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Review

Agricultural intensification in Ethiopia: Review of recent research

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This review of research presents recent agricultural studies conducted in Ethiopia. After a brief contextualization of the discourse regarding agricultural research globally, material specific to Ethiopia is discussed in themes, synthesizing the types of findings, summarizing the trends and highlighting knowledge gaps. A review of this nature makes diverse research results available and accessible, facilitates knowledge translation and enables researchers to identify areas for future research.

Key words: Ethiopia, agriculture, intensification, diversification.

INTRODUCTION

Researchers, organizations and governmental bodies inside and outside Ethiopia recognize the crucial role of smallholder agriculture and have engaged in the agricultural sector for decades. However, significant debate exists as to what form of change ought to be advocated. Additionally, researchers often specialize in specific areas of agricultural research and may be unaware of the developments outside of their area of interest. This study aims to address this by reviewing recent agricultural research in Ethiopia, synthesizing the types of findings, summarizing the trends in research and highlighting areas of knowledge gaps. A brief global context will begin this work so as to contextualize the debates about the desired direction of agricultural development generally.

This review presents an overview of recently conducted research, specific to Ethiopian agriculture. Some of the material comes from 'grey' literature (such as non-governmental reports), with some studies that are small and methodologically problematic while many studies are robust, peer reviewed and appear in important academic journals. The reason that all forms of research have been included is because the aim of this review is not to analyze the validity of the studies themselves, but to present the types of findings, trends and gaps in the research conducted within recent years. Although this review presents findings from a large number of research projects, there are some that will have been missed and areas that could have been further expanded with sector-specific developments, such as irrigation technologies or innovations in crop breeding.

The first section provides a global context for the understanding and role of agriculture, and its debated direction moving forward. The review of research of Ethiopian agriculture that follows includes over one hundred published studies and is presented thematically, such as the subjects of livelihood, inputs and tenure. The discussion at the end points out areas for future research.

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GLOBAL CONTEXT

Individuals, organizations and governments interested in agriculture in Africa assert that change is required. Although, as described below, they differ as to what the change ought to entail. The world has sufficient agricultural production per capita to meet collective needs (FAO, 2002) and suggestions have been made about how production can be made more efficient and equitable (Godfrey et al., 2010). At present, chronic food insecurity persists making it clear that availability and access are as important as yield. Increasing production is vital (Wegner and Zwart, 2011), but that does not necessarily result in improved access for all. Even with highly proactive policies, the current level of availability may not increase in some countries with changes in population, food demand, global markets and climate (Vervoort et al., 2013).

According to Norman Borlaug and Jimmy Carter, African agricultural production is significantly lower than its global counterparts; average yields in Africa are one-third of Asia's, and less than one-third of its cropland uses seed developed by modern plant breeding techniques, compared to eighty-two percent in Asia (Paarlberg, 2008:vii).

Food production per capita has declined in sub-Saharan Africa since the 1980s (Carr, 2011), indicating that the *Modus operandi* will not result in improvements in human development.[1] New complexities, such as environmental change, may result in increasing scarcity (Wegner and Zwart, 2011) and create other unforeseen vulnerabilities in the existing food system (Ericksen, 2008). This is particularly the case for Ethiopia which is both expecting adverse changes as a result of climate change and is home to an economy that is agriculturally dependant (Admassu et al., 2013). The negative impact of this change will not be restricted to the agricultural sector either, and may negatively impact Ethiopian human and economic development generally (Block et al., 2008).

Global population increases in the coming decades expected to reach 9.1 billion by 2050 will largely occur in nations with relatively lower financial capacity which will face difficulty ensuring the nutritional needs of their expanding populations (FAO, 2009). This will also occur in the context of increasing global urbanization which stood at 49% in 2009 and may reach 70% by 2050 (FAO, 2009). Unlike other regions of the world, a significant proportion of the population in sub-Saharan Africa are rural and involved in smallholder agriculture.

In the countries of Eastern Africa, for example, not only are the majority involved in agriculture but the backbone of the national economies are also agriculturally-based (Salami et al., 2010). Additionally, 80% of people that suffer from malnutrition and chronic hunger are located in the rural areas, people who are largely disconnected from markets (Human Rights Council, 2010), which is mostly due to insufficient infrastructure (Aerni, 2011). As a result of these trends, particularly in the nations experiencing significant increases in population growth, agricultural policy and practice reform are advocated. The nature of these suggested reforms and the processes that ought to be initiated in order to improve and intensify smallholder agriculture are subject to on-going debate. One side of the discussion suggests that Africa can 'leapfrog' into intensification by adopting new biotechnology and synthetic inputs, amongst other, more traditional agricultural reform. The other side suggests that successful, sustainable and appropriate agricultural reform can only be done in the form of organic agro ecological practices, amongst other, more traditional agricultural reform. Although proponents of each side of the debate distance themselves from each other, many policy and practice reforms are shared by parties from all sides of the debate, as shown in (Table 1). Indeed, far more commonalities exist, as demonstrated in the (Table 1), than differences. An example of an agreed upon area of intensification is crop diversification and use of integrated pest management techniques, which can improve smallholder yields (Pretty et al., 2011).

REVIEW OF RECENT RESEARCH

As demonstrated, agricultural intensification has been defined in significantly different ways. For the purposes of this research review, intensification refers to action that makes agricultural systems more productive, which might be a result of the use of improved seed varieties, improved resource management, irrigation, farming practice(s), diversification and so forth. Intensification in a general sense does not imply sustainability or a lack thereof nor does it imply improved human or environmental resilience. That being said, many smallholder farmers are reluctant as discussed in the research to adopt new practices that are unsustainable environmentally, economically or as a result of inconsistent access and availability.

The concept of sustainability has been applied to diverse spheres from ecology to politics and has many different definitions. It is beyond the scope of this paper to explore this myriad of meanings. However, in the context of agricultural intensification, certain directions and shifts are more suited to sustained intensification than others. Increasing irrigation with a higher use rate than replenishment rate may result in higher immediate yield but is unsustainable in the long term. Resiliency on the other hand, is the ability to overcome challenges or viewed in another way, a reduction of vulnerability such that change is manageable. Ensuring land tenure

[1] Human development here refers to the indicators of the Human Development Index, which include inequality, life expectancy, education and income. This approach to understanding development is in contrast to common analyses of gross domestic product per capita and was first developed by Mahbub ul Haq and Amartya Sen in 1990.

Table 1. Approaches of Intensification.

The Monpellier Panel (2013)	Shared	Alteiri (1993, 1995, 2000)
(i) Biotechnology	(i) Integrated Pest Management	(i) Organic Methods
(ii) Synthetic Inputs	(ii) Crop Rotation	(ii) Self Sufficiency
(iii) Herbicides	(iii) Intercropping	(iii) Sovereignty
(iv) Pesticides	(iv) Water Conservation	(iv) Traditional Practices
(v) Market Connectivity	(v) Diversification*	(v) Preserving and supporting genetic diversity within a crop
(vi) Improved Value Chains	(vi) Access to Information	
(vii) Infrastructure	(vii) Biodiversity*	
(viii) Access to Credit	(viii) Develop Social Capital	
(ix) Genetically engineered improved varieties	(ix) Low/no Plowing	
	(x) Sustainable Livelihoods	
	(xi) Precision Irrigation	
	(xii) Retain and Build Soils	
	(xii) Develop Human Capital	

*Although the same terminology are used, they are defined differently.

facilities for increased investment such as planting trees and building terrace systems, which improves resiliency to shocks such as drought or flooding as soils are retained and built and water can be utilized more efficiently. Although not a focus of this work, both sustainability and resilience will be referred to in the exploration of current research.

The research presented in this review includes all forms of research, the vast majority of which have been published within the last five years. Although a large number of studies have been included some will have been missed. Research was collected using academic databases, general search engines and keyword tracking from 2012 to 2014 (academic and general).

The objective of this overview is present in all forms of on-going research in order to identify trends and knowledge gaps. This section provides a thematic overview of recent research done in Ethiopia related to agricultural intensification. The themes were determined after having reviewed the research. The content was clustered into themes although many areas do intersect and overlap in some instances there are areas of overlap; some sections refer to others while some specific points are repeated so as to present a review that represents the interconnectedness of the research. The section that follows presents a brief summary, knowledge gaps and explores the future direction of agricultural intensification. Unless otherwise mentioned, the studies included in this section are specific to Ethiopia.

Seed and crop diversification

Ethiopia is home to a diverse array of agro-ecologies which results in an agricultural context that is significantly influenced by location (Chamberlin and Schmidt, 2012). This is further complicated with differing degrees of geographical connectivity to markets, city centers, telecommunications, roads and electricity. These infrastructural factors, although not a focus of much of the literature play an important role in supporting food security (Gebrehiwot and Veen, 2014). As a result of these diverse contexts, crop production varies widely throughout the agro-ecological zones .Although, five cereals (teff, wheat, maize, sorghum and barley) account for three-fourths of total cultivated area and almost a third of agricultural gross domestic product (Taffesse et al., 2012).

Over the last decade significant improvements have occurred in the agricultural market system (Minten et al., 2014), production has risen (Taffesse et al., 2012) and chronic food insecurity has significantly fallen (GHI, 2013).The adoption of seed developed as a result of modern breeding

practices seed varieties in Ethiopia such as wheat and maize have the potential to increase food security and protect against disease (Geta et al., 2013; Joshi et al., 2011; Shiferaw et al., 2014). However, in 2007 and 2008 season, improved seed was applied on only 5% of cereal acreage (Taffesse et al., 2012). In 1970s, more than forty improved varieties have been utilized in Ethiopia although adoption during that period varied greatly being influenced by individual, community and institutional factors (Jaleta et al., 2013). Low uptake of improved seed has been attributed to supply being less than demand resulting in inconsistent availability (Spielman et al., 2012) which may continue to be the main constraint for widespread adoption of improved varieties (Tefera, 2013). With regards to the means of achieving this, efforts to stabilize market conditions through investments in infrastructure and market institutions may be more effective in signaling farmers to the long-term availability of inputs than subsidies (Larson and Gurara, 2013).

As almost all of smallholder agriculture in Ethiopia is rain-fed, crop choice and irrigation are important factors that may help address variable and deficient rainfall. As the expansion of irrigation takes investment and time, new crop types are being tested, such as mungbean, which may be suitable to arid and semi-arid regions of the country (Ambachew et al., 2014). Research on drought-tolerance of bean varieties in Ethiopia, as another example, indicates how important research and breeding can be in adapting to changing environments as well as improving yield (Asfaw and Blair, 2014). Others crops, such as disease-resistant potato have been tested and introduced (Tefera, 2013). However, more research needs to be conducted on potato varieties that are suitable to soil, rainfall and other environmental factors (Fufa, 2013).

Biotechnology

Juma and Gordon (2014) suggest that genetically modified crops should be considered as one component of system-wide agricultural improvement in Africa. Although the introduction of such crops poses potential opportunities there are also many challenges in implementation (Falck-Zepeda et al., 2013) as well as concerns about environmental impacts (Altieri, 2005). The Ethiopian Biosafety Proclamation of 2009 which banned genetically modified crops is viewed by some as unwise as it stifles innovation being driven by external pressure and having sought little national input (Demissie and Muchie, 2014; Paarlberg, 2008). The government approved the ban as a means to protect biodiversity and health. Alternatively, some argue that a well-designed regulatory framework to evaluate genetically modified crops may have facilitated research, innovation, protected health and safety allowed for Ethiopia to take advantage of appropriate and safe developments in food and non-food agricultural crops (Horna et al., 2013; Wedding and Tuttle, 2013).

Livelihood diversification

It has been suggested that biofuels markets may negatively impact land used for food production whereby farmers switch to cash crops and move away from nutrient producing crops (Wendimu, 2013). One example from a food insecure region indicates otherwise; when smallholders plant, on average, 15% of their land is for contract-based biofuel markets. The result is improved household food security and may also result in a spill over effect of increasing food crop productivity (Negash and Swinnen, 2013).

Diversification efforts are also underway to reduce vulnerability in pastoral areas. For some this includes advocating a shift away from pastoral livelihoods to ones which are supported with sedentary agriculture and non-farm related economic activity (Headey et al., 2014). Much of the research, however, looks at ways of improving production and income within the existing livelihood practice. Diversification of livestock for example supports improved dietary intake and reduces vulnerability to loss, although that may not address all forms of micronutrient deficiencies (Megersa et al., 2013).

Livestock accounts for 11% of national gross domestic product and acts as an important household level asset (Negassa et al., 2012). Yet, this important asset also requires agricultural resources and some regions are not able to supply sufficient feed suggesting that integrated extension services need to take into account livestock demands (Abera et al., 2014) as well as changing environmental conditions.

Some shifts in livestock are already underway in response to a changing climate (Yosef et al., 2013). Agricultural extension services in Ethiopia have not focused upon livestock and respective veterinary services; however, the potential for targeted programming of this nature is significant (Atsbeha, 2013). This is particularly the case for regions where specific livestock such as poultry or camel, play an important economic and nutritional role in households. Research with agro-pastoralists suggests that in addition to livestock and land, food security is linked with the educational level of both spouses and security (Asenso-Okyere et al., 2013). Other work has found that educational background was not an important factor for the level of conservation effort undertaken by those engaged in livestock production (Atanga et al., 2013). Another important factor in parts of Ethiopia is market access, as many pastoralists sell livestock that are destined for export markets (Debsu, 2013).

Irrigation

Expanding access to and availability of irrigation is not a

simple process. Low seasonal river flows result in a limited area that can be irrigated by surface water throughout the year including in areas of relative water plenty such as the Lake Tana basin. As a result, expanded irrigation requires infrastructural supports (Wale et al., 2013). Investment in irrigation can contribute to poverty reduction particularly when rural markets and human capital are also developed (Hanjra et al., 2009). An additional benefit of having such infrastructure is that time spent previously obtaining water allows more time for other activities. Research in Ethiopia indicates that 1% reduction of time spent obtaining water can result in a per capita increase of food consumption by a fifth of a percent (Aklilu, 2013).

It is unrealistic for resource constrained and capacity limited community-based groups to be expected to develop institutional frameworks, achieve economic efficiency, and enact social equity within a model of environmental sustainability (Gutu et al., 2014). Many community-based organizations that are established are unable to sustain themselves and their work which is commonly due to a lack of participation and training (Simane, 2013).

However, principle-driven and policy-enforced water sharing often do not take into account complex socio-cultural factors affecting water use and water sharing. Supporting the development of sustainable and equitable water sharing systems requires consideration of a diverse array of socio-cultural, historical, environmental, political and institutional factors (Gutu et al., 2014). Although complex, meeting the irrigation needs of smallholders with sustainable use levels requires that such an investment be made which may be most effective when traditional systems are supported with research, extension services and local government.

All of the small-scale irrigation practices used in the Lake Tana basin were found to have resulted in significantly higher (27%) household income, when compared to those not using an irrigation system (Ayele et al., 2013). Research on the staple teff grain showed a three-fold yield increase when irrigated fields were compared with rain-fed ones, and the crop yield significantly dropped when it experienced seasonal water stress (Yihun et al., 2013). A study conducted in an agro-pastoral area of the Somali Region found that high levels of poverty are related to a lack of access to irrigation, as well as distance from a market, land size, off-farm activities, educational status, livestock holding and livestock diversification (Muktar et al., 2014).

Cultivation practices

A set of principles are being tested and scaled-up by the Agricultural Transformation Agency in Ethiopia, which include techniques to reduce competition between plants, increasing organic matter in soil and soil aeration which contribute to increased productivity and profitability (Abraham et al, 2014). These practices were first developed for rice intensification and are now being applied to a broad range of crops, which is on-going within Ethiopia. A study conducted in northern Ethiopia found that planting techniques including spacing and transplanting greatly affected rice yield and can shorten growing periods (Birhane, 2013). Other techniques such as row planting for teff, resulted in moderate positive impacts (Vandercasteelen et al., 2013). Intercropping is commonly practiced in parts of Ethiopia. One study of legumes found that basic intercropping reduced weeds by almost a third and that intercropping and weeding significantly increased plant height, yield and monetary benefit (Workayehu, 2014).

Fertilizers and pesticides

In the 2007and 2008 season, about 40% of cereal acreage used chemical fertilizers and pesticides were applied to 20% of cereal acreage (Taffesse et al., 2012). The Government of Ethiopia is actively promoting the use of these types of agricultural inputs yet unstable and insufficient supply is not matching demand (Spielman et al., 2012). One estimate is that Ethiopia must double its current consumption of 1.2 million metric tons of fertilizer products in order to meet the government objectives (IFDC, 2012). Many of the challenges, as with seed and crop diversification, require market stabilization and expansion, infrastructure development and the supply chain, from procurement to extension services, must be strengthened (IFDC, 2012).

Some research suggests that agricultural output might be increased by almost 60% with the appropriate input mixes in production (Tirkaso, 2013); although not as high as that theoretical figure, field studies show higher yields are significant (Abera and Abebe, 2014). Despite a rise of fertilizer use in Ethiopia, overall usage remains low, despite its profitability in use with primary cereal crops, such as wheat (Rashid et al., 2013). In many parts of Ethiopia land holdings are declining in size; in land constrained villages inputs are used more often to raise yield and income (Headey et al., 2013). However, farm size remains strongly correlated with farm income and linked with rural poverty (Headey et al., 2013).

Some innovative practices reduce the need for pesticide application and are particularly important for rural smallholders that do not have access or capacity to purchase such inputs. An example of innovative locally-developed practice is that of termite control through integrated pest management and crop choice. These improved practices may also support improved water productivity as well as rehabilitate damaged rangelands (Legesse et al., 2013; Peden et al., 2013; Taye et al., 2013). In addition to controlling pests as an alternative to pesticides, integrated management systems have the

potential to significantly raise production as many farmers cite this as one of the primary reasons for loss (Mulualem and Melak, 2013).

Environmental interventions

Modeled scenarios that utilized integrated land-use redesign and conservation practices showed the greatest potential for soil loss reduction include terracing, grassed waterways and stabilization structures (Tesfahunegn et al., 2012). Vegetation cover and exclosure practices have been found to be the most effective means to prevent runoff, better utilize available water resources and prevent nutrient loss (Descheemaeker et al., 2006; Girmay et al., 2009). Exclosures can also support land rehabilitation which includes vegetation restoration as well as nutrient restoration (Mekuria et al., 2007, 2011; Yayneshet et al., 2009), although it can negatively impact horticulture and needs to be analyzed before expansion in communally used areas (Mekuria et al., 2011). Promotion of sustainable resource management practices has not resulted in widespread adoption of them by smallholders, despite struggles with soil erosion, nutrient depletion and land degradation. Educational level, contact with extension workers and slope of land positively affected farmers adoption of soil conservation technologies (Fentie et al., 2013).

One important factor found to promote uptake of new techniques and technologies was connectivity to informal networks and the size of those networks (Krishnan and Patnam, 2012). These existing networks need to be integrated with extension services in order to increase adoption (Wossen et al., 2013). Other studies suggest the role of social networks is similarly important in adoption of irrigation practices (Dessalegn, 2013).

The importance of sustainable resource management practices cannot be understated. A 25 year follow-up of a pilot terracing project showed sustained improved crop productivity as well as soil and water conservation (Adgo et al., 2013). In another follow-up study of households that maintained sustainable land and watershed management investments, a 24% higher value of production continued almost two decades after having started compared to those that did not (Schmidt et al., 2014). Such investments, however, need to be supported with other input changes to result in profitability that outweighs comparable off-farm income (Schmidt et al., 2014). This research indicates that packaged smallholder approaches will be the most effective. Two factors that have the greatest potential to inhibit adoption of new, more appropriate, practices are a lack of information and a lack of finance (Gebrehiwot and Veen, 2013).

Teklewold et al. (2013) analyze decision making of sustainable agricultural practices, its impact on income (for maize specifically), chemical input use and labour. They find that the adoption of sustainable agricultural practices increases income and the greatest increases occur when such practices are adopted in combination, rather than in isolation. Teklewold et al. (2013) also find conservation tillage increased pesticide use and demand of labour.

Sustainable land management practices must not focus solely upon yield and soil. Some areas of Ethiopia are experiencing increasingly extreme weather, particularly flooding, which include loss of yield as well as livestock, households and result in disease outbreaks (Haile et al., 2013). Planning at national, regional and district levels, as well as by individual households, must be informed by changing climate and how that may affect their respective areas of work in order to engage in planning that anticipates such changes. In this regard, sustainability planning must be considered in light of resiliency enhancing and vulnerability reducing interventions.

Soil quality and soil quality degradation significantly impact smallholder production. Smallholder knowledge and assessment of soil quality were found to be highly accurate showing that local knowledge-based assessments can be effective and low-cost, and need to be integrated into research and extension services (Tesfahunegn et al., 2011). Similar studies indicate local ecological knowledge can be used to better understand water, plant types and deforestation (Pagella et al., 2013).

In addressing the serious challenge of soil erosion, food for work and cash for work programs have been utilized as a means to implement improved land and water use. However, participants in community efforts of this nature are often not convinced of the effectiveness of processes undertaken (Gebre and Weldemariam, 2013). The government has done an effective job at raising awareness about the importance of tree planting so effective that many associate climate change only with deforestation (Cochrane and Costolanski, 2012). These successful campaigns need to be expanded and diversified so that other land and water management changes are supported the way that tree planting and reforestation are.

The expansion of smallholder agriculture and wood harvesting has resulted in high rates of deforestation in parts of Ethiopia which occurred alongside population growth and the nationalization of land, which affected forest responsibility and control. Unofficial traditional systems have had limited impact in keeping this process in check (Stellmacher, 2013). Initiatives that counter deforestation need to take into account rural household needs, such as that of wood for fuel (Bekele et al., 2013). Meeting the needs of smallholders through alternatives will be crucial in substituting the unsustainable use of forest products.

Gender

Although a framework has been proposed, limited data

exist to-date on the gendered allocation of labor and resources (Arora and Rada, 2013). One study on gender differentials suggests there is a productivity gender gap in Ethiopian agriculture (Aguilar et al., 2014), while another indicates that despite participating in a wide variety of farming activities, women have little to no decision making ability (Mulugeta and Amsalu, 2014). This was suggested to be the result of a wide array of factors, such as illiteracy, socio-cultural assumptions and a lack of experience.

A majority of Ethiopian women are poor and vulnerable and are disproportionately affected by food shortages within the household (Gebreselassie and Haile, 2013). Research outside of Ethiopia suggests that agricultural development can disenfranchise women furthering existing vulnerability and economic insecurity (Carney, 2007) and there are some indications that this may also be the case with some developments in Ethiopia (Hebo, 2014).

One study in Ethiopia found that the adoption of sustainable agricultural practices increased the workload for women and suggests policy makers be aware of the potential gender-specific outcomes (Teklewold et al., 2013). A review of recent land reform suggests that despite improvements in tenure for women, these changes have not brought about change in socio-cultural and traditional norms that would allow for greater decision making power, income control, and political participation (Gebreselassie and Haile, 2013; Tefera, 2013). As such, the gains made in tenure need to be understood within this context and understood as just one of many required interventions to support the rights and empowerment of women. Some progress in policy and practice has been made in areas outside of tenure (Ogato, 2013), however implementation varies across the country (Lavers, 2014) and greater integration of efforts is required so that changes reinforce one another, rather than in piecemeal fashion.

Supportive policy

Infrastructural change can result in improvements both for smallholders and consumers in Ethiopia. An example of this is in the dairy industry, wherein supply has not kept pace with demand, yet supply chains and production technologies and extension services require investment in order to support smallholder engagement with the sector (Altaye et al., 2014; Bereda et al., 2014; Ergano et al., 2013). This is an area where the private sector and private-public partnerships may facilitate investment and market creation (Hoddinott et al., 2014). As with elsewhere, and particularly in capital-strained Ethiopia, the government cannot be relied upon to develop all sectors. It can however, support the direction of private development through. In addition to investment, knowledge and skills required to support the sector, not specifically related to livestock but also entrepreneurship, need to be embedded within education systems (Lemma, 2014).

In addition to the Government of Ethiopia's agricultural extension services and research into inputs, geographical conditions, agroecology, access to markets and population density also affect the opportunities and constrains that smallholders encounter (Chamberlin et al., 2006). In the last two decades significant expansion in road networks, telecommunications, electricity and market institutions have taken place resulting in improved market efficiency and expanded market access (Rashid and Negassa, 2012). An additional supportive proposed initiative in this realm is minimum support prices for staple crops to encourage domestic production and reduce reliance upon imports (Minot and Rashid, 2013). Innovative practice in Ethiopia, ranging from pest management to irrigation and breeding, is on-going and shows great potential (Abebe et al., 2013).

Much of the research done in recent years has been conducted by local researchers and government in collaboration with smallholders. Supporting innovation is an area that agricultural extension can work more on, in order to bring together respective resources and expertise as well as share lessons learned. New opportunities, such as rapidly expanding mobile network coverage and mobile ownership as experienced in Uganda, present potential for integration with extension services and information sharing (Campenhout, 2013). This might include enabling farmers to have greater access to market prices, facilitate increased information sharing amongst informal social networks and increase the accessibility of information sources via such technologies.

Safety net

In 2005 the Government of Ethiopia launched the Productive Safety Net Programme which would support food insecure individuals and households to ensure their needs are met and assets not depleted. Although not directly related to agricultural research per se, the safety net is linked with agriculture in that many of its manifestations support agricultural development through the protection of asset loss, creation of infrastructure and food security. Analyses of the Productive Safety Net Programme in Ethiopia found that the program is effective (IFPRI, 2013a; Katane, 2013), targets beneficiaries (Fisseha, 2014; Kassa, 2013), positively impacts child nutrition in the shot-term (Debela et al., 2014) and positively influenced the adoption of fertilizer, with no known disincentive impacts (Bezu and Holden, 2008).

Despite regional variation of the Productive Safety Net Programme, it is more targeted than the average global safety net program and better than any other reported African programs (Coll-Black et al., 2012). The safety net has improved since its inception (Hoddinott et al., 2013)

and can become increasingly effective as capacity at the district level increases and improved data and predictive models forecast drought with greater accuracy (Belayneh et al., 2014; Tadesse et al., 2014).

Other research challenges the effectiveness of the program. One study found disincentives for creating successful systems done by those involved in the Food for Work program and that failure helps secure employment in the program (Segers et al., 2008). Another study found the Programme is effective at protecting household food security and maintain asset levels but was not an effective mechanism to overcome poverty or result in the governmental objective of food self-sufficiency (Maxwell et al., 2013; Rahmato, 2013; Siyoum, 2013). Some suggest that the impact of these programs may be limited in terms of sustained change when compared with enhancing land tenure security through on-going certification systems (Gebremariam et al., 2013), however they appear to be highly effective at targeting those in need and working towards the provision of basic needs (Devereux and Teshome, 2013).

Insurance and credit

In the last decade millions of Ethiopians were affected by drought; 12.6 million in 2003, 2.6 million in 2005, 6.4 million in 2008, 6.2 million in 2009, 4.8 million in 2010 and 1 million in 2012 (IFPRI, 2013b). This emphasizes the importance of social safety nets as well as the potential that smallholder insurance schemes could play in Ethiopian smallholder agriculture and the role they may play in light of on-going climate change. Farmers that were offered insurance but did not take it were correlated with areas that were covered by social safety net programs, thus safety nets may potentially impact uptake of insurance negatively (Oren, 2013). That study also indicates that governmental trust and therefore reliance upon safety nets, may be stronger than that of alternative market-based options, finding that greater governmental credibility results in less insurance uptake (Oren, 2013).

The availability of formal credit in Ethiopia is limited due to banking regulations within the country, which also restrict non-governmental action that would provide such a service as a stand-alone service or part of a package. However, credit and insurance are important supports for smallholder intensification. The provision of credit is key to the work of One Acre Fund, whose work has supported more than 130,000 smallholders in East Africa, resulting in two- to three-fold yield increases and a doubling of farm profits, with a 98% repayment rate (Juma, 2011; One Acre Fund, 2014). The organization is currently running pilot projects in Ethiopia, with plans for expansion. More research is required to support the development of an enabling environment that is supportive of micro-credit services and meets the credit needs of smallholders.

Credit rationing systems, often practiced in informal forms in Ethiopia, are commonly linked with social and political networks (Ali and Deininger, 2012). These play an important role throughout the country and more research is needed to understand the potential, demand and methods of the practice as well as the means available to support and formalize existing informal credit systems. Such research also needs to take into account who takes part in these informal systems and who is excluded from them, which may be a result of gender, ethnic or religious difference. Supporting informal networks that exclude marginalized members of society may further entrench their marginalization.

Tenure

The Ethiopian Constitution prohibits the sale or exchange of land, which is owned by the state, and people (nationals or foreigners) are limited to land use rights (Mekonnen, 2012). The government has initiated a land-use certification system as a means to ensure tenure within its current system. In general, land rights result in increased investment (Deininger et al., 2003). The Ethiopian land certification system allows for analysis of this question. The Government of Ethiopia's land certification system that affirms the right to use land has protected tenure, reduced disputes, increased land security and therefore investment enhanced women's control of land and helped to improve yield (Deininger et al., 2007, 2009; Gebre-Egziabher, 2013; Hagos and Holden, 2013a; Hagos and Holden, 2013b; Holden et al., 2011). These outcomes support development of resiliency, as smallholders feel more secure with their land, make investments that enhance soils and improve resource management.

External advocacy and international donors have long suggested Ethiopia privatize land ownership and land sale, although the current system is not foreign to Ethiopia historically (Crewett et al., 2008). The restrictive nature of land use rights may have resulted in inefficient types of land use (Deininger et al., 2011), but the restrictive nature of tenure and rules regarding land use inheritance may have other purposes, such as slowing the rate of urbanization. Population growth rates are high in Ethiopia with its current 93 million person population expected to reach 119 million by 2030 and 145 million by 2050 (Evans, 2012). Its urban population is relatively low, under twenty percent, but the country is urbanizing and is expected to reach one-third urban by 2040 (Evans, 2012). The government recognizes these challenges and is working to address both population growth and urbanization rates. For example, during the last two decades Ethiopian contraceptive use has increased nine-fold and the fertility rate fell from seven to under five (Olson and Piller, 2013). However, relatively lower population growth rates have not been matched by sustainable agricultural output growth, resulting in high import costs to meet demand (Demeke et al., 2013).

There are concerns that the lease of large tracts of land in Ethiopia will negatively impact smallholders (Rahmato, 2011), decrease local accessibility and food security (Cochrane, 2012) and result in human rights violations (Human Rights Watch, 2012; Makki, 2013). However, recent developments indicate that the scale of land leases are not as large as originally assumed (Cotula et al., 2009) and that human rights abuses may not be as extensive as claimed (Cochrane and Thornton, 2014). Some leases have already been ended by government and/or investors and the government has implemented new land size restrictions for agricultural investment (Africa Intelligence, 2013; Hallam, 2013).

In the small versus large farm debate which underlies the smallholder-investor discussion, it appears that size itself does not result in greater productivity while the practice of efficient farming does (Deininger et al., 2013). In the Ethiopian context, smallholders work most of the agricultural land with low technical efficiency (Geta et al., 2013), thus focusing on smallholder intensification can result in the same levels of productivity as large investment firms, while at the same time protecting rights and livelihoods.

TRENDS AND GAPS

Despite a significant amount of research in agricultural intensification, there are knowledge gaps that require continued research and dissemination. Research on diversification particularly with improved varieties as well as crop types has received a significant amount of research yet uptake remains low and requires more research to ensure that smallholders benefit from the developments in this area.

Irrigation research has indicated the potential and need as well as the complexity, and the large gaps at this stage are in the area of implementing sustainable, relatively low-tech, irrigation systems and water harvesting/storage systems so that irrigation is available throughout the dry season. Important research is available on the potential practices to manage land, soil and water.

However, more research is needed in understanding how to support smallholders to utilize these practices. Much more research is needed in order to understand the gendered nature of agricultural practice in Ethiopia. Innovative practices may not be the result of research directly, but research can support innovation through evaluation, dissemination and collaboration with extension services to expand the use of effective practices. Working with smallholders as well as sharing that research with extension service agents will enable research and researchers to pay an important role in the on-going intensification process. Similarly with systems development, areas in need of systematic change require multi-stakeholder engagement of which researchers may play an important contributing role. Potential efficiencies in this realm are numerous and on-going, and research has the potential to support systematic and policy change that can result in improvement for entire sectors. The relationship between social programs and market services require a greater understanding, as the government cannot annually support millions for the long-term. Research may indicate directions for the program to support beneficiaries to overcome poverty traps and graduate from the program, potentially through engagement with market services. This may include the expanded provision of credit and insurance as well as the development of markets and infrastructure.

In addition to the on-going research, there needs to be greater attention given to the relationships between on-going changes so that research anticipates change in a holistic fashion. In particular, this means better understanding the role of climate change, vulnerability and resiliency in smallholder agriculture. Current seed development, for example, may be suitable for current rainfall but may not be as suitable for different rainfall patterns or take place within agricultural settings that are able to withstand weather of events of greater intensity. As Ethiopia has a history of both drought and flooding, agricultural research should be connected with, and feedback into, research related to climate change, which also needs to be integrated with research about vulnerability and resiliency. This is particularly important as some research indicates outcomes contrary to what might be expected (Bezabih et al., 2014).

CONCLUSION

Improved agricultural productivity for smallholders can reduce poverty and improve household welfare (Abraham et al., 2014; Abro, 2014). A review of 40 projects of intensification in Africa suggest a number of key lessons ought to be integrated, shared and scaled-up in on-going and future work. These include:

(1) Scientific and farmer input for technology and practice development
(2) Creation of new social infrastructure
(3) Improvement of farmer knowledge and capacity
(4) Engagement with the private sector
(5) Improving the participation of women in intensification activities
(6) Ensuring the availability of financing or banking
(7) Ensuring public sector support for agriculture (Pretty, Toulmin and Williams, 2011).

This review of recent agricultural research in Ethiopia has found that a significant amount of research is being done and that international and national bodies as well as individual researchers are investing in this sector.

Research to-date has supported the yield increase

experience in Ethiopia since the 1990s and offers new knowledge for continued improvement and expanded practice of newly developed and improved techniques, inputs and management approaches.

In addition to providing an overview of the recent research trends, this work highlights specific areas for future research as well as areas of on-going debate and discussion. The Government of Ethiopia recognizes the importance of smallholders and is investing in smallholder agriculture. It is doing so through research and services with international support acting upon a home-grown development plan that is driven by the objectives of the state. The result has not been perfect. It has however resulted in Ethiopia becoming one of the world's fastest growing economies becoming one of the nations to make the most progress on the Millennium Development Goals and having made significant progress in reducing hunger and protecting against famine. Governmental support for smallholders and smallholder agriculture has been an important factor in these changes. Although progress in some areas has not moved as swiftly as many hoped, it is expected that human and economic development, supported with an agricultural foundation, will continue to progress at higher than global average rates. This is needed as demand outstrips supply and population growth rates continue to be higher than agricultural production growth rates. On-going research strengthens the intensification process. The Government of Ethiopia has been supportive of agricultural research and researchers, which provides additional incentive for continued research as many decision makers are engaging with, and responding to, the findings.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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