and Israeli drip irrigation manufacturer.

It is quite common in the sector of irrigation dealers to start out in the partnership model and then grow into the entrepreneur model.

Collective

The Collective model, in which growers share a common interest or fiduciary relationship and own and operate the irrigation dealership, are common in Eastern Europe and South America. The collective model is also popular among growers in developed countries who have a common contract to provide agricultural products to a firm. For example, Fruit Growers Supply Company is a non-profit cooperative association in the United States that has been providing citrus products since 1907 under the Sunkist name (Fruit Growers Supply, 2013). Fruit Growers Supply purchases their products collectively and covers the operation costs by charging the net cost of products plus 10-percent to its members.

The farmer organizations practicing the Collective model in South America have not institutionalized systems to establish and "understand better the costs and margins along the value chain...(and) do not know how much it costs to provide, for example, technical assistance nor have they incorporated it into their non donor-subsidized cost structures" (Hellin, Lundy, & Meijer, 2007, p. 23). The typical services provided by the collective farmer organizations are: marketing services; facilitation of collective production activities; financial services; technology services; education services; welfare services; policy advocacy, and; managing common property resources (Hellin, Lundy, & Meijer, 2007, p. 5).

The typical famer cooperation model takes place when there is "a match between the existing skills and/or experience of members and what is required to undertake joint activities, internal cohesion and a membership driven agenda; and, successful, commercially oriented, integration of the organization in the wider society" (Hellin, Lundy, & Meijer, 2007, p. 6). This model, therefore, has formal membership requirements, and is not available for all smallholders, in particular, the poorest and least educated. The other potential challenge to the sustainability and efficacy of collective farmer organizations is the dependent relationship that can develop between the organizations and government or NGOs who tend to bail out the organizations when they become financially unstable. This dynamic tends to increase subsidies to the organizations and disassociates it from its market context (Hellin, Lundy, & Meijer, 2007, p. 7).

NGO Farm Center

The Farm Service Center is the fourth agricultural/irrigation model that is differentiated from the other three models by virtue of its lack of irrigation sales capacity, in its current configuration. The objectives of the Citizens Network for Foreign Affairs (CNFA) Farm Service Center, for example, are to "provide technical assistance to existing wholesalers to understand the benefits of quality inputs, improve supply chain management and financial planning, and establish linkages to major international suppliers" (CNFA).

The Farm Service Center input supply model calls for retailers to act as 'one-stop-shops' for local smallholder farmers, demonstrating a profitable business model that is based on a large volume of individually small transactions with small farmer clients. "The CNFA approach to improved access to inputs is coupled with training in business and financial management for input suppliers, as well as expanded extension services for clients on pest diagnosis, input selection and application. Through this model, CNFA facilitates a sustainable commercial relationship between service providers and producers, with profitable and growing farmers becoming repeat, valued customers. By providing technical assistance to existing wholesalers to understand the benefits of quality inputs, improve supply chain management and financial planning, and establish linkages to major international suppliers, CNFA facilitates increased availability and quality of inputs to retailers and smallholders'" (CNFA, 2012, p. 1)

"CNFA's Agrodealer model is aimed at improving farmer incomes and productivity by increasing smallholder access to improved agricultural inputs, especially seeds and better production practices through the strengthening of rural agrodealers. Building a strong network of agrodealers strengthens the overall agricultural sector of a country as these enterprises become centers for input supply, equipment purchase, training and agricultural best practices. CNFA certifies agrodealers after they have completed a rigorous six-module training program covering working capital, inventory control, sales and marketing, record keeping, and managing business relationships. Agrodealers also receive ongoing technical assistance in inputs and equipment, and access to working capital and trade credit through credit guarantees" (CNFA, 2012, p. 1).

Across Kenya, Tanzania, Mali, Malawi and Zimbabwe, over 7,000 Agrodealers have been certified through CNFA's programs and have sold over $170 million in higher quality seeds, fertilizers, and other essential farm inputs. Over 3 million farmers across Africa have benefitted from CNFA's Agrodealer network, resulting in higher yields and incomes; improving food security and nutrition for over 17 million individuals.

The CNFA program is featured in USAID projects—most notably in Ethiopia (USAID, 2013). However, the CNFA model does not provide irrigation equipment or expertise.

Summary

The singular, critical objective for smallholder communities for the next two generations is to increase agricultural production by 100% by implementing sustainable agricultural practices and regimes. This paradigm is successful in developed countries and has not been allowed to function in developing countries. The Development community does not provide epistemic space for the professional agricultural community and does not recognize the criticality of the distribution/grower/manufacturer nexus.

This paper how shown that sustainable agricultural regimes satisfy the two objectives of 1) improving yields and profitability for growers, and 2) mitigating environmental change. This paper has also shown that the key to improving yields involves a myriad of tools, cultivars, and practices that need to be supported on a regular basis by trained distributors. Further, this paper has shown that the current paradigms of the Development community do not provide means and methodologies for improved yields.

This paper has also shown that interventions to repair market failures are not salient for the majority of smallholders in LDCs because the vast majority of production never leaves the smallholder farm. It never enters the market.

Finally, current paradigms of distributor paradigms that function in Least Developed Countries are not fully capable of providing all the irrigation tools and support necessary but further research is needed to determine if they provide a platform upon which all important services can be provided.

Conclusion

The Development community is not the actor that can effect improved agricultural production. Farming is a business and the triangle of stakeholders that is interconnected and financially interlinked consists of the irrigation distributor, the manufacturer and the farmer. The model of the this nexus is the key driver for grower profit in the developed world and it is the basis for further research to determine how best to examine the transferability of that model to LDCs.

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