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Is there such a thing as sustainable agricultural intensification in smallholder-based farming in sub-Saharan Africa? Understanding yield differences in relation to gender in Malawi, Tanzania and Zambia

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ABSTRACT

Smallholder-based, sustainable, agricultural intensification is increasingly put forth as a development pathway that is necessary to improve farmer's livelihoods, enhance productivity and engender a surplus that can be used to feed growing urban areas across sub-Saharan Africa. The following article examines trends in yields for Africa's largest staple crop – maize – among smallholder farmers in six regions in Malawi, Tanzania and Zambia, using longitudinal quantitative data collected in 2008, 2013 and 2017 in combination with qualitative data from nine villages. Substantial increases in yields are found only in Zambia, while yields are largely stagnant in Malawi and Tanzania. In the case of Zambia, however, there is a persistent gender-based yield gap. We use the qualitative data to explain this gap and find that gender-based differences in yields need to be understood in relation to local production systems, as well as the varied positionality of women, where the biases facing women who head their own households are different than for women living in male headed households. In policy terms, technologies that can promote intensification are different depending on these factors, even within the local context of particular farming systems.

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Introduction

Smallholder-based agricultural intensification is increasingly put forth as a development pathway that is necessary to improve farmer's livelihoods, enhance productivity and engender a production surplus that can be used to feed burgeoning urban centers in developing countries. In the case of sub-Saharan Africa, in particular, the smallholder-based model is inspired by the historical experiences of the Asian Green Revolution, where intensification in rice was promoted through technological change, price incentives and state support (Djurfeldt and Jirström 2005). The sustainability and applicability of the Asian based development model have increasingly been questioned on the grounds of social and environmental sustainability, however. As such, the notion of sustainable agricultural intensification has been advanced as an alternative win-win scenario where productivity increases are tied to improvements

in environmental sustainability and more recently also to aspects of equity and social sustainability, for instance improving the lives of women and girls (Hagggar, Ramboll, and Nelson 2018). The practical details of how to ensure sustainable agricultural intensification are opaque, however, and discourses around sustainable intensification have been criticized as green washing by activist groups for instance (Tittonell 2014). Nonetheless, the need for raising agricultural productivity in sub-Saharan Africa is widely acknowledged as is the crucial role of female farmers in this process. Indeed, more or less credible assessments of the productivity gains that would result from closing gender-based asset gaps in agriculture are found in the grey area literature and in policy circles (FAO 2011).

Historically, intensification pathways have been focused on staple crops, as they are important sources of food for growing urban populations. Indeed, the

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Asian Green Revolution was strongly focused on increasing productivity in rice specifically (Hayami and Ruttan 1971). In the case of sub-Saharan Africa, the major staple crop is maize, both in terms of production as well as dietary preferences and needs (Jayne, Mather, and Mghenyi 2010; McCann 2005). and as such, productivity changes in maize are of particular relevance to understand intensification pathways, whether sustainable or not. To this end, we use longitudinal quantitative data from 2008 onwards covering 999 smallholder maize farmers in 23 villages across three African countries: Malawi, Tanzania and Zambia, and combine these with qualitative, intra-household data collected in nine villages to focus on the gendered aspects of intensification dynamics in maize. The three countries provide variation in terms of socio-economic conditions, political context and broader agricultural policies, but all contain an explicit targeting of women in their maize policies and as such present interesting possibilities for comparison.

This article sets out to answer four research questions based on a social science, mixed methods approach. Firstly, given the widespread documentation of lower agricultural productivity among female farmers, we consider whether gender-based yield gaps in maize reflect this shortfall also over time – that is do we see the expected pattern in the case of the studied sites? Secondly, we trace the sources of gender-based yield gaps and analyze any country-level differences in such patterns over time. Thirdly, we discuss the significance of the findings for agricultural policies and interventions in the context of smallholder livelihoods. Finally, we consider the theoretical implications of the study for the understanding of gender-based yield differentials and the relationship between labor, land and productivity in processes of agricultural intensification more broadly.

Conceptual framework – linking agricultural intensification to gendered productivity differentials

Intensification in staple crops is considered one of the key agricultural processes tied to broader macro-level processes of structural transformation. The latter move countries from dependence on agriculture into manufacturing and service-based economies and as such are crucial components of macro-level development trajectories. Raising agricultural productivity in the staple crop sector – historically the major employer in a country that has not undergone the structural transformation – enables the production of surplus food and the release of both food and people to growing urban areas (Chenery and Syrquin 1975; Haggblade 2007; Timmer 2009). In the case of the Asian Green Revolution,

as noted above, rice based intensification was the main driver of productivity increases in the smallholder sector. As such, productivity improvements in the staple crop sector are considered vital to rural transformation as well as broader structural change.

With respect to gender specifically, gender-based productivity gaps have been documented by agricultural economists in a number of African countries, showing lower productivity on plots managed solely by female farmers (Alene et al. 2008; Doss and Morris 2001; Horrell and Krishnan 2009; Kumase, Biseleua, and Klasen 2008; Oseni et al. 2015; Palacios-López and López 2015; Slavchevska 2015; Tiruneh et al. 2001; Udry et al. 1995). Gender-based variation in productivity is connected to differential access to agricultural resources, for instance, land, labor, technology, capital, extension services and markets (Doss 2001; Meinzen-Dick et al. 2010; Quisumbing and Pandolfelli 2010). Whether unequal control over resources is tied to a generalized discrimination of women (FAO 2011), if gender-based gaps in yields and incomes are contextual and related to local gender norms for instance (Andersson Djurfeldt, Djurfeldt, and Bergman Lodin 2013; Andersson Djurfeldt 2018a; Larson et al. 2015; Oseni et al. 2015; Slavchevska 2015) or whether such shortfalls are connected to labor market discrimination *outside* agriculture (Palacios-López and López 2015) has not been empirically established, however. While this literature documents productivity gaps, there are few studies of geographical differences in such gaps (as noted by Slavchevska 2015), while the influence of policies and localized gender norms is assumed, rather than qualitatively analyzed. A presumption in some of the theoretical literature, however, is that enhanced female control over resources would contribute to closing the productivity gap between men and women, directly or indirectly, through improving access to capital (Agarwal 2003a, 2003b), bolstering the ability to withstand shocks (Duflo and Udry 2004) and the possibilities of recovering from poverty (Doss 2006).

In policy circles, closing the gender gap in agriculture has increasingly been viewed as a panacea for dealing with productivity shortfalls, empowering women and feeding growing urban populations (see FAO 2011). More recently, this ambition has been linked also to the concept of Sustainable Intensification, as equity and social justice concerns have been raised in relation to this (Hagggar, Ramboll, and Nelson 2018; Loos et al. 2014). While gender gap analyses have been carried out within the field of agricultural economics, sustainable intensification perspectives have their origin primarily in the natural sciences. Here sustainable intensification has emerged as an approach that nuances and questions the

economic productivity biases and blueprint methodology of conventional intensification methods, such as the erstwhile Green Revolution policies. Sustainable intensification in its original formulation is defined as ‘producing more output from the same area of land while reducing the negative environmental impacts and at the same time increasing contributions to natural capital and the flow of environmental services’ (Pretty, Toulmin, and Williams 2011, 7). Sustainable intensification approaches are outcome focused in the sense that they do not prescribe particular technologies or methodologies for reaching this goal (Pretty and Bharucha 2014). This lack of practical clarity has led to criticism that the discourse around sustainable intensification is being hijacked by ‘productivist’ interests (Petersen and Snapp 2015; Pretty and Bharucha 2014). More recent contributions stress the differences between ‘earlier manifestations of intensification because of the explicit emphasis on a wider set of environmental as well as socially progressive outcomes’ (Pretty et al. 2018, 442).

The practical question of how to measure intensification varies: implicit in the production focus of sustainable intensification is productivity as yields, whereas agricultural economists also measure land productivity in terms of harvested value per unit of land (Slavchevska 2015), while gender gaps in productivity can also concern differences in labor productivity (Palacios-López and López 2015). Although the concept of sustainable agricultural intensification presupposes a multi-dimensional approach to both sustainability as well as intensification, our focus in this paper is on one measure of intensification – changes in maize yields over time, as well as one measure of social sustainability, that is how such changes affect female and male

landholders respectively. This choice is premeditated by the original design of the study as well as the nature of the data, which limits the possibilities for comparing yields among women and men more generally and also excludes more broad-based measures of agricultural intensification. Despite these limitations, we suggest that pinpointing the sources of gender gaps as well as understanding their causes offers important policy lessons, as well as possibilities for theorizing the concept of agricultural intensification further.

National productivity trends in maize and maize policies in Zambia, Malawi and Tanzania, 2008–2017

Countrywide data on changes in maize productivity for the three countries provide a national contextualization of intensification trends over the past decade, indirectly reflecting variations in land-labor ratios, climate and soil conditions for instance. Differing policy approaches, broader structural characteristics and historical trajectories also offer explanations for disparities and provide a necessary backdrop to the more localized analysis of the empirical data used in this paper.

Nationwide data on maize yields from FAO (see Figure 1) clearly illustrates countrywide differences in average maize yields over the past decade (covered by our study), showing a rise and then a drop in yields for Malawi, largely stagnant productivity for Tanzania and gradually increasing yields for Zambia. Yields were similar for Tanzania and Malawi in 2008, and gradually rose in Malawi over the period, but then dropped to converge with Tanzanian data, standing at around 1500 kg/ha for both countries by 2016. Meanwhile, yields in

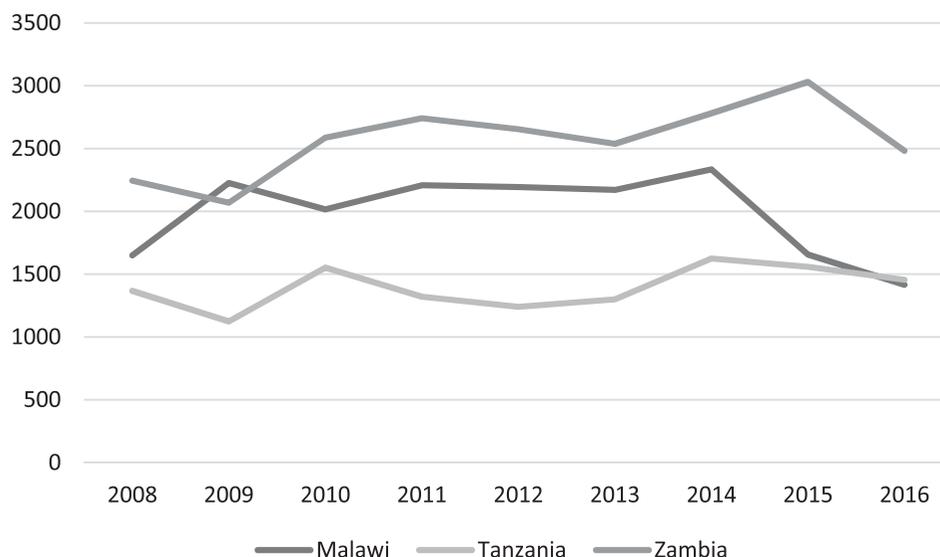


Figure 1. Average yields for maize by country, 2008–2016, kg/ha. Source: FAO-Stat.

Zambia, have increased to around 2500 kg/ha by 2016, widening the gap with the other two countries to around 1000 kg/ha. The dual structure of landholdings, especially in Zambia, where large scale, highly mechanized maize producers co-exist with smallholder production is likely to affect yields at the national level positively, and as such the figures in the graph cannot be directly compared with our yield data.

To some extent, yield data are reflective of the role assigned to maize in agricultural policies that focus on intensification, smallholders and self-subsistence. Maize dominates production patterns as well as diets in the case of Malawi, with Dorward et al. (2008) noting that between 93% and 99% of farmers in the four regions of the country grow maize. Intensification of maize production has therefore been a natural focus of Malawi's agricultural policy for many decades, following the common approach of state-controlled marketing boards and price controls in the 1980s and early 1990s and a more piecemeal approach in the late 1990s. In the teeth of strong donor resistance, a more comprehensive input support program – the Farm Input Supply Program (FISP) was established in the 2005/2006 growing season as a response to widespread shortages of maize in the previous year (Andersson 2011). The focus of the program is largely on providing subsidized maize seed and fertilizers, with Chirwa and Dorward (2013, 103) estimating that 79% of rural households were beneficiaries of the program in the 2010/2011 growing season. The program has specifically targeted vulnerable groups of farmers, for instance, female headed households since the 2008/2009 growing season (Andersson Djurfeldt et al. 2018; Mvula and Mulwafu 2018).

In Zambia as well as Tanzania, variations of input supply programs have existed for several decades, in the case of Tanzania on an on-and-off basis. In Zambia, agricultural policy, especially related to maize production, marketing and pricing, has been considerably more active than in Malawi and Tanzania. In the former case, the food security implications of an economy that has historically depended on mining and a relatively urbanized population have not been lost on successive policy makers. Boosting production and commercialization among small-scale maize producers has been the prominent goal of agricultural policy since the post-Independence era. The familiar pattern of post-independence state support being temporarily discontinued in the structural adjustment era to re-emerge again in a modified fashion in the mid-1990s is repeated also in Zambia. Here the Food Reserve Agency (FRA) was established in 1995 (replacing the former National Agricultural Marketing Board and the

Zambia Cooperative Federation) as a marketing board offering above market prices in selected regions considered to be of strategic importance to food security. The dominance of the FRA as a buyer of smallholder produce is suggested by Mason and Myers (2013) who report that the FRA procured between 30-86% of maize marketed by this group of farmers between the 2004/2005 and 2010/2011 growing seasons, at a cost of roughly a quarter of annual public sector spending on agriculture. The FRA infrastructure has expanded gradually since the mid-1990s, with the state playing a growing role in output markets. In practice, the erratic operation of the FRA, especially delayed payments, marginalizes those farmers who have urgent needs for cash, while the ability to exploit the price gap between the market and the prices offered by the FRA has opened opportunities for assembling maize for resale at high profits (Andersson Djurfeldt and Hillbom 2016).

Input subsidy mechanisms were expanded and finetuned in parallel with the development of the FRA. The Fertilizer Credit Program was introduced in the 1997/1998 growing season, and eventually replaced by a more comprehensive subsidy scheme, the Fertilizer Support Program, which nonetheless prioritized specific groups of farmers. Renamed the Farmers Input Support Program (FISP) in the 2009/2010 growing season, the number of beneficiaries and the geographical reach of the program has gradually expanded, reaching 900,000 farmers in the 2012/2013 growing season (Ricker-Gilbert et al. 2013). Although FISP targets smallholders, the program has been criticized for marginalizing the poorer farmers in the sector, since households holding less than 0.5 ha of land are excluded. Inputs are accessed through membership in registered farmer co-operatives, women's clubs or youth associations, whose membership fees present further obstacles for poor households. Sitko and Jayne (2014) estimated that these criteria in practice excluded 15–20% of the smallholders from benefiting from FISP. The requirement of co-financing through individual payments when redeeming input vouchers, is another source of exclusion, that affects poorer households. This requirement and delays have persisted even after the rolling out of the FISP Electronic Voucher implemented by the Ministry of Agriculture initially as a pilot program targeting about 241, 000 farmers across 13 districts in Lusaka, Southern and Central provinces during the 2015/2016 farming season. The e-voucher system has broadened the focus of the original FISP to include livestock feed and farming implements in addition to the original seed and fertilizer subsidies.

In Tanzania, agricultural intensification has been the focus of the agricultural policies of successive

governments since the early 1970s. Msuya, Isinika, and Dzanku (2018) identify three phases of input subsidy schemes. In the first phase (1974–1984), comprehensive subsidies were geographically targeted to the major maize producing regions in the country. Like in Malawi and Zambia, high costs in combination with structural adjustment policies aimed at reducing public spending led to a phasing out of all subsidies by the mid-1990s. A second phase, like in the other two countries, involved the introduction of a partial subsidy in 2003, which was directed towards maize in particular and aimed to redress issues of low production and falling yields. This phase ended in the growing season of 2007/2008 with the introduction of the more comprehensive National Agricultural Input Voucher Scheme (NAIVS), which provided a 50% subsidy for chemical fertilizers and improved seeds for maize and rice in six high-potential regions of the country (Iringa, Mbeya, Rukwa, Ruvuma, Kigoma and Morogoro) (Patel 2011). The geographical coverage was expanded to cover sixteen regions in 2011 and the program was also extended to 2015, by the end of which it was estimated that demand for inputs would have risen to the extent that farmers would be prepared to access these entirely through the market. Beneficiaries to the program had to fulfill two specific criteria – they had to be able to co-finance the 50% subsidy for the input package and cultivate farm sizes below 1 ha. In cases where the number of households fulfilling these criteria were higher than the availability of vouchers priority was to be given to female headed households and farmers who had not been using improved inputs during the five years preceding the NAIVS (Msuya, Isinika, and Dzanku 2018; Patel 2011).

In some respects, the three countries are united by similar policy trajectories, reflecting also wider trends in sub-Saharan Africa more generally. All countries follow a path of strong state intervention in the post-independence period, which is replaced by a nearly absolute withdrawal of the state in the structural adjustment era, followed by piecemeal and targeted involvement from the mid-1990s that has gradually grown into more comprehensive and geographically far-reaching subsidy schemes. Zambia stands out, however with an active role being played by the state also in price setting. In terms of gender, specifically, since around 2010, subsidy schemes in all countries deliberately target female headed households or women more generally, reflecting a broader turn in agricultural policy towards empowering women (Deijl, Andersson Djurfeldt, and Jirstrom 2017). Nonetheless, the requisite for co-financing inputs in practice also excludes resource poor farmers, such as women, pointing to a mismatch between the broader policy aims and the detailed implementation of such policies.

Study design and methodology

The point of departure for this study is a quantitative dataset – the Afrint database, which was collected in six African countries (Ghana, Kenya, Malawi, Mozambique, Tanzania and Zambia) between 2002 and 2015 (Andersson Djurfeldt 2018b; Djurfeldt et al. 2005; Djurfeldt, Aryeetey, and Isinika 2011). In 2016, the final phase of the project was launched in three of these countries: Malawi, Tanzania and Zambia, with the database at present containing data for 1070 smallholder farmers in 21 villages in these countries. To triangulate the quantitative data we have also gathered qualitative data in nine of these villages (Andersson Djurfeldt et al. 2018; Andersson Djurfeldt and Hillbom 2016; Andersson Djurfeldt et al. forthcoming, 2018). The present paper synthesizes the findings from these sources.

Quantitative data

Quantitative data has been collected in four phases, starting in 2002, with exact data collection periods varying slightly among the countries. Data were collected in all countries in 2002 and 2008, and then in Malawi and Zambia in 2013 and Tanzania in 2015. The final phase of data collection was concluded in Malawi and Zambia in 2017, and in Tanzania in 2018. The original study aimed to analyze the potential for replicating an Asian style Green Revolution in the context of the African maize and cassava belt and data collection has therefore focused on production and sale of four major grain staples, maize, sorghum and rice, as well as cassava.

Following a multiple stage purposive sampling design, regions and villages within regions were selected that held what was perceived to be a latent potential for agricultural intensification. Areas that were deemed to be above average in terms of agro-ecology and commercialization were selected, but excluding well-known examples of ‘islands of intensification’ (Widgren and Sutton 2004), for example Machakos in Kenya and Mount Meru in Tanzania (see Djurfeldt et al. 2005 for a discussion of the original principles for site selection). The sampled regions are therefore not statistically representative, but would in a smallholder context be expected to be above average in terms of yields and production. A number of regions were selected in each country to provide variety in terms of agricultural and commercial dynamism and production systems. In the case of Malawi, four regions were selected, Shire Highlands, Bwanje Valley, Thiwi Lifidzi and Ntchisi, the reason being that each region represented a different cropping system, with two regions being considered above average and two below in terms of agro-ecology

and infrastructure. Morogoro and Iringa were selected in Tanzania and originally Mazabuka and Mkushi regions were selected in Zambia. Mazabuka was dropped in the final data collection round due to lack of financing, and the Zambia data therefore only contains one region. In total, therefore the dataset covers data from seven regions.

Villages were selected within each region – again to provide variety, particularly with respect to agro-ecology and potential for commercialization, the latter being related primarily to infrastructure and access to markets. Finally, within each village, households were randomly sampled, except for in the case of Tanzania where a random stratified sample was used. A balanced panel design has been used, where changes in the village population related to in-migration, for instance, has been taken into consideration. Households who have left the sample through outmigration have been replaced, while one descendent of late respondents have been sampled to maintain the representativity of the sample. The samples are representative at the village level. In total, 23 communities are covered by

the sample: 8 in Malawi, 5 in Zambia and 10 in Tanzania (see Figure 2).

The self-identified farm manager was interviewed on behalf of the household as a whole. In most cases, this person was also the household head, although there were cases where the farm manager was the *de facto* household head, with the *de jure* household head residing elsewhere. The use of the term household head here, therefore, refers to the *de facto* household head, with the aim being to capture the situation on the ground. While interviewing the farm manager on behalf of the household is problematic, since household level data obscures intra-household division of labor and access to resources and also presumes that the farm manager is sufficiently knowledgeable to provide information for all household members, lack of financing in the original study prevented more detailed data collection. The share of female managed farms was 28%, 35% and 35% in the case of Tanzania, Malawi and Zambia, respectively. While Slavchevska (2015) notes that in general female farm managers are older than male landholders, this is not the case for the sampled farmers: there were no



Figure 2. The study sites. Map by Maria Francisca Archila Bustos, made with Natural Earth.

significant differences in age of the farm manager in any of the countries, with the age on average being 51 years in Malawi, 54 years in Zambia and 52 years in Tanzania.¹

Here we use a subset of the quantitative data – the households who cultivated maize in 2008, 2013 and 2017.² We use descriptive data from repeated cross-sections to analyze trends in yields in maize over time, for male and female managed farms in the three countries. Household level data are used, where the farm manager has stated the production as well as the size of the cultivated area under maize for the year of data collection as well as provided recall data for the two previous seasons. Production data are supplemented by survey data on technology use to shed light on gender-based differences or the lack thereof. The technology data on maize production captured by the survey are limited and we, therefore, focus on two specific technologies, the use of improved seed and the use of inorganic fertilizer, with the qualitative data being used to supplement this data. In total, the subset for 2017/2018 covered 999 maize producing landholders in Tanzania (331, or 83.6% of the total sample), Malawi (403 or 99.5% of the total sample) and Zambia (265, or 98.9% of the total sample).

The survey data is used to document change over time. To understand the *causes* of such change, we complement the survey with qualitative data that can explain the emergence of particular patterns over time.

Qualitative data collection

Qualitative data were collected in nine villages – three in each country. The villages were selected based on trends in the quantitative dataset with the aim of unraveling the gender dynamics of what is described as pro-poor agricultural growth. As such, quantitative data for these villages had suggested patterns of increasing agricultural commercialization leading to inclusive growth (see Andersson Djurfeldt 2013) either between the first and second round of data collection, as was the case with the Malawian sites (Andersson Djurfeldt et al. 2018) and two of the Zambian sites (Andersson Djurfeldt and Hillbom 2016), or between the second and third phases of the project, as in Tanzania (Andersson Djurfeldt et al., forthcoming). In addition, data were collected from focus groups and key informants in three of the Zambian sites in November 2016 and July 2018, respectively.

Qualitative data were collected through a set of focus group discussions and key informant interviews facilitated by senior researchers in each country, as well as intra-household data collected by country teams of research assistants, trained in workshops before the start of data collection. A common interview guide was

used but adapted to local conditions in discussions with the country level research teams. Intra-household interviews were carried out with around 25 respondents in seven of the villages, selected from the quantitative dataset. Both spouses in nine jointly headed households, stratified into three groups by income per adult equivalent (below average, average and above average), as well as nine women heading their own households, were interviewed. The intention was to sample nine women heading their own households, stratified by the same income criterion. In general, it was difficult to trace and find female farm managers and they were also over-represented among households with low incomes. As such it became necessary to supplement the sample with additional female respondents. In total, we have data from around 200 intra-household interviews.

Key informant interviews were carried out with village leaders, extension officers, chairpersons of local agricultural co-operatives and irrigation schemes, representatives of local NGOs, water user's associations, the staff at local schools and women's groups. The set-up of key informant interviews varied with the institutional setting of the communities as well as the availability of respondents. Focus group discussions were organized with at least one group of female and male smallholders, respectively per village. Respondents were stratified by age and had not been interviewed as part of the quantitative study.

Our empirical analysis is based on comparing trends in the quantitative data using simple statistical techniques – analysis of variance of means between male and female landholders, and *t*-tests to establish statistical significance in changes over time. Due to the relatively small sample size, attrition and aspects of panel bias as the panel ages it is not possible to use regression analysis, rather the purpose is to qualitatively discuss the differences in yields and qualitatively situate these with respect to local, regional and national conditions. The analysis of quantitative data hence is enhanced by using qualitative data to explain the trends in the quantitative data, providing an understanding of local dynamics, situated in the broader national context of agricultural policies and structural change. Moreover, we recognize the shortcomings of our quantitative data and as such we use intra-household data to document gender-based differences *within* households, with respect to yields and access to agricultural assets.

Empirical analysis

We return now to the two empirical research questions posed in the introduction of this paper: whether there

are gender-based yield gaps in maize and if so, we wish to identify the sources of these gaps.

Gendered expectations – are there gender-based yield gaps in maize over time?

Given widely documented lower productivity on female managed plots in studies of African smallholder agriculture, the replication of such patterns among the sampled households would be expected. Still, as noted above, agricultural policies in all three countries have focused on intensification often in combination with the targeting of women and what is considered ‘other vulnerable groups’. An additional question arises out of this policy focus, however – that is whether intensification is indeed occurring at all?

Table 1 through Table 3, present data for maize yields over more than a decade. Data have been culled to remove cropped areas below 0.1 ha, since yield data from miniscule plots are tied to well-known issues of reliability. To account for inter-seasonal variability data from three seasons (the present season, and recall data from the previous two seasons) was used. Extreme cases were removed for the final variables, with a handful of cases being removed for each year and country.

As the first point of observation, it can be noted that the trends in yield data largely tally with the available national data from FAO-stat presented in Figure 1, and

Table 1. Maize yields, kg/ha for male and female landholders 2006–2017, Malawi.

Sex of landholder	2006–2008	2010–2012	2015–2017	Yield difference over time	Sig.
Male	1142	1197	1278	136	*
SD	700	841	829		
N	219	270	253		
Female	1164	1056	1144		
SD	688	703	937		
N	171	120	138		

Note: * refers to significance at the 10% level.

Table 2. Maize yields, kg/ha for male and female landholders 2006–2017, Zambia.

Sex of landholder	2006–2008	2010–2012	2015–2017	Yield difference over time	Sig.
Male	1507	1989	2183	676	***
SD	916	1081	1086		
N	181	186	174		
Female	1494	1547	1824	330	**
SD	831	922	970		
N	43	70	90		
Difference Male–Female		442	359		
Sig.		***	***		

Note: ***refers to a significance level of 1%, **refers to a significance level of 5%.

as such the general tendencies in the data replicate broader national trends, although yields from our dataset are generally lower. Secondly, the data show generally low average yields and largely stagnant yields over time. Zambia overall has much higher yields than the other two countries (see Table 2), but also in Zambia, average yields are generally far below maximum yields. In Malawi, a minor yield improvement can be noted, with a yield increase of 136 kg for male landholders since 2006–2008. In the case of Malawi, adverse weather conditions (flooding in 2015 and drought in 2016) provide some explanation for generally stagnant yields. Moreover, qualitative data suggest that local variation in commercialization patterns that focus on potatoes and tobacco in two villages may also contribute to lower yields for maize. Zambia is the only country with a sustained yield increase, and as such the only example of sustainable intensification over time. Here yields increased by 676 kg (45%) for male landholders and 330 kg (22%) for female farm managers between 2006 and 2008 and 2015–2017. For male farm managers, intensification occurred through a jump between the first and second phases of data collection, while for female farm managers there was a more gradual increase over time.

It appears therefore that intensification has benefited both male and female farm managers. Yield increases have however been accompanied by a persistent gender gap, of around 400 kg/ha, while male landholders have also disproportionately benefited from the intensification process, in the sense that their yield increase has been more than twice as high as their female counterparts’. In Tanzania (see Table 3) and Malawi, by contrast, yields are largely stagnant, while gender gaps are absent.

Two questions arise in this context, firstly, what is holding back intensification in the case of Tanzania and Malawi – essentially, why intensification has occurred in Zambia, but not in these countries, and secondly why intensification in the case of Zambia has generated a gender-based gap in productivity?

Table 3. Maize yields, kg/ha for male and female landholders 2006–2017, Tanzania.

Sex of landholder	2006–2008	2010–2012	2016–2018
Male	1291	1453	1327
SD	855	924	952
N	266	270	237
Female	1130	1334	1366
SD	889	1042	1007
N	60	82	90

Note: Tables only show statistically significant differences (either over time or based on the sex of the landholder), so in the table above the only statistical difference is found for male landholders’ yields over time.

Technology differences between the three countries

Total cultivated area (farm size) varies strongly between the countries, with average farm sizes being by far the smallest in the case of Malawi, where respondents on average cultivated 0.85 ha in 2017, compared with 2.14 ha in Tanzania and 2.11 ha in Zambia. Given the smaller farm sizes, and the constraints to productivity that may arise from these, relatively speaking the incentive to invest in technology that raises the productivity of land would be highest in Malawi. The data, however, suggest that technology uptake in land abundant Zambia is far higher and increasing compared with the other two countries.

For maize, two main technologies (for which we have data) are relevant: the use of improved seeds and the use of inorganic fertilizer. In 2008, 75% of the surveyed households in Zambia used improved seed varieties and inorganic fertilizer. This figure rose by more than ten percent for 2013, and by 2017, 94% of the respondents had planted an improved seed and also used chemical fertilizer. By contrast, only 50% of the households used improved seed varieties in Malawi in 2008, and an even lower share – 38% had access to inorganic fertilizer. These shares increased only marginally over time, with 55% and 60% of landholders using improved seeds and chemical fertilizer by 2017, showing lower uptake than reported by Chirwa and Dorward (2013). For Tanzania, shares were even lower, starting at 26% for improved seeds in 2008, and increasing only slightly to 34% in 2017. The use of inorganic fertilizer was slightly more widespread at the end of the final phase of the project, increasing from 24% in 2008 to 51% by 2018. In the case of Tanzania, high natural soil fertility in some of the study sites, especially within Kilombero valley, is used to explain the relatively low use of chemical fertilizer, whereas in Malawi, poor soil quality raises the need for nutrients. Nonetheless, in the case of Tanzania the gradual removal of the NAIVS from 2013 onwards, following earlier phases of expansion, explains the largely stagnant yields noted above.

We do not have data on the use of subsidized seed and fertilizer per se, but data on how respondents acquired maize seed is indicative of this. The growing importance of the state as a provider of seed fertilizer technology in the Zambian case is illustrated by data showing how respondents accessed improved seeds, where 23% stated that they received or purchased improved seed from extension agents, NGOs or other formal organizations in 2008, compared with 56% in 2017. In Malawi, by contrast, only 26% of the households that used improved seeds accessed them through these channels. While the

importance of seeds and fertilizer may be more important to raising land productivity especially in the context of land constrained Malawi, the availability of state-sponsored inputs explains the uptake of this technology in the extensive farming systems of Zambia. In the case of Tanzania, similarly yield differences should be placed in the context of agricultural policies that stress the dual role of both rice and maize as the drivers of agricultural intensification (Andersson Djurfeldt et al., forthcoming).

Gender bias of production systems

Since differences in seed fertilizer technology uptake explain country-level variation in yield trajectories over time, intuitively, the gender gap in productivity that emerged in Zambia between the first and second phases of data collection and has persisted into the final round of data collection should be possible to explain in the same way. Indeed, the slight increase in yields among male farmers noted for Malawi appears to be connected to higher use of inorganic fertilizer among male landholders, where 63% of the male respondents used chemical fertilizer compared with 54% of their female counterparts in 2017 – a difference that was statistically significant at the 10% level.

Zambian smallholder policies have been widely criticized for excluding smallholders, but at the same time make specific allowances for women through targeting women's groups as recipients of fertilizer seed technology. The data seem to suggest that policies and commercial opportunities have encouraged intensification among female landholders, but that male farmers have benefited even more, begging the question of why. The data on seed fertilizer adoption shows no gender-based differences for any of the years for the Zambian sample. This contradicts the qualitative data which identified the need for co-financing as a challenge for women in particular. This discrepancy may in part be related to the fact that the survey has recorded the uptake of a particular technology rather than the amounts of fertilizer used or the share of cultivated area planted with improved seed. Nonetheless, the lack of *any* gender-based household level differences suggests that the explanation for the yield gap may lie elsewhere.

Zambian production systems are largely extensive, with labor rather than land being the limiting factor of production. Despite the abundance of land, mechanization has occurred through the adoption of the plough as an implement for land preparation – between 2008 and 2017, the share of households who use a plough or a tractor for land preparation has increased from 25% to 43%. Qualitative data collected from a focus

group of farmers in one of the communities in July 2018, suggested that methods of conservation farming had been adopted in previous years in response to an outbreak of livestock disease, but had since been abandoned with the successful restocking of herds, possibly explaining the increases in ploughing. This finding is consistent with the data collected through focus group discussions in another community in 2016. Although there were no gender-based differences in the use of land preparation methods either at the start or end of the study – and as such women’s access to mechanization is unbiased, the control over mechanization varies greatly between the two groups of farmers and explains the yield gap in maize. This control comes in different forms and intersects with the strongly seasonal aspect of maize farming in the villages in question.

Firstly, the direct control over oxen differs strongly between male and female respondents, with 32% of male landholders reporting ownership of oxen in 2017, compared with 11% of female respondents, a difference that was strongly statistically significant (at the 0.01% level). Access to oxen had also increased over the period, while the gender gap broadened over the period. In 2008, none of the female respondents owned oxen, compared with 16% of the male farmers. The quantitative data are confirmed by qualitative interviews from a mixed group of farmers collected in July of 2018, who argued that a lack of ox-drawn implements and lack of oxen pose challenges for women in general. Those households who do not have access to oxen of their own are dependent on hiring labor and oxen from other households for land preparation. In addition, this data suggest a strong gender dynamic, with 91% of female headed households reporting that they hire labor for land preparation, compared with 66% of the male farmers, again a difference that is statistically significant at the 5% level. The income streams of male headed households confirm this picture of male control over land preparation technology: only 10 households reported earning cash income from leasing out farm equipment, 8 of these were men.

Qualitative interviews with a women’s focus group in one of the villages provide the link between lower yields and lacking control over land preparation: single women have to wait for their turn, and are not prioritized as they do not have men who can defend their interests. In the strongly seasonal context of smallholder farming, this affects their yields negatively. Earlier studies from the broader sample show that *de jure* female headed households, have poorer access to male labor in particular (Andersson Djurfeldt 2018a), whereas *de facto* female headed households (where a husband is not co-resident with the rest of the household) have labor profiles

largely similar to those of male headed households. For the 2017 data, labor does not appear to be a decisive explanation for yield gaps in the Zambian case, however. The share of male household members at 48% was slightly higher in male headed households than in households headed by women, where it stood at 44%, a difference that was statistically significant at the 10% level. Still, the number of workers was much smaller among female headed households, who on average had access to 3.62 workers compared with 4.70 for the male headed households, a difference that was strongly statistically significant. Surprisingly, labor shortages were reported by 45% of the male headed households compared with 43% of the female headed households, however. To the extent that labor was a limiting factor on production, it was unbiased in terms of gender. The explanation for this, in turn, may be related to the household structure in Mkushi district, where 52% of the respondents lived in extended families, suggesting a relative abundance of labor.

Whereas the Mkushi production systems, in general, are extensive, gender-based differences related to the degree of land abundance exist *within* such systems. Qualitative data link the relatively smaller land resources of female landholders to gender-based yield gaps, as female farmers do not practice crop rotation because of smaller farm sizes. Gender-based discrepancies in farm sizes are strongly reflected also in the quantitative data, with female farm managers on average cultivating nearly a full hectare less than their male counterparts in 2017, 1.60 ha compared with 2.40 ha, a difference that is strongly significant at the 0.1% level.³ Qualitative data from the Chief in one of the villages as well as information from a mixed focus group of farmers, suggest that land access and registration is supported at the central level, with land being easily available from the Chief. The constraint to land for female headed households rather lies in the access to family land, where clan and family land is restricted – a situation which biases women. Limited land sizes, therefore, constitute a damper on productivity for female farm managers in particular. At the intra-household level, similarly, different, gender specific conditions may be limiting productivity for women specifically, although productivity for the farming system as a whole is not generally affected by these factors. In this context, qualitative data points to an internal division of labor and resource access where men control both subsidized fertilizer as well as women’s labor and time, leading to lower productivity on women’s plots compared with men’s plots.

In the case of Malawi, input policies have also targeted vulnerable groups such as women heading their own households, but as shown by the data only male

landholders have achieved a small increase in yields over time, which appears to be related at least in part to differential access to inputs such as fertilizer and seeds. Farming systems in the Malawian villages are highly labor intensive but based almost entirely on manual labor. Small, fragmented landholdings (with parcels of land being located in different parts of the village), as well as the topography of the communities and high poverty levels, prevent the use of ploughs. As such, mechanization and oxenization do not become differentiating factors of production. Varied access to labor provides further explanation for the yield gap in the case of Malawi – female farm managers on average had access to 2.45 able workers in 2017 compared with 2.90 workers for their male counterparts, a difference that was statistically significant at the 10% level. Among the female respondents, 40% reported having experienced labor shortages during the past year compared with 24% for the male farm managers (sig. at the 1% level). The labor intensity of the farming systems in the Malawian villages is confirmed by qualitative data, both at the intra-household and community level with farmers frequently describing single women heading their own households as the poorest households in the village (Andersson Djurfeldt et al. 2018).

Maintaining soil fertility in the communities is difficult as soil fertility is low, external inputs are few, the topography in many places is challenging and farming techniques rely on building ridges and terracing. Data shows a wholesale drop in intensification technologies, such as composting and green mulching, suggesting that labor intensity is increasing over time as soil fertility is falling. Access to extension and uptake of particular techniques remain a male domain, while household chores and the strongly gender biased care burdens of women, undermine the ability of single women to engage in agriculture. Divorces in the communities are common with detrimental effects for yield preservation, as described by one female respondent in her fifties:

Contour ridges were introduced by her former husband who has left her for another wife. This method was practiced for over five years until the husband left her two years ago. He was responsible for using it and since he left, the respondent finds it difficult to sustain the contour ridges due to the labour involved. It helped to control soil erosion and yields were considerable as the field is on steep slopes. The departure of the husband is contributing to the method to slowly die. (female divorcee, 50 years, average income)

At the intra-household level, external inputs (as in Zambia) are directed towards the male head of household – as the husband is listed as the beneficiary, with

qualitative interviews suggesting that the decision of what to do with the fertilizer (resell it for instance) rested with the husband. While Chirwa and Dorward (2013) show that in practice women are perceived as the guardians of household food security and as such subsidized fertilizer, in fact, decreases the bias against plots controlled by women (236–240), the listing of male household heads as beneficiaries strengthens the male household head norm. Moreover, practical issues tied to using fertilizer vouchers, for instance, restrictions on female mobility and the gender specific dangers involved in accessing fertilizer warehouses in practice restricts women's access to fertilizers (Andersson Djurfeldt et al. 2018; Chirwa and Dorward 2013).

In the case of Tanzania, as seen in Table 3, there are no gender gaps in maize yields, although yields, in general, are low as is the use of external inputs. The absence of gender-based productivity gaps for maize for Tanzania as a whole is shown by Slavchevska (2015) using data from the Tanzania National Panel Survey, as is the lack of general gender-based agricultural productivity gaps in the Southern Highlands and the Eastern Zone, where the studied regions are located. Nonetheless, ploughing has grown considerably since 2008, with the share of respondents using ploughs or tractors increasing from 24% to 52%, with no gender-based differences in their usage rates. In 2018, 31% of the respondents used oxen to plough, while 20% used tractors, showing a much higher degree of mechanization in Tanzania. Slightly more than a third, 36% of the respondents reported hiring farm labor for land preparation, with no difference between male and female farm managers. Ownership of oxen showed no statistically significant differences between the two household types, with 27% of female respondents stating that they owned oxen compared with 19% of male farm managers. Productive resources, hence are distributed equally between the two household types, which is also reflected in a lack of gender gaps. Qualitative fieldwork in the rice-growing communities covered by the dataset, confirms widespread growth in mechanization and the changing and increasing role of women in agricultural intensification processes more generally (Andersson Djurfeldt et al., forthcoming).

Intensification, agricultural policies and gender

The findings of the study suggest some crucial policy lessons related to intensification in general, but also with respect to gender patterns of resource access that

enables intensification. Here the relative importance of particular production factors for attaining yield increases may be different for sub-systems of specific production systems, while they can also vary between men and women broadly speaking, but also for women within male headed households and for women heading their own households.

At the national level, all three countries have as an explicit policy aim to enhance the opportunities for women in the agricultural sector. In practice, this translates into targeting female headed households, or women in subsidy schemes. Zambia and Tanzania have more far-reaching aims of redressing differences in gender-based access to land with certification schemes targeting female landholders being promoted in both countries. In Malawi, by contrast, apprehensions exist in terms of the new land policy and legislation regarding women's rights to land (Peters and Kambewa 2007). While changes to land policies may alter the structural condition of smallholder agriculture in the long run, in the short run, subsidized input schemes are the primary expression of agricultural policies in the daily lives of small-scale farmers in all countries. In the case of Zambia, the ambit of these subsidies has been broadened to enable also the buying of farm implements, whereas the other two countries have a preoccupation with fertilizer seed technology. In the case of Malawi, yield gaps are explained by poorer access to fertilizer and seeds and smaller labor resources, whereas in Zambia they appear to be tied to differences in oxenization and farm sizes between male and female farm managers. In all countries, gender specific obstacles exist to accessing subsidized fertilizers, the primary one being the requirement for co-financing by the recipient. A secondary one relates to mobility constraints caused by labor intensive domestic chores, care burdens and social norms that restrict women. Both of these suggest that policy measures to improve women's lot in agriculture may rest within as well as outside agriculture, on the one hand improving women's possibilities for income generation would ease some of the capital constraints that women experience, on the other hand freeing women from the drudgery of chores found mainly outside agriculture would ease the labor constraints of women heading their own households as well as women within male headed households. To this end, investments in child health facilities, electrification and clean water may be more important than improving women's access to farm seed technology.

A separate point relates to women who head their own households, who in effect lack male representation in the village context, effectively limiting their ability to participate in intensification processes through poorer

and less timely access to ploughing. Here social norms that consistently place women (whether as heads of their own households or within male headed households) at the back of the queue need to be redressed. In the qualitative data for Tanzania, the demonstration effect of successful wives was mentioned by male respondents, who argued that men who see the improved living standards of their neighbors connect this to better commercial opportunities for women. Disfranchising men of their superior access to agricultural resources, for instance through land reform programs that redistribute land from men to women, is a no-starter for achieving gender equality unless this process provides other tangible benefits for male farmers.

Conclusions

Several theoretical conclusions can be drawn from the study. It is clear that at a general level, also within a general system that is traditionally described as land abundant and labor scarce, considerable variation exists. Moreover, the gender dynamics within these systems, produce sub-systems, where limiting factors vary by gender, sometimes in opposing ways. The relative land scarcity of female farm managers in Zambia in the context of a largely extensive production system, in this sense more closely mirrors the production systems in Malawi, than the production being carried out by Zambian men within the same village. In turn, this suggests that the particularities of substitution (and by extension the possibilities for technology uptake) vary by gender even within the same locality. In such contexts, intensification pathways are therefore likely to be gender rather than location specific.

Within the context of broader perspectives of agricultural transformation that regard staple crop intensification (sustainable or not) as the stepping stone to long term structural change, obstacles to productivity increases among very resource poor farmers are leading to questions of whether such farmers can carry the smallholder model and whether scarce public resources would be better spent on targeting more successful farmers on the one hand and providing safety net arrangements on the other (Hazell 2015). Given that women's poorer access to agrarian resources is well-documented, the resource poor are likely to be over-represented among female landholders. An open question, therefore is whether comprehensive rural development policies that enhance income-earning opportunities in the non-farm sector in combination with agricultural interventions would be a more viable way of reducing poverty among women.

Notes

1. The relatively high age of the sampled farmers as well as the lack of a difference between male and female landholders could be related to the aging of the panel as well as a panel bias, where the more successful farmers stay in the panel and the less successful leave over time.
2. We exclude the first phase of the study, since the area held under maize in the case of Malawi was on average 0.13 ha, and this creates artificially high yields.
3. Seven extreme cases have been removed.

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