



Governing Seeds in East Africa in the Face of Climate Change: Assessing Political and Social Outcomes

Ola Tveitereid Westengen^{1*}, Ruth Haug¹, Paul Guthiga² and Eric Macharia²

¹ Department of International Environment and Development Studies/Noragric, Faculty of Landscape and Society, Norwegian University of Life Sciences (NMBU), Ås, Norway, ² International Livestock Research Institute (ILRI), Nairobi, Kenya

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*Correspondence:

Ola Tveitereid Westengen
ola.westengen@nmbu.no

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Climate change is already negatively affecting Sub Saharan African agriculture. One of the most effective ways to adapt *on farm* is to switch crop varieties. This technological change depends on the policies and institutions involved in governing the *seed systems* on which farmers rely for access to suitable seeds. Whilst the need for seed systems to adapt and become more resilient is indisputable, the question of *how* this is best achieved is debated. The dominant seed system development pathway promoted by international development actors is characterized by formalization and commercialization of the seed sector. In order to assess political and social outcomes of this development agenda, we compare maize seed system development in Ethiopia, Malawi and Tanzania, combining policy analysis with quantitative analysis of farmers' seed use. We show that while the development policies promoted by international donors have similar objectives in the three countries, national policies and the seed systems farmers use differ substantially. National policies are shaped by political and historical factors and established in an interplay between state institutions, international donors and private input suppliers. Drawing on a new livelihood dataset, we show that in all three countries the formalization agenda is most visible in maize seed systems, with 25, 61, and 58% of the maize farmers planting improved maize varieties in the study sites in Ethiopia, Malawi and Tanzania, respectively. The inroads of improved maize, and particularly hybrid maize, in farmers' seed systems reflects these seeds high profitability for private seed companies. The tenuous use of improved varieties in crops such as sorghum reflects the limitation of the private sector-based seed system development approach in other crops and illustrates the need for public research and governance. Comparison of households cultivating improved maize with households cultivating local maize reveals that the first group is significantly wealthier and more food secure than the latter. This suggests that better-off households are likely to benefit first from the commercial formalization agenda. We argue that climate-smart seed policies and seed system development strategies must be sensitive to differences between farming systems and different groups of farmers if they are to deliver socially fair outcomes.

Keywords: climate-smart agriculture, seed systems, seed law, seed policy, adaptation, crop varieties

INTRODUCTION

African agriculture is under increasing climatic stress and farmers on the continent will have to adapt practices and technologies to new climatic conditions (Schlenker and Lobell, 2010; Thornton and Herrero, 2015). In the meta-study of crop yield impacts conducted for the latest IPCC report, AR5, the most commonly studied on-farm adaptation measures are assessed, and “cultivar adjustment” comes out as the single most effective strategy (Challinor et al., 2014; Porter et al., 2014). Cultivar adjustment can refer to any shift in variety cultivated, but in impact studies, it is typically understood as a shift from the varieties currently grown to “climate-smart varieties,” with adaptations to new climatic conditions such as drought and heat tolerance or ability to withstand floods. Furthermore, studies combining yield impact models with socio-economic models of variety development and dissemination have called not only for adapting the *varieties* (i.e., the technology), but also the *seed systems* (i.e., the institutions and policies) involved in the breeding, delivery and adoption (BDA) of the new climate-smart seeds (Challinor et al., 2016; Atlin et al., 2017). Since the climate is projected to change faster than the current pace of BDA, this research has added a sense of urgency to the seed system development question.

The climate-smart agriculture (CSA) agenda has, since it first originated in a FAO report to the *Conference on Agriculture, Food Security and Climate Change* at the Hague in 2010, come to encompass a broad range of strategies and approaches to agricultural development (Lipper, 2010; FAO, 2013). Critical scholars have argued that the dominant CSA agenda in reality is a repackaging of existing agronomic and institutional/policy approaches and that the outcome of the agenda largely will be determined by the power and interests of the actors promoting it (Clapp et al., 2018). That the CSA agenda is not only science-based but also has political dimensions is illustrated by how it is embraced by some actors (e.g., World Bank, 2015) and rejected by others (e.g., Via Campesina, 2014). When seeking to understand what climate-smart agriculture entails in practice, it is therefore necessary to study the politics involved in operationalizing the concept; what type of technological and institutional changes are called for, by whom and on what grounds?

In relation to seed system development, the climate-smart agenda is formulated explicitly in the World Bank publication *Ending Poverty and Hunger by 2030: An Agenda for the Global Food System* (Townsend, 2015). Two of the six “key elements” for “ensuring a more climate-smart agriculture” are about seeds and seed systems: “promoting the adoption of drought- and flood tolerant crop varieties (such as drought tolerant maize and scuba rice) (...); further harmonizing seed standards and certification (at regional levels) to ease administrative procedures for seed trade and variety release to bring access to a wider diversity of seed varieties.” The seed sector development agenda presented in this and ensuing reports and communication material from

the WB on CSA¹ resonates with the agenda elaborated by the “New Alliance for Food Security and Nutrition” (NAFSN). NAFSN has since it was initiated by the G8 in 2012, provided an overarching framework for some of the most powerful donors within agricultural development (De Schutter, 2015) and can be assumed to be particularly influential in comparison with other policy frameworks because of its explicit conditionality. The so-called “Country Cooperation Frameworks” (CCFs) present the participating countries’ commitments to facilitating private investment in the agricultural sector (G8, 2012). The three countries included in this study, Ethiopia, Malawi and Tanzania, are all participants in NAFSN². While their CCFs differ, they all include something along the lines of the following seed-related commitment, from the Tanzania report: “Develop and implement domestic and regional seed and other inputs policies that encourage greater private sector participation in the production, marketing and trade in seeds and other inputs.” The national “policy actions” listed include revisions of regulations pertaining to intellectual property rights (IPRs), seed production and certification (G8, 2012). The inter-regional harmonization agenda in the World Bank strategy is currently a priority policy for the regional trade organizations Southern African Development Community (SADC) and the Common Market for Eastern and Southern Africa (COMESA)³, and is also emphasized by the African Union in the Malabo declaration of 2014 (AU, 2018). These important political economic institutions are expressions of an underlying liberalization and privatization trajectory dating back to the structural adjustment period in the 1980s. The private sector has since been perceived by dominant international and national actors as being a more efficient driver of agricultural development than public institutions and farmer organizations (Easterly, 2005; Erenstein and Kassie, 2018).

This liberalization agenda for African seed systems is implemented in a context where most of the seeds used by smallholders are acquired from other sources than those supplying certified seeds of registered varieties. The proportion of the total amount of seeds planted by farmers that are certified varies considerably between crops and countries. In the East African countries included in this study, estimates of improved maize use is typically placed at around 20–30% of the total use, while the share is considerably lower for most other staple crops (DeVries and Toenniessen, 2002; Langyintuo et al., 2010; McGuire and Sperling, 2016). Most of the seeds used by farmers are therefore uncertified seeds from sources such as own harvest, other farmers, and local markets (Almekinders et al., 1994; Louwaars et al., 2013). The latter type of seed systems are referred

¹CSA is one of the WBs four “focus areas” within the theme Agriculture and Food. Available online at: <https://www.worldbank.org/en/topic/climate-smart-agriculture> (accessed May 13, 2019).

²The Country Cooperation Frameworks. Available online at: <https://www.gov.uk/government/collections/the-new-alliance-for-food-security-and-nutrition-corporate-frameworks> (accessed May 13, 2019).

³The policies and current status for the common variety catalogs can be found here for SADC. Available online at: <http://sadcseedcentre.org/index.php/seed-harmonization> (accessed May 13, 2019) and here for COMESA Available online at: <https://varietycatalogue.comesa.int/web/> (accessed May 13, 2019).

to as “informal seed systems,” but the formal/informal binary is problematic not only because of its normative connotation of inferiority of the informal, but also because empirical research has shown that the boundary between the two systems is highly permeable (Bellon et al., 2006; Westengen et al., 2014). Seeds developed in the formal system are ultimately based on genetic resources from the informal system, and informal systems are often open to considerable influx of seeds from the formal system. The WB and NAFSN formulation of the climate-smart policy agenda for seed system development in the aid and trade agreements implies that the seed systems that farmers predominantly use today should be transformed toward a system that delivers new climate-smart varieties through formal outlets licensed to sell certified seeds. Considering that approximately 80% of the population in the three countries has agriculture as its core livelihood activity and that about 80% of the seeds that farmers use are acquired from non-formal seed sources, such a transformation will undoubtedly have large economic, social and political consequences.

The aim of this article is to assess what type of agricultural development the formalization and commercialization governance agenda for seed system development leads to in Ethiopia, Tanzania and Malawi. This is done through a two-pronged comparative study of seed systems in the three countries. First, we compare the national seed regulatory frameworks and their recent and ongoing reform processes. Second, we use new household-level data on seed use from the three countries to analyse how different policies leads to different outcomes for different actors in the national seed systems.

By integrating the policy-level study with a comparative analysis of farmers' seed use and their socio-economic and food security situation, we contribute to an empirically grounded discussion about seed system development and its social outcomes.

MATERIALS AND METHODS

In order to understand how climate-smart framings of seed system development shape agricultural development and the implications this has for farmers, we draw on political agronomy (Sumberg et al., 2013; Andersson and Sumberg, 2017) and literature on the political economy of seed system development (Kloppenburger, 2005; Scoones and Thompson, 2011; Thompson, 2012) as well as the emerging political economy literature on climate-smart agriculture (Clapp et al., 2018; Westengen et al., 2018). Political agronomy is used to analyse the “knowledge politics” involved in the problem and solution framing used by proponents for climate-smart seed system development. A political economy perspective helps in locating the knowledge politics within a broader analysis of political and economic power relations in agricultural development. Taking a comparative, mixed methods approach we analyse how the agenda plays out in national policy formulation as well as in farmers' livelihood practices.

The types of policies and regulations relevant for the current research on seed system change span from trade, agriculture and

environmental policies to the specific set of instruments falling under the auspices of national seed policies. The FAO defines a seed policy as “a statement of principles that guides government action and explains the roles of relevant stakeholders in the coordination, structure, functioning and development of the seed system comprising both formal and informal sectors. The seed policy normally serves as the overall framework for regulatory instruments, such as the seed law and related legislation” (FAO, 2015). We therefore focus our analysis on four nested policy levels: agricultural policies; seed policies; intellectual property policies and; seed laws and regulations. With a particular focus on the NAFSN, we discuss how international and regional seed policy initiatives are reflected in national policy reforms and processes in Ethiopia, Malawi and Tanzania.

Our quantitative data is from a household-level survey conducted in the research project *Innovations in Technology, Institutional and Extension Approaches toward Sustainable Agriculture and enhanced Food and Nutrition Security in Africa* (InnovAfrica). The data was collected in six project sites in three countries: the two districts Meta and Kombolcha in Oromia region in Ethiopia; the district Rungwe in Mbeya region and Lindi district in Lindi region in Tanzania; Dedza district in the Central region and Mzimba district in the Northern region of Malawi. A representative random sample of households was generated based on census lists, and a total of 1,965 households were surveyed. The surveys were carried out in the 2017/2018 season in accordance with the guidelines for research ethics of the project coordinators, the Norwegian Institute of Bioeconomy Research (NIBIO) and the Biosciences eastern and central Africa-International Livestock Research Institute (Beca-ILRI) Hub (NIBIO and Beca-ILRI Hub, 2018), and in accordance with the relevant guidelines of the organizations conducting the survey in Ethiopia (Haramaya University), Malawi (University of Malawi and Soils, Food and Healthy Communities Organization) and Tanzania (Sokoine University of Agriculture). The applicable national and institutional guidelines did not require an explicit ethics approval. The regional, district and village authorities were informed and gave permission to carry out the surveys. The selected respondents were informed about the objective of the survey and interviews were always carried out on the basis of prior informed consent to participate in the survey. The participants were ensured anonymity.

Our analysis of the household-level data focus on associations between socioeconomic variables and use of different types of seeds. We particularly focus our analysis on the maize seed use for three reasons: (1) Maize is the most commonly grown crop across the three countries; (2) Maize is the staple crop with the largest proportion of certified seed use and; (3) A number of climate-smart maize varieties are released both by public and private sector breeding programs (Cairns et al., 2013; Setimela et al., 2017). We performed different statistical tests of the difference between households growing local and improved varieties of maize, based on a set of continuous and categorical socio-economic and food security variables included in the survey. We calculate wealth quintiles for each country separately by first generating a wealth index using principal component analysis based on the total number of assets owned

by the household, followed by grouping the index into five 20 percentile categories. We performed a Mantel Haenszel odds ratio test to test if some socio-economic groups are more likely than others to cultivate improved varieties. All statistical analyses were performed in STATA (StataCorp, 2017) and figures made in R (RStudio Team, 2015).

RESULTS

Seed System Policy and Governance

Ethiopia, Tanzania and Malawi are all part of COMESA and the two latter countries are also members of SADC. Thus, the regional seed policy harmonization under these agreements is official policy in all countries. Furthermore, all three countries are participants of the NAFSN and have committed to varying degrees of liberalization of the domestic seed systems in line with their respective CCFs. Comparing seed policies and related legal frameworks reveals a number of similarities, but also considerable differences between the three countries (Table 1).

Seed Policy in Ethiopia

The Ethiopian government has a clearly articulated goal for its agricultural policies: “The overall target is a minimum growth rate of at least 8.1% per annum in the agricultural sector over the five-year period. Sub-sectoral targets include tripling the number of farmers receiving relevant extension services, reducing the number of safety net beneficiaries from 7.8 to 1.8 million households, and more than doubling the production of key crops from 18.08 million metric tons to 39.5 million metric tons. Specific targets are aligned with and in support of the targets contained in the CAADP Compact and other Ministry of Agriculture-led initiatives” (MoANR, 2016)⁴. Ethiopia has a dedicated Agricultural Transformation Agency (ATA) tasked with coordinating this ambitious goal. One of the central programs of ATA is on seed delivery systems. The country has formulated a Seed System Development Strategy that recognizes three parallel systems: The formal system in which the public seed enterprises and private seed companies operate, an intermediate system with seed producer cooperatives and the informal system encompassing farmers own seed saving, local exchange and purchase from local markets (MoA and ATA, 2013). The rationale behind this approach is a recognition of the unique characteristics and contributions of both formal and informal seed systems (Sisay et al., 2017). It is expected that the national seed policy currently in development will be aligned with this “pluralistic” seed system development strategy.

Ethiopia is not signatory to the UPOV convention but is negotiating membership of WTO and is therefore required to establish a Plant Variety Protection (PVP) law compliant with the WTO agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). The current seed proclamation applies to formal seed sector only and permits smallholders to save, share and exchange seeds. Ethiopia has designed a “Quality Declared Seeds scheme and community based seed production

directive” (MoA and ATA, 2015) to regulate seed production in the intermediate seed sector. This scheme is used for registered small holders and medium-scale farmers’ cooperatives focusing on crops that private companies are not targeting, and serving mainly marginal areas. In terms of varieties, such producers can multiply both registered improved- and local “superior” varieties (MoA and ATA, 2015).

Seed Policy in Malawi

The overall national policy framework for agriculture in Malawi is the National Agriculture Policy published by the Ministry of Agriculture, Irrigation and Water Development in 2016 (MAIWD, 2016). This policy was developed in the context of the World Bank-funded Agriculture Sector Wide Approach Support Project (ASWAp-SP)—a process that also led to the development of management guidelines for the strategic grain reserve and a revised national seed policy. The goal of the revised National Seed Policy launched in 2018 is “to provide clear guidelines for the development and promotion of the seed industry in order to raise agricultural productivity through the provision of sustainable, adequate and high quality seeds.” (MAIWD, 2018). The preamble of the seed policy refers to the Malawi Growth and Development Strategy III (MDSIII) as well as a range of international agreements and policies Malawi’s seed sector needs to align with in connection with the MDSIII priority area “agriculture and climate change.” Notably, the preamble explicitly state that seed legislation harmonization is done “in order to provide a robust policy that is in harmony with the existing pieces of legislation in the region and beyond to which Malawi is a signatory” (MAIWD, 2018, p. V). In order to meet the WTO-TRIPS agreement’s IPR requirements, Malawi, together with the rest of the African Regional Intellectual Property Organization (ARIPO), has initiated the procedure for acceding to the UPOV Convention. The focus on seed legislation harmonization and market development is reflected in the four objectives of the seed policy (MAIWD, 2018):

- To enhance appropriate and effective seed regulatory framework
- To enhance seed quality assurance for better performance of agriculture
- To establish reliable and internationally acceptable seed certification system
- To enhance growth of the domestic seed industry

The revised seed policy is contested and a number of civil society organizations (both national and international) have opposed it (ACB, 2018b). The public contestation was one of the factors that delayed the policy several years before it was officially launched in May 2018 (Munthali, 2016; Phiri, 2018). The concerns of the critical civil society organizations over what they saw as a bias toward commercialization and formalization in the seed policy drafts led to the incorporation of some elements reflecting a recognition of the importance of informal seed systems. On the occasion of the policy launch, the World Bank country manager said “These seeds, which are traditionally passed on from one farmer to the next without growing through a formal channel, need also be captured in a certain way under the formal

⁴Also available from ATA webpage: <http://www.ata.gov.et/about-ata/origin-history-2/>

TABLE 1 | Policies and laws important for seed system governance in Ethiopia, Malawi and Tanzania.

	Ethiopia	Malawi	Tanzania
Agriculture policies	2016 Second Growth and Transformation Plan (GTP II) 2016–2020	2016 National Agriculture Policy	2015 Agricultural Sector Development Strategy for the period 2015/16–2024/25
Seed policies	2013 National Seed System Development Strategy 2018 New Seed Policy awaiting approval, will replace the 1992 National Seed Industry Policy and Strategy	2018 National Seed Policy replaced the 1993 version	No overall seed policy
IPR legislation	2018 PBR proclamation. Replaced the 2006 proclamation Ethiopia is not a UPOV member	2018 Malawi and the rest of the African Regional Intellectual Property Organization (ARIPO) initiated the procedure for acceding to the UPOV Convention	2013 New Plant Varieties Act replaced the 2002 Act 2015 Full membership in UPOV-91
Seed laws	2013 Seed Proclamation (No. 782/2013) replaced the first Seed Proclamation from 2000. 2015 Ministerial Quality Declared Seeds (QDS) directives issued to regulate the intermediate seed sector	2018 National Seed Commission Bill is drafted and pending finalization / parliamentary endorsement in 2019	2014 Amended version of the Seed Act from 2003

seed system but that requires some work. So, this policy now recognizes what we call QDS—quality declared seeds⁵.”

Seed Policy in Tanzania

The Tanzanian government’s general agricultural policy is stated in the Agricultural Sector Development Strategy for the period 2015/16–2024/25 (GURT, 2015). It aims at “operationalizing transformation of the agricultural sector into modern, commercial, highly productive, resilient, competitive in the national and international market which leads to achieving food security and poverty reduction, contributing to realization of Tanzania Development Vision 2025 (TDV) that envisages raising the general standard of living of Tanzanians to the level of a typical medium-income developing country by 2025” (GURT, 2015). One of the goals is to “strengthen the national seed system that includes all the stakeholders, i.e., Agricultural Research Institutes, ASA, TOSCI, private seed producers and distributors, QDS producers, including enhancement of breeding capacity of Agricultural Research Institutes” (GURT, 2015, p. 24).

This course for seed system development was charted already in the 1990s when the Tanzanian government took several initiatives to encourage private sector involvement in the seed sector. The legal and regulatory framework was reformed, and several new laws were passed including the Protection of New Plant Varieties Act (2002), which established WTO TRIPS compliant PVP and the Seed Act (2003), which established seed regulations governing certification and sale. As in the case of Malawi, the new laws have been met by concerns and critique by some civil society organizations and scholars on the grounds that they will limit farmers’ rights to save, use, exchange and sell farm-saved seeds (Haugen, 2015; Mkindi, 2015; Daems, 2016). In 2015, Tanzania was the first Least Developed Country (LDC) in the world to join UPOV91. In Tanzania, certified seed is produced on public and private seed farms, as well as by small-scale farmers located in various parts of the country under a QDS

scheme (Ngwediagi et al., 2009). Quality control and certification is the responsibility of the Tanzania Official Seed Certification Institute (TOSCI). The emphasis on reforms to enable private seed companies to increase their markets is done in parallel with continued support to the public seed multiplication and production association ASA, as well as with recent concessions to QDS producers.

The Seed Systems Farmers Use

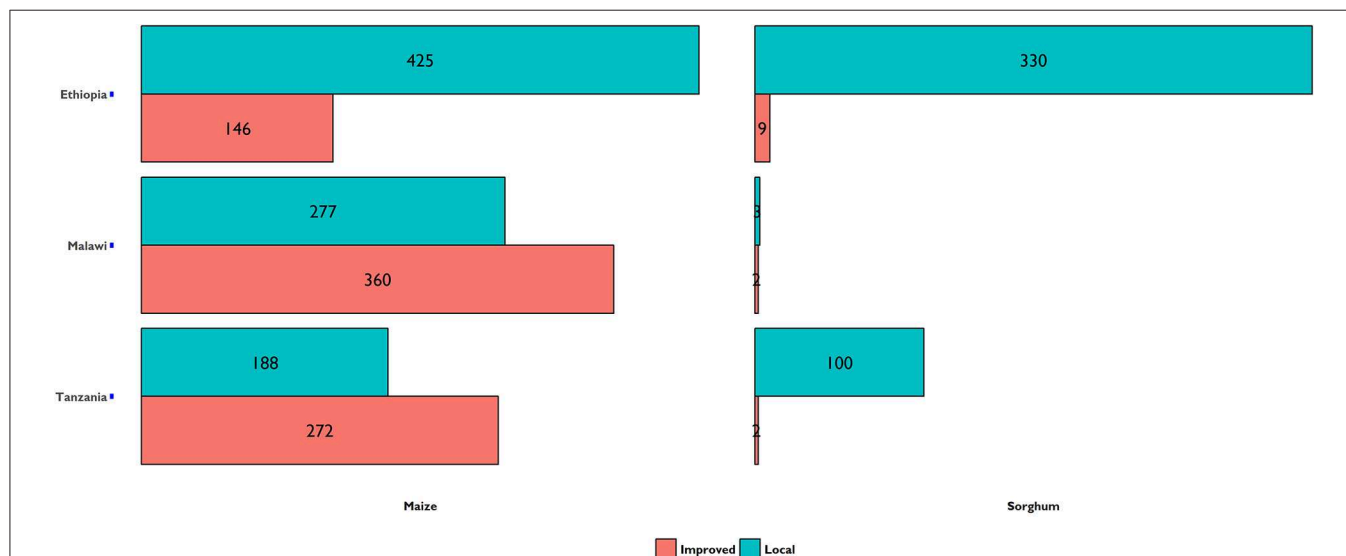
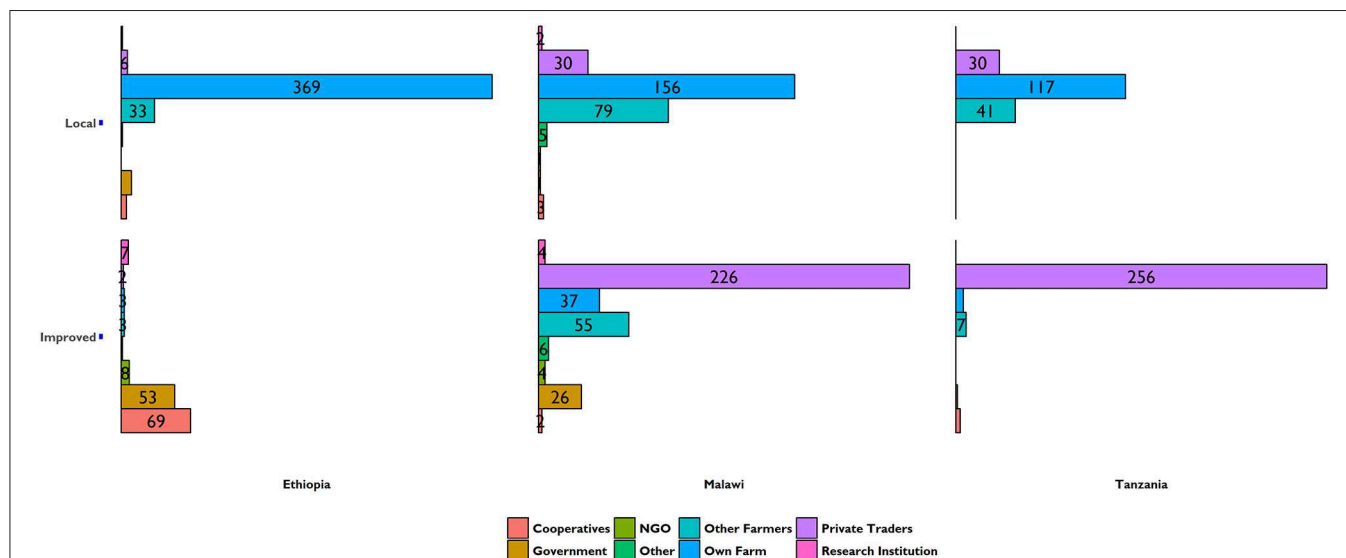
Whilst agriculture in the areas included in this study varies substantially with regard to political-economic and agro-ecological contexts, there are also many commonalities in the way rural households farm. The core crops are commonly a combination of grains with legumes, and maize is by far the most common and most abundantly grown crop (Table 2). Comparing maize with the second most common crop in our dataset, sorghum, we find that maize is widely grown in all countries and sites, while sorghum is only widely grown in Ethiopia and Tanzania (predominantly in the southern site, Lindi). The use of improved varieties of sorghum is much lower than in the case of maize (Figure 1). Focusing on maize as the crop for which formal seed systems are already supplying a substantial share of the seeds, we find that private traders (also known as agro dealers) are the major source for improved seeds in Malawi and Tanzania, while seed producer cooperatives (SPCs) are the most important suppliers of improved seeds in the Ethiopian sites (Figure 2). Furthermore, we see that seed saving on-farm is by far the most important source of seeds of the local maize variety across the three countries (Figure 2). Across countries, the reason most frequently cited for growing local maize was “easy and stable access to seeds” while “high yield” was the most frequently cited reason for growing improved varieties.

Comparing households according to the type of maize cultivated, there is considerable variation between countries with regard to land size, distance to markets and infrastructure, the head of households’ level of education, and the household head’s reported income from on-farm and off-farm work (Table 3). The

⁵Interview in Zodiac. Available online at: <https://www.zodiakmalawi.com/top-stories/malawi-s-new-seed-policy-protects-local-farmers>

TABLE 2 | Maize cultivation and variety type in the study sites in Ethiopia, Malawi and Tanzania (*N* = 1,965 Households).

Country	N total	N growing maize (% of total)	Improved (% of maize growing HHs)	Both (improved and local) (% of maize growing HHs)	Local (% of maize growing HHs)	Unknown (% of maize growing HHs)
Ethiopia	615	575 (93.5)	145 (25.2)	1 (0.2)	425 (73.9)	4 (0.7)
Malawi	653	641 (98.2)	322 (50.2)	69 (10.8)	246 (38.4)	4 (0.6)
Tanzania	697	472 (67.7)	272 (57.6)	0 (0)	188 (39.8)	12 (2.5)

**FIGURE 1** | Number of households growing local and improved varieties of sorghum and maize at the study sites in Ethiopia, Malawi, and Tanzania.**FIGURE 2** | Seed sources for local and improved maize at the study sites in Ethiopia, Malawi, and Tanzania.

income distribution is, as can be seen from the large standard deviations, highly variable.

The dichotomous socioeconomic variables (**Supplementary Table S1**) show that across the three countries

there is a significantly higher share of women-headed households among those growing local maize than among those growing improved maize. On the other hand, a higher share of the households growing improved maize use external inputs such

TABLE 3 | Comparison of households growing local and improved varieties of maize. Only households cultivating one of the types are compared and the households cultivating both types (see **Table 2**) are excluded from the analysis ($N = 1,598$).

Characteristic	Ethiopia			Malawi			Tanzania		
	Local	Improved	T-stat (<i>p</i> -value) sig.	Local	Improved	T-stat (<i>p</i> -value) sig.	Local	Improved	T-stat (<i>p</i> -value) sig.
	Mean (SD)	Mean (SD)		Mean (SD)	Mean (SD)		Mean (SD)	Mean (SD)	
Total land size of all parcels in hectares	0,42 (0,32)	0,46 (0,31)	−1.36 (0.17) n.s. ¹	0,83 (0,7)	0,99 (0,66)	−2.84 (0.00)***	2,37 (2,13)	1,65 (1,59)	4.14 (0.00)***
Household size/members	4,39 (1,91)	4,84 (1,9)	−2.47 (0.01)**	3,43 (1,82)	3,83 (1,78)	−2.62 (0.01)***	3,39 (1,78)	3,95 (1,85)	−3.24 (0.00)***
Age of household head	38,73 (11,11)	40,14 (10,79)	−1.33 (0.19) n.s.	46,36 (17,17)	43,66 (14,18)	2.05 (0.04)**	50,9 (15,16)	50,51 (12,98)	0.30 (0.77) n.s.
Number of years spent in school by household head	3,15 (3,56)	3,59 (3,8)	−1.27 (0.21) n.s.	5,66 (4,12)	6,94 (4,05)	−3.71 (0.00)***	4,36 (3,58)	7,1 (2,95)	−8.95 (0.00)***
Approximate distance to the nearest trading market/urban center (km)	5,52 (2,41)	4,82 (2,3)	3.06 (0.00)***	12,8 (5,73)	14,16 (5,4)	−2.90 (0.00)***	2,39 (2,28)	3,89 (2,61)	−6.38 (0.00)***
Approximate distance to the nearest paved road (km)	1,6 (1,45)	1,46 (1,56)	1.03 (0.30) n.s.	13,4 (10,16)	12,11 (10,85)	1.45 (0.15) n.s.	5,9 (4,81)	2,81 (2,8)	8.67 (0.00)***
Monthly income of household head from off-farm source	4,94 (18,03)	10,22 (35,19)	−2.33 (0.02)**	15,06 (35,88)	16,05 (27,76)	−0.37 (0.71) n.s.	20,86 (38,49)	26,33 (64,13)	−1.04 (0.30) n.s.
Monthly income of household head from on-farm source	44,86 (53,59)	41,11 (41,71)	0.75 (0.45) n.s.	10,95 (20,69)	18,89 (35,16)	−3.15 (0.00)***	124,17 (277,68)	68,22 (76,4)	3.16 (0.00)***
Maize total quantity consumed (kg)	427,83 (337,97)	581,02 (405,54)	−4.45 (0.00)***	519,9 (578,84)	781,06 (785,68)	−4.33 (0.00)***	267,59 (538,48)	433,93 (435,18)	−3.61 (0.00)***
Maize total quantity sold (kg)	6,47 (64,4)	22,53 (110,53)	−2.11 (0.04)**	160,33 (725,13)	220,95 (654,97)	−1.03 (0.30) n.s.	19,04 (75,37)	86,29 (389,29)	−2.31 (0.02)**
Number of months with food scarcity	4.34 (2.22)	3.72 (2.16)	2.92 (0.00)***	3.43 (2.84)	2.67 (2.84)	3.18 (0.00)***	2.27 (2.53)	1.83 (2.4)	1.87 (0.06)*
Household dietary diversity score (24 h–12 points)	5.03 (1.82)	5.9 (2.01)	−4.86 (0.00)***	5.87 (2.19)	6.59 (2.29)	−3.75 (0.00)***	6.69 (2.29)	8.26 (2.29)	−7.24 (0.00)***

¹n.s., not significant; *significant at $p < 0.10$, **significant at $p < 0.05$, ***significant at $p < 0.01$.

as inorganic fertilizer and the hiring of labor both for land preparation and harvesting. The households growing improved maize also had more access to extension and a higher proportion of them were affiliated with farmer associations.

Considering food production and consumption factors, we see a pattern where households cultivating improved maize both sell and consume more maize than households cultivating local maize (this pattern is not, however, significant for maize sold in Malawi). Also, households cultivating improved maize experience a shorter annual period with self-reported food scarcity, and have a higher dietary diversity score than households cultivating local maize.

Further probing the question of what difference there is between households cultivating improved varieties of maize and those cultivating local varieties, we used principal component analysis based on the total number of assets owned by the household to develop a wealth ranking index, grouping households into five 20 percentile categories. The Mantel-Haenszel Odds Ratio test reveals that across all three countries the “rich” quintile has a statistically significant higher likelihood of cultivating improved maize compared with the “poor” quintile. In Ethiopia, the odds in favor of using the improved maize variety were 1.72 times greater (72% more) in the wealth group “rich” compared with the “poor” ($p < 0.1$). In Malawi and Tanzania the same odds are considerably higher (4.95 and 34.67, respectively) with a $p < 0.01$ (Table 4).

DISCUSSION

Public Policy and Private Business?

The national seed policies and their general agricultural development policy contexts in the three countries all emphasize the importance of enabling greater private-sector investment in the agricultural sector. The “theory of change” behind this approach has been summarized as “market led technology adoption” (Scoones and Thompson, 2011). That is, increased availability of technology in the market will make agriculture more productive, and this will in turn reduce poverty and food insecurity at the national and continental level in the long term. This policy direction has historical roots going back to the liberalization and privatization policies ushered in by the structural adjustment programs (SAPs) in the 1980s. It was reinforced in connection with increased policy attention and funding to agriculture and food security efforts following the food price crisis in 2007/2008. Sometimes referred to as the “neoliberal project” (Sumberg and Thompson, 2012), this policy direction is now so omnipresent that it is difficult to single out the actors that are the most important drivers. The market-led approach is promoted in global policy advice from international financial organizations such as the WTO and the World Bank, as well as in African continental and regional policies from AUs NEPAD and CAADP, in the trade agreements in COMESA and SADC and in national agricultural development initiatives in the three countries. As mentioned above, one of the more recent frameworks that have attempted to coordinate and align policies from donors, national governments and the private sector in this direction is the New Alliance for Food Security and Nutrition

(NAFSN). The World Bank’s participation in NAFSN makes this initiative particularly interesting when studying what the climate-smart agriculture agenda entails in seed system development in the three countries. In the CCFs, encouraging private-sector involvement in seed system development is singled out as a key policy commitment made by the governments. Overall, these efforts seem to have succeeded. When NAFSN and Grow Africa (a closely related policy initiative launched at the World Economic Forum in Davos in 2011 and led by AU) published their joint stock-taking report on the CCFs, government “input policy reform” came out as the type of commitment that had seen most progress (NAFSN, 2015). Since the launch of NAFSN, several other initiatives have been launched with similar goals; we do not, therefore, suggest that the reforms and policy changes reported in Table 1 are directly attributable to NAFSN or any other global policy strategy alone. Rather, we see the policy changes as expressions of the dominant trend in ODA for agricultural development, in which NAFSN is one prominent example. As such, it is interesting to study how NAFSN and the CCFs are being implemented in the different countries.

In the case of Ethiopia, a report from the Alliance for a Green Revolution for Africa (AGRA) presents a common problem-framing: “Agricultural sector growth in Ethiopia has been strong from a low base, while agribusiness investment has been less forthcoming than in other Sub-Saharan Africa (SSA) countries. This is due to many factors, including policy and regulatory constraints.” (AGRA, 2014). The policy and regulatory constraints singled out as being in need of reform in Ethiopia’s CCF are the ratification of the seed proclamation and the establishment of various “protocols” to encourage private actors to enter the seed sector (G8, 2013b). Interestingly, this was already fulfilled by the time the CCF was published in 2013 and in comparison with the policy commitments made by the Tanzanian and Malawian government in their respective CCFs, the policy actions promised by the Ethiopian government are rather limited. The most explicit action to encourage foreign private seed companies states that the country will incentivize “international seed companies to operate in Ethiopian seed markets, with the exception of certain open/self-pollinated or indigenous crops, specifically teff, coffee, niger seed, and inset.” (G8, 2013b). The governmental limitations on what the private sector in general and the foreign private sector in particular are allowed to do, is connected to the privileged role given to public institutions such as the Ethiopian Institute of Agricultural Research (EIAR) and the Ethiopian Seed Enterprise (ESE) in the BDA process. Rather than focusing on the policy direction charted in the private-sector led formalization agenda, promoted by the NAFSN and similar initiatives, the Ethiopian government has chosen a policy direction better described as public sector-led integrated seed system development. This policy direction is seen in the Integrated Seed System Development strategy (MoA and ATA, 2013), the community-based seed production directive (MoA and ATA, 2015) as well as in the choice of a less restrictive IPR regime than UPOV-91. Alemu characterized the influence of liberalization in Ethiopian seed system development thus: “While there has been much policy rhetoric about the benefits of liberalization in Ethiopia, the state retains a strong

TABLE 4 | Wealth ranking and maize variety use at the study sites in Ethiopia, Malawi and Tanzania.

Ratio of odds of using improved variety in country				
Country	Reference group	Comparison group	MH Odds Ratio (lower-, upper-limit)	Two-sided <i>p</i> -value
Ethiopia				
Sex of the household head	Female	Male	1.58 (0.72,3.50)	0.25
Wealth quintiles	Poor	Second poor	1.36 (0.72,2.59)	0.34
		Middle	1.66 (0.88,3.12)	0.11
		Second rich	1.44 (0.77,2.73)	0.25
		Rich	1.72 (0.92,3.21)	0.09*
Malawi				
Sex of the household head	Female	Male	2.09 (1.42,3.06)	0***
Wealth quintiles	Poor	Second poor	1.91 (1.12,3.26)	0.02**
		Middle	2.51 (1.46,4.32)	0***
		Second rich	4.56 (2.52,8.25)	0***
		Rich	4.95 (2.69,9.11)	0***
Tanzania				
Sex of the household head	Female	Male	1.67 (1.03,2.70)	0.04**
Wealth quintiles	Poor	Second poor	1.81 (0.73,4.52)	0.2
		Middle	8.30 (3.33,20.65)	0***
		Second rich	17.73 (6.46,48.70)	0***
		Rich	34.67 (10.31,116.55)	0***

The Mantel-Haenszel (MH) Odds Ratio and the associated two-sided *p*-value indicates the odds ratio between the reference group and the comparison group.

*Significant at $p < 0.10$, **significant at $p < 0.05$, ***significant at $p < 0.01$.

The population is ranked into five wealth groups (quintiles) and all groups are compared with the poorest group.

hold over market actors” (Alemu, 2011, p. 74). It seems that this is still the situation after the recent liberalization drive from the donor community. The role assigned to the private sector is primarily to serve farmers and companies involved with export oriented industrial crop production, while public companies and seed production cooperatives are tasked with supplying seeds for domestic food crop production.

The Malawian government has taken a rather different approach to that of the Ethiopian government. In the original Malawian CCF, the overarching seed-related input policy commitment was “Commitment to implementation of SADC and COMESA Seed Harmonization Programme” (G8, 2013a) followed by a list of concrete measures regarding IPR regulation, phytosanitary regulations and seed law/certification reforms. All of this was originally planned to be in place by January 2015 but, as indicated in **Table 1**, these reforms were for the most part first concluded in 2018 and the seed law is still pending approval. In the updated CCF from 2015, the objective of the government for input policies was changed to the more farmer-focused wording “Create a conducive environment with reduced risk in doing business and fair market returns for farmers” and the policy action was simplified to “Review seed policy, strategy and certification to enhance regional harmonization.” The set of policy reforms listed in **Table 1** is testimony to the considerably larger influence of the NAFSN policy direction in Malawi compared to the situation in Ethiopia. The NAFSN donors have been more hands-on in the policy formulation in Malawi, as illustrated by the USAID’s New Alliance Policy Acceleration Support initiative, which has provided both technical advice and financial support to move the policy processes in the CCF

forward. At the same time, the NAFSN policy represents a continuation of a longer term trend in reforms of Malawian seed policy. As Chinsinga wrote about the political economy of the Green Revolution seed system development strategy in the country: “For most donors, a private sector-led system, supported by a permissive, liberalized policy environment, is the surest strategy to kick-starting an African Green Revolution” (Chinsinga, 2011, p. 65). The public breeding program has been weakened, the National Seed Company has been closed down and the Association of Smallholder Seed Multiplication Group (ASSMAC) is designated a role as seed producer for the type of seeds the private companies are less interested in (Chinsinga, 2011). Despite almost three decades with liberalization of the formal system, these donors remain critical to the role of the state and the performance of the system in Malawi. This is reflected in the draft National Seed Commission Bill discussed at the time of writing, which is not only a seed law, but also a plan for institutional reform of the national seed certification system. Central donors have demanded that the current Seed Service Unit under the Ministry of Agriculture, Irrigation and Water Development is moved out to become a semi-autonomous National Seed Commission to avoid confluence of political and economic interests. The push to take such measures to separate political power from the operation of the formal system stems from the considerable donor discontent with the large Farming Inputs Subsidy Program (FISP). The EU’s representative to the Donor Committee on Agriculture and Food Security expressed this concern at the launch of the so-called National Agriculture Investment Plan, in June 2018: “Over the past 5 years, the government Public Expenditure on FISP and Maize purchase

has ranged between 71–84%, thus leaving only 4–16% for other strategic areas. This trend has been confirmed in next year's budget and it is a concern⁶." This was followed by a statement expressing what is seen as suffering in the shadow of FISP: "I wish to re-emphasize the importance of an enabling environment for private sector investment in agriculture. We would like to commend the Government for progress done so far, in particular the approval of the Seed Policy by Cabinet." There is more continuity than change in this rhetoric from the international donors who have remained critical to FISP despite evidence showing that the program is associated with a strong increase in productivity and total production of maize (Haug and Wold, 2017). The question is what the current reforms in Malawi's seed system and the "wobbly state of FISP" (Kasakura, 2018) amidst the donor pressure to close it down will mean for private-sector input providers and Malawian smallholders in the years to come. In his political economic analysis of the seed system in Malawi under FISP, Chinsinga asserts that "multinational seed companies are (...) the major beneficiaries of the subsidy programme because they have a guaranteed market" (Chinsinga, 2011, p. 65).

Also in the case of Tanzania, the NAFSN CCF is a useful entry point for understanding how the private-sector focus shapes seed system development. The CCF from 2013 listed the following policy commitments from the government in order to "encourage greater private sector participation in the production, marketing and trade in seeds:"

- Revised Seed Act that aligns plant breeder's rights with the International Union for the Protection of New Varieties of Plants (UPOV) system
- Time required to release new varieties of imported seeds from outside the region to be reviewed and benchmarked with international best practices
- Qualified private sector companies authorized to produce foundation seed under proper supervision and testing
- ISTA and OECD seed testing accreditations achieved to enable regional and international seed sales (G8, 2012)

As shown in **Table 1**, the seed regulatory framework in Tanzania was revamped around the time of the launch of the CCF and since the 1990s, key donors have put in place policies to encourage the private sector to step in to fill the void left by the reduction of the public sector in BDA activities in response to structural adjustment programs and other austerity measures. The return of agriculture on the development agenda after the food price crisis in 2007 was actively encouraged by the government in Tanzania, who gave agriculture a central role in national development efforts such as with the *Kilimo Kwanza* (Agriculture First) program, a Public Private Partnership initiative where the private agricultural sector was envisioned to become "the engine of economic growth⁷." The role of seed system development was

central in this revival of agricultural development, and actors such as AGRA and BMGF got involved early on with support to private actors as well as policy reforms in the country (AGRA, 2014). A report on how the formal seed system can become more private-sector friendly, "*A Legal Guide to Strengthen Tanzania's Seed and Input Markets*," published by AGRA in 2017, is explicit about the conditionality of NAFSN support to formal seed system development: "Building these systems is central to Tanzania's commitments under the G8 Cooperation Framework to Support the NAFSN" (SAGCOT, 2017). While the Tanzanian government has put in place a private-sector friendly regulatory framework, including a strong IPR regulation, it has also maintained support for the public seed agency ASA, and insisted on the importance of strengthening the public seed certification agency TOSCI despite critique of these institutions as bottlenecks in the system (USAID and EAT, 2013; SAGCOT, 2017). The Tanzanian government appears to be more concerned with maintaining strong public institutions in the seed sector compared to the case in Malawi (Haug et al., 2016).

The NAFSN CCFs and the various other "market-led technology adoption" policies with which they align are expressions of a dominant narrative in which the African food insecurity problem is framed in terms of lack of technology and institutions to deliver this technology to the continent's food producers (Scoones and Thompson, 2011; Sumberg et al., 2013). As illustrated by ongoing debate both within national policy processes and in the wider public debate, this is not a universally shared narrative. The negotiation between the international policy agenda based on this narrative and the interests, power and values of the stakeholders involved in operationalizing policies helps explain why the policies unfold in different ways in the three countries. The historically strong grip of the Ethiopian government on rural development policies and the importance placed on national autonomy in policy formulation (Keeley and Scoones, 2000) is central to understanding why Ethiopian seed system development remains focused on maintaining national public control of the food crop sector. In Tanzania, promotion of the nation state through rural development programs is a political tradition which is central to understanding the persistence of public seed system institutions, despite pressure from development partners to liberalize the sector (Havnevik, 2010; Haug et al., 2016). Furthermore, the explanation for the endorsement of market-oriented formalization in Malawi is not that the government doesn't consider seed supply an important sector—on the contrary, analyses of the political economy of seeds in Malawi have shown that it is precisely the political importance of seeds, and maize in particular, that has forged an alliance between the state, the donors and the private seed sector (Chinsinga, 2011; Scoones and Thompson, 2011).

We argue that climate change is used an argument for speeding up efforts on the already dominant pathway for seed system development. This framing of the CSA agenda in relation to seed system governance resonates with three critical

⁶Speech by the EU Ambassador, Marcel Gerrmann on Behalf of the Donor Committee on Agriculture and Food Security-DCAFS; at the Launch of the National Agriculture Investment Plan-NAIP Lilongwe. Available online at: https://eeas.europa.eu/delegations/malawi/46448/node/46448_ro (June 13, 2018)

⁷Presentation by Revelian S. Ngaiza Head Unit of Investment Policies and Private Sector Development, Department of Policy and Planning. Available

online at: http://www.fao.org/fileadmin/templates/esa/Workshop_reports/Smallholders_2012/Presentations_1/Ngaiza_Kilimo_Kwanza_Tanzania.pdf

themes identified in recent scholarly analyses: power and interest plays a large role in shaping the agenda; existing approaches promoting open markets and technology often dominate and; questions of inequality are often side-lined (Clapp et al., 2018). The situation also relates to some perennial themes in the classical work on the political economy of plant breeding: Seeds are increasingly commodified and the social division of labor is increasingly shifting from the public sector to the private sector (Kloppenburger, 2005). This trend has run to almost complete fulfillment in the Global North, where seeds have not only completely transformed from a social good to an economic good, but where four multinational agro-chemical corporations now account for around 60% of global seed sales (Clapp, 2018). Maize was the frontrunner crop in the US commodification and privatization process (Kloppenburger, 2005) and our data reflects that maize is the most commercialized food crop in Sub Saharan Africa today. Furthermore, crop scientists have already noted that an increasing amount of the maize varieties released on the African market are proprietary and protected by IPRs (Setimela and Mwangi, 2009; Erenstein and Kassie, 2018).

Social Outcomes of the Formal System Reforms

The picture of the policies and their operationalization presented above is to a large extent reflected in the data from our household survey. In all three countries, a high proportion of households report cultivating local varieties of maize sourced from their own harvest or from other farmers, whilst the proportion of households growing local maize is considerably higher in Ethiopia than in the two other countries (**Figure 1**). The pattern for cultivation of improved maize complements this picture, as Ethiopia has the lowest proportion of households cultivating improved maize and Malawi the highest proportion, with Tanzania in an intermediate position. This tallies well with the policy analysis, with Malawi as the country with the most private sector conducive policy regime, both in terms of private-sector friendly seed policies and in terms of supporting farmers' purchase of improved maize. The source of the improved maize (**Figure 2**) reflects the dominance of private traders (agro-dealers) in Malawi and Tanzania, while this is absent in our data from the study sites in Ethiopia where parastatal seed companies and seed production cooperatives supply most of the improved seeds. Furthermore, we find that a larger proportion of households in Malawi report that they are sourcing improved seeds from own harvest and fellow farmers, compared to the two other countries. There is also a larger proportion of households reporting that they are cultivating both improved and local varieties in Malawi. A possible explanation here is that the FISP only distributes vouchers for small quantities (5 kg) of improved (hybrid) seeds and it is not necessarily the same households that gain access to this subsidy every season. One can thus expect that some households plant only part of the field with improved maize and that they recycle their seeds in years when the subsidy is unavailable.

The question of who wins and who loses in the resulting governance regimes is complex to answer, but by following the seeds disseminated by the current formal system, we find that

the better-off households use improved seeds to a larger extent than the poorest households. Since we have cross-section and not panel data, we cannot readily say what way the causality goes: are households better off because they use improved seeds or is it because households are better off that they use improved seeds? There are factors that could be seen to support both explanations: The better food security situation and relatively higher amount of maize consumed and sold by households cultivating improved varieties indicates that high yields from improved maize is an important contributor to the household well-being. On the other hand, comparing households growing improved maize with those growing local varieties reveal that they to a lesser extent are women-headed, have better access to extension services, to a larger extent are affiliated with farmer associations, to a larger extent use inorganic fertilizer and to a larger extent hire labor for planting and harvesting. This suggests that better-off households are likely to benefit first from the commercial formalization agenda. This could be due to lower purchasing power of the poor, but may also be due to lack of "social capital," facilitating access to technology. Examples of factors that increase the social capital for access to improved seeds include institutional factors such as membership in farmer organizations and possession of social and political connections. The importance of farmer organization membership for access to improved seeds is clear in the case of the Ethiopian sites where the sale of improved seeds is centrally organized and seed demand is compiled and later distributed by farmer cooperatives and unions (Erenstein and Kassie, 2018). Another possible political explanation for the disparity between rich and poor groups' likelihood of using improved seeds is "elite capture" in input subsidy schemes (Alemu, 2011; Chinsinga and Poulton, 2014; ACB, 2018a). The greater difference in the likelihood of use of improved varieties between rich and poor in Malawi and Tanzania than in Ethiopia further indicates that purchasing power is a more important determinant of improved maize use in the two first countries.

CONCLUSION

Climate change has become an overarching concerns for agricultural development. In order for crop production to adapt to climate change it is fundamental that farmers have access to well-adapted seeds. Both state- and non-state actors involved in seed supply policy and governance now frame seed system activities in terms of making them more climate-smart. However, whilst the need for seed systems to adapt and become more resilient is indisputable, the question of *how* this is best achieved is contested. The dominant development pathway promoted by international development actors is the same that was promoted during the heydays of the SAPs and later reinforced under the African Green Revolution agenda ushered in by the food price crisis: Development of formal legal and policy frameworks that incentivizes the private sector to take the lead in seed supply.

Our policy study highlights the complex dynamics involved when multilateral regimes interact with nation states and private sector actors from the national and the multinational level to shape seed system governance. The comparative approach reveals that global governance policy for seed system development has translated quite differently in the three national contexts.

This does not necessarily mean that the national policies and institutional landscape unfolding is attentive to the needs of farmers and consumers. Whilst it is not surprising that commercial actors will pursue the best market opportunities for their most profitable varieties, this market dynamic is also the reason why public governance is needed in order to ensure that the many crops and farmers that do not represent profitable market opportunities are not forgotten. In order to understand the actual effect and impact of policy reforms more research is needed on how international and national policies play out through the national and local organizations and institutions in the formal seed system.

The science based calls for adapting breeding and seed systems to climate change (Challinor et al., 2016) and priority setting for climate-smart agriculture research in general (Thornton et al., 2018) emphasize that multiple alternative pathways exist and that their suitability is highly context dependent. More than 30 years of farming systems research, participatory approaches to agronomic research and integrated management practices represent a rich evidence base and toolbox for technological and institutional innovation for seed system development in the face of climate change. This toolbox includes a broad suite of breeding, regulatory, and dissemination approaches including:

- Public breeding of open pollinated crops and crops with limited private sector interest;
- Crop improvement programs that include farmers at different stages of the plant breeding (Ceccarelli, 2015);
- Cooperative seed production (as done on a large scale in Ethiopia);
- QDS schemes (as already existing in Tanzania and Ethiopia and currently planned in Malawi) and
- IPR and seed laws that allow for coexistence and integration of seed systems governed by different types of institutions (Louwaars et al., 2013).

Unless policies focus on enabling a diversity of approaches, the urgency climate change has added to the importance of supporting seed system development can paradoxically lead to less adaptive seed systems. Policies that open up legal and institutional space for a diversity of seed system development pathways will not only provide more options for adapting to climate change, but also for adapting to the diversity of agroecological, economic, social and cultural needs and preferences of farmers.

ETHICS STATEMENT

The surveys were carried out in accordance with the guidelines for research ethics of the project coordinators,

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the Norwegian Institute of Bioeconomy Research (NIBIO) and the Biosciences eastern and central Africa-International Livestock Research Institute (BecA-ILRI) Hub (NIBIO and BecA-ILRI Hub, 2018), and in accordance with the relevant guidelines of the organizations conducting the survey in Ethiopia (Haramaya University), Malawi (University of Malawi and Soils, Food and Healthy Communities Organization) and Tanzania (Sokoine University of Agriculture). The applicable national and institutional guidelines did not require an explicit ethics approval. The regional, district and village authorities were informed and gave permission to carry out the surveys. The selected respondents were informed about the objective of the survey and interviews were always carried out on the basis of prior informed consent to participate in the survey. The participants were ensured anonymity.

AUTHOR CONTRIBUTIONS

OW and RH contributed conception and design of the study. PG, EM, and OW performed the statistical analysis. OW wrote the first draft of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fsufs.2019.00053/full#supplementary-material>

Supplementary Table S1 | Comparison of households growing local and improved varieties of maize with regard to gender and farming practises. Only households cultivating one of the types are compared and the households cultivating both types (see **Table 2**) are excluded from the analysis (N = 1598).

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