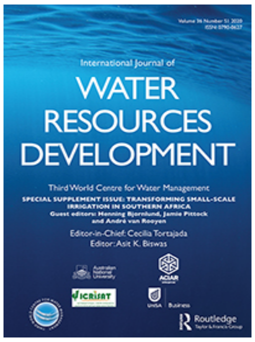

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International Journal of Water Resources Development

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/cijw20

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To cite this article: A. Manero , H. Bjornlund , S. Wheeler , A. Zuo , M. Mdemu , A. Van Rooyen & M. Chilundo (2020) Growth and inequality at the micro scale: an empirical analysis of farm incomes within smallholder irrigation systems in Zimbabwe, Tanzania and Mozambique, International Journal of Water Resources Development, 36:sup1, S224-S245, DOI: 10.1080/07900627.2020.1811959

To link to this article: https://doi.org/10.1080/07900627.2020.1811959

INTERNATIONAL JOURNAL OF WATER RESOURCES DEVELOPMENT
2020, VOL. 36, NO. S1, S224–S245
https://doi.org/10.1080/07900627.2020.1811959

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Growth and inequality at the micro scale: an empirical analysis of farm incomes within smallholder irrigation systems in Zimbabwe, Tanzania and Mozambique

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ABSTRACT

The mechanisms linking growth and inequality are critical for poverty reduction, yet they remain poorly understood at the micro level, as current knowledge is dominated by country-wide studies. This article evaluates farm income growth and changes in inequality among five smallholder irrigation communities in Mozambique, Tanzania and Zimbabwe. Over the period of study, the poorest sections of the population became better-off. Over an income growth spell, at low levels of growth, relative inequality increases, but it starts to drop as growth rises beyond a certain rate. Thus, careful design is required to ensure that pro-growth strategies also become inequality-reducing.

ARTICLE HISTORY
Received 20 January 2020
Accepted 10 August 2020

KEYWORDS
Inequality; economic growth; agricultural development; irrigation; sub-Saharan Africa

Introduction

The 2015 Sustainable Development Goals (UN, 2015b) identify poverty, growth and inequality as three key areas of intervention towards the UN's 2030 Agenda for human well-being and environmental sustainability. The Sustainable Development Goals constitute an integrated strategy, in which individual goals are interlinked. Importantly, the interconnection between poverty, growth and inequality (PGI) is grounded on long-lasting economic theory and numerous empirical studies (Adelman, 1973; Ahluwalia, 1976; Atkinson et al., 2009; Bourguignon, 2004; Dollar & Kraay, 2002; Ferreira & Ravallion, 2008; Fosu, 2017; Kanbur, 2005; Kuznets, 1955; Ram, 1988; Ravallion, 1997, 2014; Sen, 1973). As Bourguignon (2004, p. 2) explains, such linkages are captured in the PGI triangle, given that 'poverty reduction in a given country and at a given time is fully determined by the rate of growth of the mean income of the population and the changes in the distribution of income'.

According to the latest comprehensive data on global poverty, 736 million people (10% of the global population) lived in extreme poverty in 2015, down from 1.85 billion

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Supplemental data for this article can be accessed here.

(35%) in 1990 (World Bank, 2018b). Extreme poverty is defined as average daily consumption of USD 1.90 (purchasing power parity, PPP) or less, and means living on the edge of subsistence (World Bank, 2019a). Although poverty rates have declined across all regions, progress was uneven and mainly driven by China, Indonesia and India. In sub-Saharan Africa (SSA), extreme poverty dropped from 56% in 1990 to 41% in 2015. But with the doubling of the subcontinent's population, the absolute number of extreme poor increased by 9 million, to 413 million. Today, over 50% of the world's extreme poor live in SSA, a proportion expected to rise to 90% by 2030 (World Bank, 2018b).

Over the last three decades (1990–2017), SSA's annual GDP has grown by an average of 3.7% (World Bank, 2019a). Although sustained growth has reduced the poverty headcount, growth spells are often accompanied by rising inequality (Ravallion, 2001, 2014). Today, not only do two in five sub-Saharan Africans live in extreme poverty, they do so amid some of the world's starkest wealth and income inequality (World Bank, 2019b). Economic inequality remains a matter of concern due to its links to extreme poverty (Ravallion, 1997), corruption (Khagram, 2005), political stability (Alesina, 1996) and social mobility (Rothman, 2015).

According to data from the World Bank (2019b), the world's eight most unequal countries (by Gini coefficient) are in southern Africa, with South Africa (0.63), Botswana (0.61) and Namibia (0.59) heading the list. Mozambique (0.54), Tanzania (0.38) and Zimbabwe (0.43) rank, sixth, 64th and 34th, respectively, out of 146 countries. These three countries also score among the world's lowest on the Human Development Index, a composite of average life expectancy, education and income (UNDP, 2017). On a scale from 0 to 1, the 2017 scores were Mozambique 0.44, Tanzania 0.54 and Zimbabwe 0.56, putting them 180th, 154th and 156th out of 189 countries (UNDP, 2017).

The associations between poverty, growth and inequality are particularly important in rural areas, where poverty is most prevalent, typically above 70%, and where agriculture is the principal source of income (World Bank, 2019b). Agriculture-driven economic growth can become a vector for poverty reduction if it is not accompanied by extreme inequality, including in income and land (FAO, 2003). Importantly, (rural) populations may become worse-off during growth spells, even if poverty falls as a national average (Manero, 2018; Ravallion, 2001).

Despite the specific importance of poverty, growth and inequality for rural development, much of the empirical literature is dominated by macroeconomic studies (Atkinson & Lugo, 2010; Dartanto & Patunru, 2015; Ferreira & Ravallion, 2008; Fosu, 2017; Go et al., 2007; Hartmann et al., 2016; James et al., 2005; Kabubo-Mariara et al., 2012; De Silva & Sumarto, 2014; Thorbecke, 2015; Virtanen & Ehrenpreis, 2007), which are facilitated by readily available national and international statistics (CIA, 2019; UNDP, 2019; World Bank, 2019b). However, growth and distributional change at small scales remains under-studied (Ferreira & Ravallion, 2008), partially due to the difficulty in collecting the required data. As Ravallion (2001, p. 1803) explains, only through micro-empirical work will we 'have a firm basis for identifying the specific policies and programs that are needed to complement growth-oriented policies'. Hence, studies in SSA have emerged that demonstrate how inequality *within* agricultural groups can be the main driver of total inequality (Cogneau et al., 2007), and that the impact of growth on inequality may vary widely across villages and over time (Takane & Gono, 2017).

The purpose of this study is to contribute to the literature on growth and inequality at the micro scale in SSA. We use data from five irrigation communities in Mozambique, Tanzania and Zimbabwe, collected through two rounds of household surveys in 2014 and 2017, as part of an overarching research-for-development project. The study evaluates distributional changes in land use, crop production and farm incomes, and how they relate to agricultural development interventions during this period. Further, the study seeks to understand whether growth and inequality dynamics previously observed at the macro scale are also verified at the local level.

Literature review

The importance of economic inequality in rural development

In the context of international development, a key concern is the well-being of the population, which depends on a variety of social, political and economic factors, such as health, education, freedom and security (Van Phan & O'Brien, 2019). To capture these, a number of composite indices have been formulated (Booysen, 2002). A limitation of these indices is that they require a wide range of data often unavailable at subnational levels (e.g. regions or villages). Thus, straightforward indicators such as levels of poverty, inequality and growth are often used.

Economic inequality, whether in terms of income, expenditure or wealth, has long been recognized as a major obstacle to poverty reduction at global, continental and national scales (Ravallion, 2014). Kuznets (1955) theorized that, over time, economic growth and inequality follow an inverted-U curve, whereby inequality rises with growth in the short term, but trickle-down effects will narrow the gap in the long term. Early empirical studies of rising inequality in developing countries supported this hypothesis (Ahluwalia, 1976; Ahluwalia et al., 1979; Robinson, 1976; Srinivasan, 1977). But in an initial review of growth and social equity in developing countries, Adelman (1973) raised concerns about increasing relative and absolute poverty; the lack of evidence of trickle-down effects; and the importance of relationships among income groups as a determinant of income distribution. Ram (1988) later argued that the internationally observed inverted-U relationship was due to structural differences between developed and developing countries, and that such a pattern was not replicated in samples of developing countries only.

As more data became available in the 1990s, further empirical studies emerged that analyzed the PGI nexus across countries and over time. Two important determinants of how much the poor benefited from economic development were the level of initial inequality, and changes in inequality during growth spells (Bourguignon, 2004; Ravallion, 2001; Ravallion & Chen, 2003). The PGI triangle explains that at any positive rate of growth, the greater the initial inequality, the slower income-poverty falls. Moreover, with very high inequality, it is possible for growth to result in greater poverty (Ravallion & Chen, 2003).

Analyzing data from 130 countries over 25 years, Ferreira and Ravallion (2008) found a clear negative association, globally, between inequality and development. In a comparative analysis of PGI across developing countries, Fosu (2009) found that the greater the initial inequality, the lesser the impact of GDP growth on poverty reduction. Importantly, the responsiveness of poverty reduction to growth was substantially lower in SSA than in other developing regions. Further, analyzing PGI links across 123 developing countries from 1997 to 2007, Fosu (2017) identified average income growth as the main driver of poverty reduction; but inequality, both at the start of and during the growth period, played a decisive role in determining *how much* poverty declined. Fosu's studies highlight the need for policy makers to look beyond averages and consider country-specific drivers of PGI.

In Tanzania, between 1983 and 1991, agricultural reforms brought higher commodity prices and incomes for some farmers, who could then escape poverty. However, less advanced farmers were left behind, resulting in a 40% increase in income inequality (Ferreira, 1996). If income distribution had not changed during this period, then assuming the same growth, poverty reduction would have been much greater: 39% instead of the actual 14%. More recently, a study analyzing the 2000–2007 growth spell in Tanzania concluded that greater poverty reduction could have been achieved if the absolute increases in real income had been more evenly spread (Atkinson & Lugo, 2010). Similarly, between 1995 and 2002 in Mozambique, incomes rose in rural areas a result of higher food prices. But then 60% of rural households, who were net grain buyers, were hurt by declining purchasing power and eroded welfare levels (Boughton et al., 2006). Economic inequality in Zimbabwe is partly due to its agrarian socio-economic situation, still reflecting the legacy of the colonial era, the civil war and the reforms of the late twentieth century. Throughout the 1980s and 1990s, Zimbabweans' livelihoods deteriorated significantly, as a result of recurrent droughts and issues associated with land reform (Kinsey, 2010; Mazingi & Kamidza, 2011).

While the literature on PGI is predominantly based at the macroeconomic level, there is a need to understand growth and distributional change at the micro (local) scale (Ravallion, 2001). In a review of studies across SSA, Thorbecke (2012) explains that the interconnection between growth and inequality may lead many households to remain trapped in vicious circles of poor education, health and livelihoods. In the context of rural development, particularly that of smallholders, irrigation is often suggested as an effective strategy for welfare and development (De Bont & Veldwisch, 2020; Kannan & Anandhi, 2020; Nonvide, 2018), yet a growing body of literature raises fundamental questions regarding its implications for equity and social justice (Giordano & De Fraiture, 2014; Gorantiwar & Smout, 2005; Lefore et al., 2019; Van den Berg & Ruben, 2006). As noted by Lipton et al. (2003, p. 414), 'the poor are not a homogenous group', and thus irrigation may impact them differently. Kanbur (2005, p. 229) points out that, while common analyses focus on the rich–poor gap, poverty reduction polices can 'pit some poor against other poor' as a result of aggravated disparities among them. Studies among rural communities in developing countries have found that the largest driver of total inequality is inequality *within* groups of households having agricultural and non-agricultural incomes, rather than disparities *between* groups (Cogneau et al., 2007; Manero, 2017). Importantly, the level of impact and direction (increasing or reducing) of inequality drivers may vary considerably across locations and time (Takane & Gono, 2017).

Measures of inequality

Many different measures exist of economic inequality, although monetary figures (i.e. income or consumption) are the most common (McKay, 2002; Sahn & Stifel, 2003). Typically, international inequality figures are based on household income, including those of the World Bank (2018a), UNDP (2019), and CIA (2019). The Gini (1912) coefficient is the most popular inequality measure, given its relative ease of calculation and comparison across countries and population sizes (Bellù & Liberati, 2006; Manero, 2017). It measures the degree to which the distribution of income (or any other metric) differs from a perfectly equal distribution across all individuals in a group (World Bank, 2011). Its value ranges from 0 to 1 (from total inequality to total equality). The coefficient can also be decomposed by source (Lerman & Yitzhaki, 1985), which provides an understanding of which sources of income (or consumption) are the strongest drivers of total inequality. Hence, it remains the most commonly used measure of inequality, including in the PGI literature (Atkinson et al., 2009; Biancotti, 2006; Bourguignon, 2004; Dollar & Kraay, 2002; Ram, 1988; Ravallion, 2014). However, it also has important limitations, notably its difficulties in handling negative values (Chen et al., 1982; Manero, 2016; Raffinetti et al., 2014b), its not being decomposable by population subgroups (Bourguignon, 1979), and its high sensitivity to inequality in the middle of the income distribution (De Maio, 2007).

Another easy-to-interpret measure of inequality across populations of different sizes is the decile dispersion ratio or inter-decile ratio (UN, 2015a). These are based on the extreme ends of the distribution: they compare the average income (or income share) of the top *x*% to the bottom *x*% of the population. Two of these, often used, are the income quintile ratio and the Palma ratio. The income quintile ratio (or 20:20 ratio) is the average income of the top 20% over the average income of the poorest 20% (UNDP, 2013). The Palma ratio (Cobham & Sumner, 2013; Palma, 2011) compares the top 10% to the bottom 40% and has been used in the Global Monitoring Report (World Bank & IMF, 2016).

Materials and methods

Study sites

This study is part of the Research for Development project Transforming Small-Scale Irrigation in Southern Africa and focuses on the changes that occurred over the course of the project, from 2013 through 2017. The project covers six smallholder irrigation schemes, two in each of Mozambique, Tanzania and Zimbabwe. These three countries were selected following a scoping survey of nine countries, evaluating a range of factors, including national institutions, research capacity, irrigation development, and the potential to increase food production (Bjornlund et al., 2019; Wheeler et al., 2017). The six schemes were selected based on their potential to improve agricultural practices, accessibility, institutional capacity and collaboration with local agencies. In the three smallest schemes – Mkoba (Zimbabwe), 25 de Setembro and Khanimambo (Mozambique) – all households in the irrigation community were targeted, although some farmers were absent or chose not to participate. In Silalatshani (Zimbabwe), Kiwere and Magozi (Tanzania), the population was stratified based on gender and wealth category (poor, medium or well-resourced), and then 100 were randomly sampled (Manero, 2017). During a severe flooding in 2015 at the Khanimambo scheme, the pump and infrastructure were damaged, and irrigation largely stopped, so it was removed from this study.

The project carried out two major interventions in the schemes. One of them facilitated famer learning around soil-water-nutrients dynamics, though the use of soil moisture and nutrient monitoring tools (Stirzaker et al., 2017). Except for Magozi, where rice is flood-irrigated, the monitoring tools provide farmers with data about the crop’s water and nutrient availability, enabling more effective irrigation and fertilizer application. The other key intervention was the establishment of 'agricultural innovation platforms' to help farmers and their communities overcome barriers to higher productivity and profitability. For a discussion of these interventions and their outcomes, see Moyo et al. (2020) for Zimbabwe, Mdemu et al. (2020) for Tanzania, and Chilundo et al. (2020) for Mozambique.

The five schemes vary in size and type of irrigated crops (Table 1). Poverty rates within the Zimbabwean and Tanzanian schemes are considerably higher than their respective national levels, which in 2011 were 21% in Zimbabwe and 49% in Tanzania (World Bank, 2019a, 2019b). By contrast, Mozambique's national poverty rate of 62% in 2014 (World Bank, 2019a) is well above the 39% in 25 de Setembro. As detailed in Manero (2017), income inequality across all schemes exceeds those at national scales.

Data

Data were collected twice: a baseline survey in May and June 2014 and an-end-of-project survey between March and May 2017, re-interviewing the same participants as in 2014. However, as some irrigators were unable to participate in the second survey, the 2017 sample was smaller (Table 1). The loss of participants over time can result in attrition bias (Miller & Hollist, 2007) if individuals dropping out have unique characteristics (Hausman & Wise, 1979) – a common phenomenon in studies of farming communities across Africa (Sheahan et al., 2013; Verkaart et al., 2018). Non-parametric tests of statistical significance (Wilcoxon-rank sum and Kolmogorov-Smirnov, Table A1) were applied to detect differences between dropped and retained households (Kolmogorov, 1933; Wilcoxon, 1945). No statistically significant differences were identified in relation to the variables of this study, although attrition could be due to unobservable variables, such as migration or change in livelihood activities.

To allow comparison, this study uses a panel data set-up, which only includes households with data from both 2014 and 2017 surveys. The surveys used a combination of quantitative and qualitative questions, collecting information on family structure and characteristics, farm characteristics, revenues and expenses, agricultural production and sale prices (Manero, 2017).

This study uses gross income to measure inequality as it is a common approach across developed and developing countries. Accounting for expenses would result in negative farm incomes, which poses serious obstacles for the study of inequality (Chen et al., 1982; Manero, 2017; Raffinetti et al., 2014a). Gross income was computed as the cash received from the sale of irrigated and rainfed crops and livestock over the 12-month period prior to each survey. Income calculations could not include agricultural production used for self-consumption, such as chickens, maize, groundnuts or sugar beans, (Bjornlund et al., 2019; Moyo et al., 2017), because famers did not keep such records. While excluding self-consumption may lead to an underestimation of incomes, it is understood that variations across households due to crop self-consumption would be minor compared to income disparities from cash crops. Outliers were identified using summary statistics and graphical methods (Manero, 2018; Manero et al., 2019). After thorough verification of the data sets and consultation with expert in-country researchers, four observations were dropped from the overall sample, as their veracity could not be confirmed.

Table 1. Characteristics of the irrigation schemes and surveys undertaken in 2014 and 2017.

Country	Scheme	Major crops	Total irrigated area in the scheme (ha)	Poverty in 2013/2014[†]	Irrigator population	Survey participants 2014	Survey participants Retained in 2017
Zimbabwe	Mkoba	Maize, vegetables	10	81%	75	68	54
	Silalatshani	Maize, wheat, sugar beans	110	95%	212	100	72
Tanzania	Kiwere	Tomatoes, onions, leafy vegetables, green maize, rice	194	64%	168	100	60
	Magozi	Rice	939	53%	512	100	77
Mozambique	25 de Setembro	Vegetables (cabbage, green beans, tomatoes), maize	40	39%	38	25	19

[†]Percentage of households with average daily consumption of less than $1.90 PPP per adult equivalent. Source: Adapted from Mwamakamba et al. (2017) and authors' calculations.

In order to compare incomes between the start and end of the project, baseline survey figures were adjusted by the Consumer Price Index. Between May 2014 and March 2017, the changes in the index in Zimbabwe, Tanzania and Mozambique were −4%, 17% and 40%, respectively (Trading Economics, 2018). Given that the purpose of this study is to analyze changes in production, income and inequality within schemes, rather than between, monetary figures are kept in the local currencies.

Hypothesis

This study seeks to understand growth and inequality dynamics at small scales, i.e. within smallholder irrigation schemes. This includes changes in landholdings, crop production and incomes. Regarding the latter, a key question is whether dynamics observed at large (national) scales are also verified at small (local) scales. Therefore, departing from results from cross-country studies (Bourguignon, 2004; Ferreira & Ravallion, 2008; Ravallion, 2014), the following hypotheses were formulated, to be tested at the scale of small irrigation schemes:

H1: Over an income growth spell, initially high levels of income inequality are associated with lower growth rates (i.e. initial inequality hinders growth).
H2: Over an income growth spell, higher income growth rates are associated with greater declines in income inequality.

Inequality calculations

In this study, the Gini coefficient is used to calculate inequality in cultivated areas and farm household incomes by source. For comparison, income quintile (20:20) and Palma (10:40) ratios are also calculated on gross farm incomes.

This study adapts Ravallion and Chen's (2003) approach to calculate the growth rate of farm income mean by quintiles (ranked by income), in order to understand the growth rates among the poorest section of the population, and how they compare to those at the upper end of the distribution (the richest). Thus, population subgroups were defined by their economic status, based on total gross household income as a proxy. Using baseline data for 2013/2014, population samples in each scheme were divided into quintiles, where the first quintile is that of the poorest households, and the fifth quintile represents the top economic level. Then changes in farm incomes by quintile from 2013/2014 to 2016/2017 were calculated in absolute terms (local currency in 2017 prices) and in relative terms (change as a percentage relative to 2013/2014).

Differences between 2013/2014 and 2016/2017, by household, in cultivated areas, farm incomes and crop productivity (Tables 2–4) were tested using the Wilcoxon signed-rank test (Wilcoxon, 1945). This is the nonparametric equivalent of the paired *t*-test and checks whether two related samples originate from populations with the same distribution (Harris & Hardin, 2013). In this study, non-parametric tests were used because the data follow non-normal distributions and no assumptions can be made about the parameters characterizing the populations' distributions. Although the 25 Setembro scheme, in Mozambique, does not have enough observations for statistical tests to be robust, its results are reported for consistency across all schemes.

Results

Cultivated areas

Over the course of the project (2013/2014 to 2016/2017), when analyzing the data across both years, the changes in average area cultivated by household (irrigated, rainfed and total) are significantly positive across most schemes (Figure 1 and Table 2). In Zimbabwe, the average area irrigated per household more than doubled, while rainfed land grew by only one-third. In Tanzania, the expansion in rainfed area was the greatest of the three countries, whereas the increase in irrigated land was relatively modest. Magozi was the only scheme to see a decline in any of its average cultivated areas by household – a 9% drop in irrigated land. Magozi's significant increase in dry-land farming contrasts with the drop in irrigated area. In Mozambique's 25 Setembro, irrigated and rainfed areas contributed in approximately equal parts to the overall area increase per household. Detailed inequality statistics of cultivated areas are reported in Table A2 in the supplementary online materials.

The distribution of cultivated area among the population changed in all the schemes over the course of the project. However, half of these variations were only marginal, with the Gini coefficient of land distribution changing by less than 10%. In Tanzania, large expansions of rainfed land (51% and 140%) were accompanied by notable declines in inequality (−44% and −22%). Contrastingly, in Silalatshani, the mean irrigated area per household grew 1.5-fold, but distribution became more unequal (by over two-thirds), and 50% of the newly irrigated area was concentrated in 15% of the households.

Farm incomes by source

Changes in average farm income per household were mostly positive and statistically significant across schemes and sources (Table 3). Across the five schemes and both years, irrigated crops were the largest contributor to farm incomes, well above rainfed crops and livestock.

Table 2. Change in cultivated area per household between 2013/2014 and 2016/2017 in five irrigation schemes.

	Absolute change in mean cultivated area (ha)			Percentage change in mean cultivated area			Gini coefficient of total cultivated area	
Scheme	Irrigated	Rainfed	Total	Irrigated	Rainfed	Total	2013/2014	2016/2017
Mkoba	0.19***	0.24**	0.43***	112%	38%	54%	0.39	0.34
Silalatshani	0.65***	0.23	0.88***	150%	31%	74%	0.34	0.32
Kiwere	0.26**	0.50***	0.81***	24%	51%	37%	0.40	0.31**
Magozi	−0.10	0.47***	0.23*	−9%	140%	25%	0.42	0.42
25 Setembro	0.24**	0.25	0.49*	23%	38%	28%	0.33	0.35

***1%, **5%, *10% significance.

Table 3. Mean annual gross farm incomes per household by source in 2013/2014 and 2016/2017, at 2017 prices, in local currencies.

	2013/2014, at 2017 prices				2016/2017			
Scheme†	Irrigated	Rainfed	Livestock	Total	Irrigated	Rainfed	Livestock	Total
Mkoba	110	32	99	241	404***	97*	295***	796***
Silalatshani	231	78	127	436	854***	71	364***	1289***
Kiwere	1168	537	155	1861	1877***	992**	269***	3138**
Magozi	2,030	230	128	2389	1520*	194	417***	2131
25 Setembro	68,799	3021	8215	80,035	80,832	-	30*	80,862

† Mkoba, Silalatshani in USD; Kiwere, Magozi in TZS thousands; 25 de Setembro in MZN.
***1%, **5%, *10% significance.

Table 4. Mean crop productivity (in local currencies) in 2013/2014 and 2016/2017, at 2017 prices.

	2013/2014 (2017 prices)		2016/2017	
Scheme†	Irrigated	Rainfed	Irrigated	Rainfed
Mkoba	636	64	1344**	127
Silalatshani	537	93	854	133
Kiwere	1487	886	1663**	541
Magozi	1828	791	1549	181***
25 Setembro	71,586	8750	53,323	-

† Mkoba, Silalatshani in USD; Kiwere, Magozi in TZS thousands; 25 de Setembro in MZN.
***1%, **5%, *10% significance.

The Zimbabwean schemes (Mkoba and Silalatshani) experienced the largest relative gains, close to a three-fold increase between 2013/2014 and 2016/2017 (Table 3), presumably reflecting the significant increase in the area under irrigation (Table 2). In Tanzania, the Kiwere scheme saw farm incomes rise across the three sources. In Mkoba, Silalatshani and Kiwere, income increases from irrigated and rainfed crops are consistent with directional changes in cultivated area (Table 2). By contrast, in Magozi the only income rise in our panel data set was from livestock, while irrigate-crop incomes dropped by one-quarter. On average, Magozi's farm incomes fell by over one-tenth, although the differences are not statistically significant. Magozi was the only scheme experiencing a decrease in income from irrigation, reflecting a decrease in land under irrigation. In 2016/2017, farmers in 25 Setembro mostly grew rainfed crops for their own consumption, but not for sale. Irrigated income saw an absolute increase of about 17%, but this is not significant.

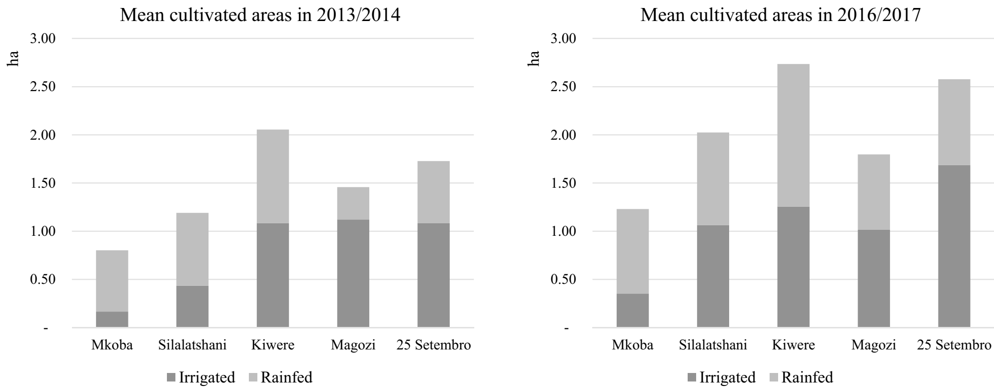

Figure 1. Average cultivated area per household in 2013/2014 and 2016/2017 in five irrigation schemes of Zimbabwe (Mkoba and Silalatshani), Tanzania (Kiwere and Magozi) and Mozambique (25 de Setembro).

Across all schemes and in both years, crop productivity – defined as crop income per cultivated area – was notably higher for irrigated than for rainfed crops (Table 4). Mkoba exhibits the biggest difference, with irrigated exceeding rainfed by a factor of 10. In 2016/2017, crop productivity in Mkoba was close to twice that of 2013/2014, though the changes are only statistically significant for irrigated crops. Irrigated and rainfed productivity in Silalatshani also rose (around 1.5-fold), although these were not statistically significant at the 10% level. In Tanzania in 2013/2014, income per hectare of irrigated crops was close to twice that of rainfed crops. By 2016/2017, the difference had widened, as a result of a sharp decline in rainfed productivity. Notably, the two Tanzanian schemes had comparable irrigated productivity, despite growing completely different crops. In Kiwere, a large variety of horticultural crops are cultivated year round, whereas Magozi operates as a one-season, rice monoculture scheme. In Mozambique (25 Setembro), irrigated productivity dropped by over 25%. Chilundo et al. (2020) report, based on detailed farmers' field book records of a subset of farmers growing green maize each season in 25 de Setembro scheme, significant yield and income increases for those farmers and that crop.

Farm income inequality

Measures of inequality and growth

Except for Mkoba, initial levels of farm income inequality were very similar (0.54–0.58) across the schemes. However, growth and inequality changes over time appear to be considerably different. The Gini coefficient and inter-decile ratios (Table 5) show an increase in farm income inequality between 2013/2014 and 2016/2017 in three schemes, though it is only statically significant in Mkoba (p = 0.019). In Zimbabwe and Tanzania, schemes within the same country experienced opposite directional changes in inequality. Farm income inequality dropped in Mkoba and Kiwere (−17% and −8%, respectively, in Gini coefficients), while it rose in Silalatshani and Magozi (3% and 9%, respectively). The greatest increase occurred in 25 Setembro (Mozambique), where the Gini coefficient grew by over one-tenth and inter-decile ratios more than doubled during the study period.

Table 5. Measures of inequality in total gross farm income between 2013/2014 and 2016/2017.

Scheme	Gini coefficient		Income quintile ratio (20:20)		Palma ratio (10:40)	
	2013/ 2014	2016/ 2017	2013/ 2014	2016/ 2017	2013/ 2014	2016/ 2017
Mkoba	0.73	0.61	n/a†	71	n/a†	7.6
Silalatshani	0.55	0.57	n/a†	36	0.8	5.1
Kiwere	0.57	0.53	62	26	5.3	4.2
Magozi	0.56	0.61	27	35	4.2	6.3
25 Setembro	0.56	0.63	8	16	5.4	10.9

Note: In 2013/2014 in Zimbabwe, the 20:20 ratio and the Palma ratio were by definition infinite, as the bottom quantile reported nil farm incomes.

Across all the schemes, the directional changes in the income quintile and Palma ratios are consistent with those observed in the Gini coefficient. Income inequality by source of farm income is reported in Table A3 in the supplementary online materials.

Regarding a possible negative effect of initial inequality on growth, Figure 2 displays 2013/2014 farm income Gini coefficients (*Y* axis) against annual growth rates (*X* axis). There is a positive association between growth rates and initial inequality (R^2 = 0.43), contrary to H1 (that initial inequality hinders growth). This suggests that, within the schemes of study, initial levels of inequality do not hinder future growth – contrary to trends shown by studies at national levels. It should be noted that the results are based only on five points, and that the Zimbabwean schemes (Mkoba and Silalatshani) may be considered outliers. To test for the influence of each individual scheme, sensitivity tests were conducted (Figure A1 in the supplementary online materials). While the results cannot be automatically generalized for other locations across the developing world, this evidence suggests a positive association between initial inequality and growth rates.

To test H2 (faster income growth is associated with greater declines in inequality), changes in farm income inequality (points in the Gini coefficients per year on the *Y* axis) were plotted against farm income annual growth rates (*X* axis in Figure 3). The data seem to display an association between higher growth rates and falling inequality. Remarkably, the two Zimbabwean schemes had similar annual growth rates, but a sharp contrast in inequality. Over the three-year period, Mkoba's farm income Gini coefficient fell by 13 points, whereas in Silalatshani it increased three points. In Magozi and 25 Setembro, not only did incomes fall (negative growth), the resulting income distribution was more unequal (higher Gini coefficient).

Changes in household farm income by income quintile

Changes to farm incomes of the first quintile (poorest 20%) were positive and statistically significant (Figure 4) and represented the largest income gains, both in absolute (local currency) and relative (percentage) terms – except for Mkoba, which came third in dollar terms. Detailed statistics of changes in farm incomes from 2013/2014 to 2016/2017 by quintile are reported in Tables A4–A6 in the supplementary online materials.

In Tanzania, the second quintiles were the second-largest beneficiaries, by absolute and relative measures, whereas the fourth and fifth quintiles perceived the smallest gains, and even losses in most cases – albeit without statistical significance. Kiwere's three bottom quintiles increased their average farm incomes by close to TZS 2 million per year, equivalent to the 2017 national average GDP per capita (National Bureau of Statistics, 2018).

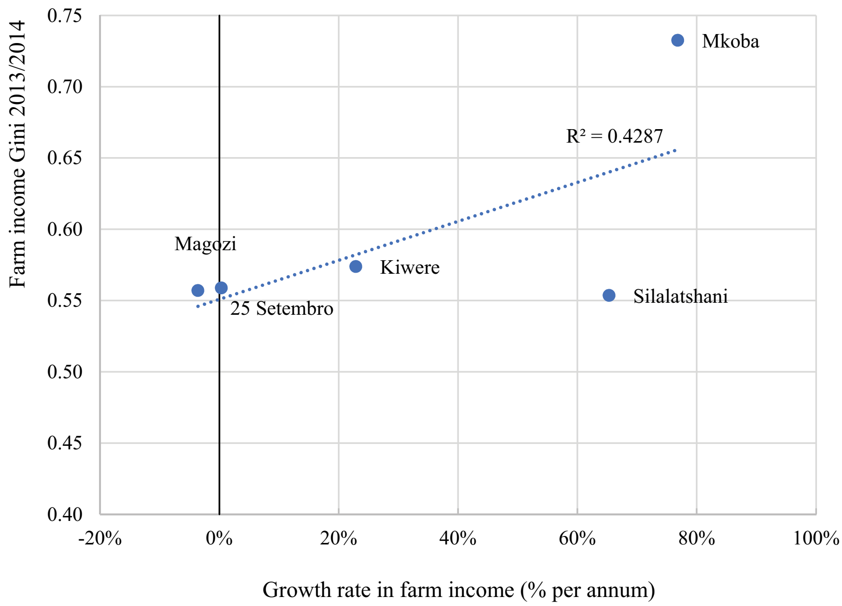

Figure 2. Initial farm income inequality and annual farm income growth (averaged over the three-year period) across five schemes.

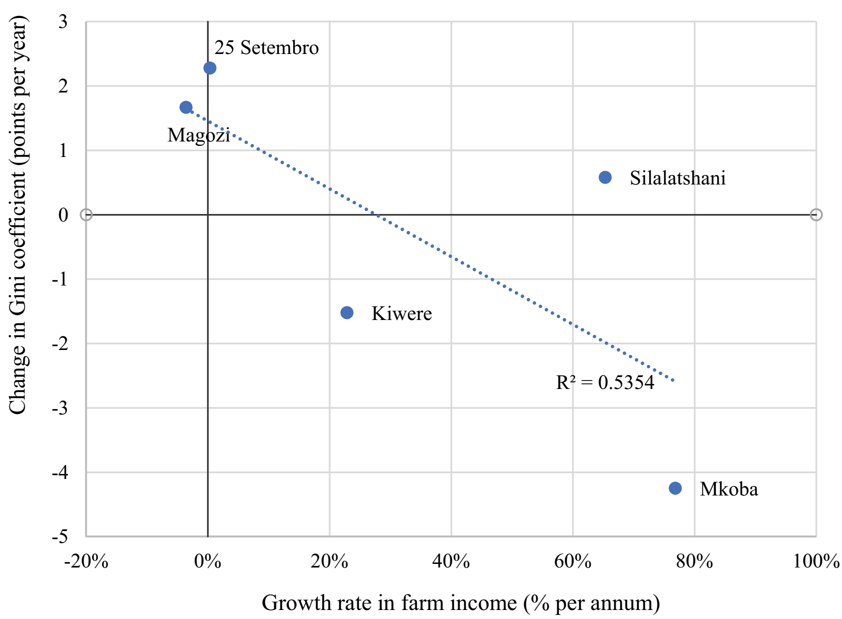

Figure 3. Annual farm income growth and changes in income inequality (averaged over the three-year period) across five schemes.

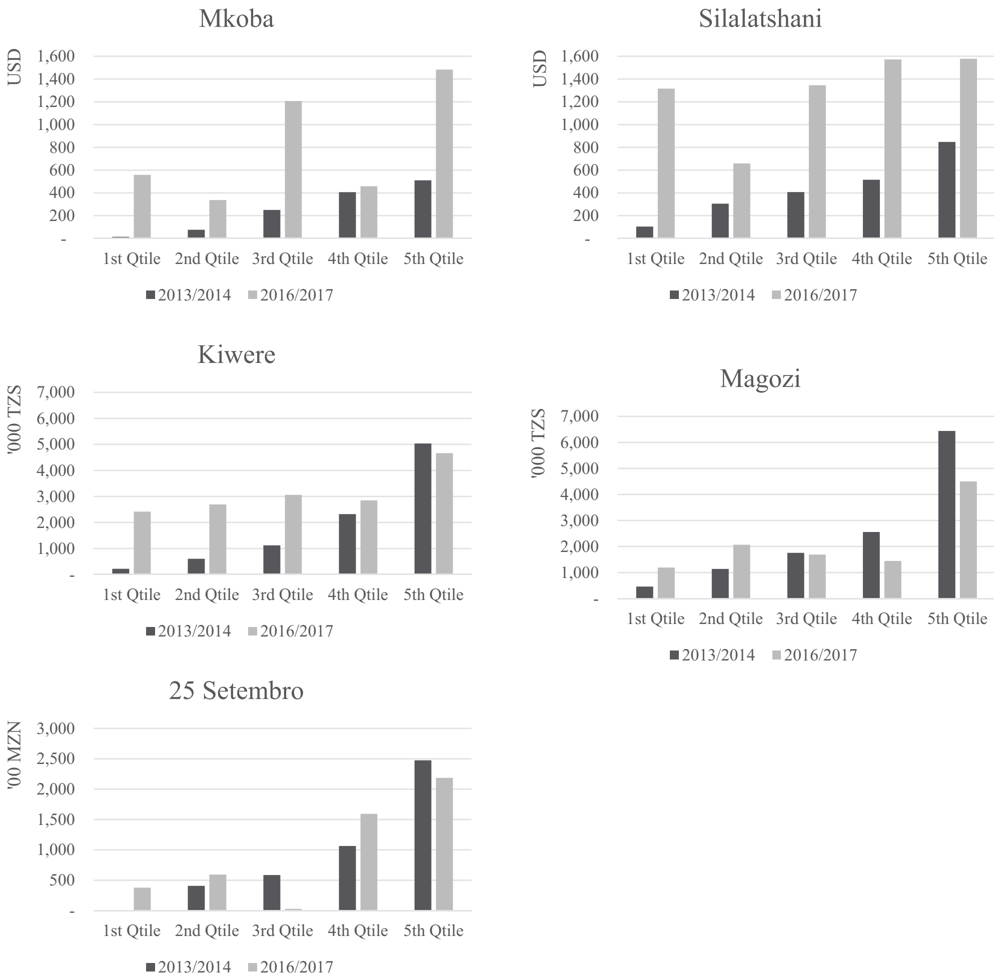

Figure 4. Farm income by quintile and year for five schemes in Zimbabwe (Mkoba and Silalatshani), Tanzania (Kiwere and Magozi) and Mozambique (25 de Setembro).

Contrasting with Tanzania and Mozambique, all quintiles in Zimbabwe saw their average farm income rise between 2013/2014 and 2016/2017. In Mkoba, the largest gains, in USD, were those of the third and fifth quintiles, whose mean annual farm incomes rose five-fold and three-fold, respectively. In relative terms, incomes of the first quintiles in Mkoba and Silalatshani grew 40-fold and 13-fold, respectively. In general, the households who in 2013/2014 were at the bottom of the income distribution seemed to have experienced the largest increases in farm income.

Discussion

The micro-level results on income and inequality in this study highlight notable within-country differences. While in our household panel data analysis irrigators in Zimbabwean schemes shared comparable levels of farm income growth (a four-fold increase over three years), inequality (measured by Gini coefficient) in Mkoba dropped by 12%, while it rose by 3% in Silalatshani. In Tanzania, Kiwere's average farm income rose and inequality declined, while the trends were reversed in Magozi (negative growth and growing inequality). Growing Gini coefficients in Silalatshani, Magozi and 25 Setemebro were also reflected in rises in income quintile and Palma ratios. A stark dichotomy between the 'top' and 'bottom' echelons of the irrigation communities may have important implications for social dynamics, such as perpetuation of local political elites who control shared water resources (Manero, 2018).

The observed differences between irrigation schemes located within the same country may be due to a range of local factors, including access to markets, barriers to land expansion, or farmers' re-investment strategies (Takane & Gono, 2017). In fact, previous research in the study areas (Bjornlund & Pittock, 2017; Bjornlund et al., 2017) found two main types of barriers to productivity and profitability: those associated with technical aspects and infrastructure, and those linked to markets, knowledge and governance. Such anthropogenic barriers may be associated with the observed high economic inequality. In small communities in rural, developing areas, it is often the well-resourced who gain preferential access to extension services, education and local decision-making institutions (Agarwal, 2015). Hence, future project interventions should maintain a focus on inclusive growth, bringing benefits to all members of the farming community, particularly at the bottom of the income distribution.

Across the five schemes, the bottom quintile experienced the largest farm income rises, in both absolute terms (except for Mkoba) and relative terms. In this regard, it can be argued that the growth over the three years was pro-poor, as it benefited the poor more than anyone else. As the project progresses (2017–2021), it would be of value to monitor further changes in incomes and inequality, particularly to check whether (and to what extent) sustained growth leads to a narrowing income gap. Further, even during pro-poor growth spells, it will be critical to understand how the social ramifications of economic inequality (e.g. access to education or farming resources) affect the poor's overall well-being.

Hypotheses testing on the association between growth and inequality provides important insights on the dynamics of distributional change at small scales. Initially high inequality is shown to be associated with higher growth rates, contrary to trends observed at national levels, where high inequality can slow future growth (Ferreira & Ravallion, 2008; Ravallion, 2014). Because of the data limitations of this study, it is not possible to draw affirmative conclusions from the comparison between results at local and national scales. Nonetheless, the different dynamics observed in this study suggest that communities within the same country or region may respond differently to similar interventions. Such heterogeneity calls for careful consideration of growth and inequality interactions at the local level, to developed context-specific programmes, as opposed to broadly defined national or regional strategies.

The household results suggest that higher growth may be accompanied by larger declines in inequality. However, the reverse is also true: lower growth rates are associated with smaller declines in inequality – up to a point where inequality starts to rise. In other words, there is a growth rate threshold (in this case, 20% per year) below which inequality tends to rise and above which inequality will drop. An important interpretation is that, for a given intervention to be successful in reducing inequality – a typically favourable development outcome – a minimum level of growth may be required. Although one of the main limitations of the analysis in this article is that it is based on only five data points at the micro scale and over a relatively short period of three years, the direction of the growth–inequality association is consistent with previous studies at the macro scale. Using data from 100 countries over 20 years, Ravallion (2014) found that the growth threshold marking the shift from increasing to decreasing inequality was around 2% annual growth. In addition to using more extensive and higher-quality data, it should be noted that Ravallion (2014) reports on both absolute and relative measures of inequality, while this study refers exclusively to the latter.

Micro-empirical studies (such as this one) typically require a good understanding of local contexts, which means that the researchers carrying out primary data collection are often limited to a small number of locations. Small samples constrain wide-reaching interpretation and extrapolation of results. Thus, to corroborate our observations, we note that the results of this study could be used as secondary data in a future meta-analysis investigating growth and inequality across multiple small communities in different countries. We also suggest that future research conducted as part of this project includes poverty analysis, which was omitted here because the 2016/2017 data did not include off-farm income or expenses. In addition, future studies covering a longer time period will allow observation of how the impacts of the project interventions flow through to the slow adopters of the new, improved production practices.

Conclusion

It is well recognized that growth and inequality play critical roles in poverty reduction, particularly in rural, developing areas. However, studies on poverty, growth and inequality are dominated by analyses of nationwide statistics; an important knowledge gap remains at the local level. In recent times, development interventions have shifted from a top-down to a bottom-up approach, which calls for an evaluation of whether the dynamics observed at the macro level are indeed relevant to the micro (local) scale. Filling this knowledge gap is paramount to be able to better design pro-growth strategies that will avoid unfavourable inequality outcomes in local communities. Based on a small number of observations, this study suggests that initial high levels of inequality at the small scales do not necessarily hinder future growth. Instead, our results suggest that what is important is the *change* in inequality over a growth spell, rather than its initial level. Importantly, in smallholder farming communities, growth and inequality can be affected by a combination of factors, both internal and external to farmers' control. On the one hand, crop selection and improved agronomic practices can boost yields, leading to higher incomes. On the other hand, availability of water supply and sharp fluctuations in international crop prices can easily destabilize the livelihoods of entire communities. In summary, for local development interventions to be most effective, the microeconomic dynamics of poverty, growth and inequality need to be well understood, along with how they differ between communities and compared to the macro level.

Acknowledgments

This research was part of the projects Increasing Irrigation Water Productivity in Mozambique, Tanzania and Zimbabwe through On-Farm Monitoring, Adaptive Management and Agricultural Innovation Platforms (FSC-2013-006) and Transforming Smallholder Irrigation into Profitable and Self-Sustaining Systems in Southern Africa (LWR/2016/137), both funded by the Australian Centre for International Agricultural Research and participating organizations. It was also partly supported by the Australian Research Council (FT140100773). The authors are grateful to constructive comments received by two reviewers.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the Australian Centre for International Agricultural Research [FSC-2013-006,LWR/2016/137]; Australian Research Council [FT140100773].

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Appendix

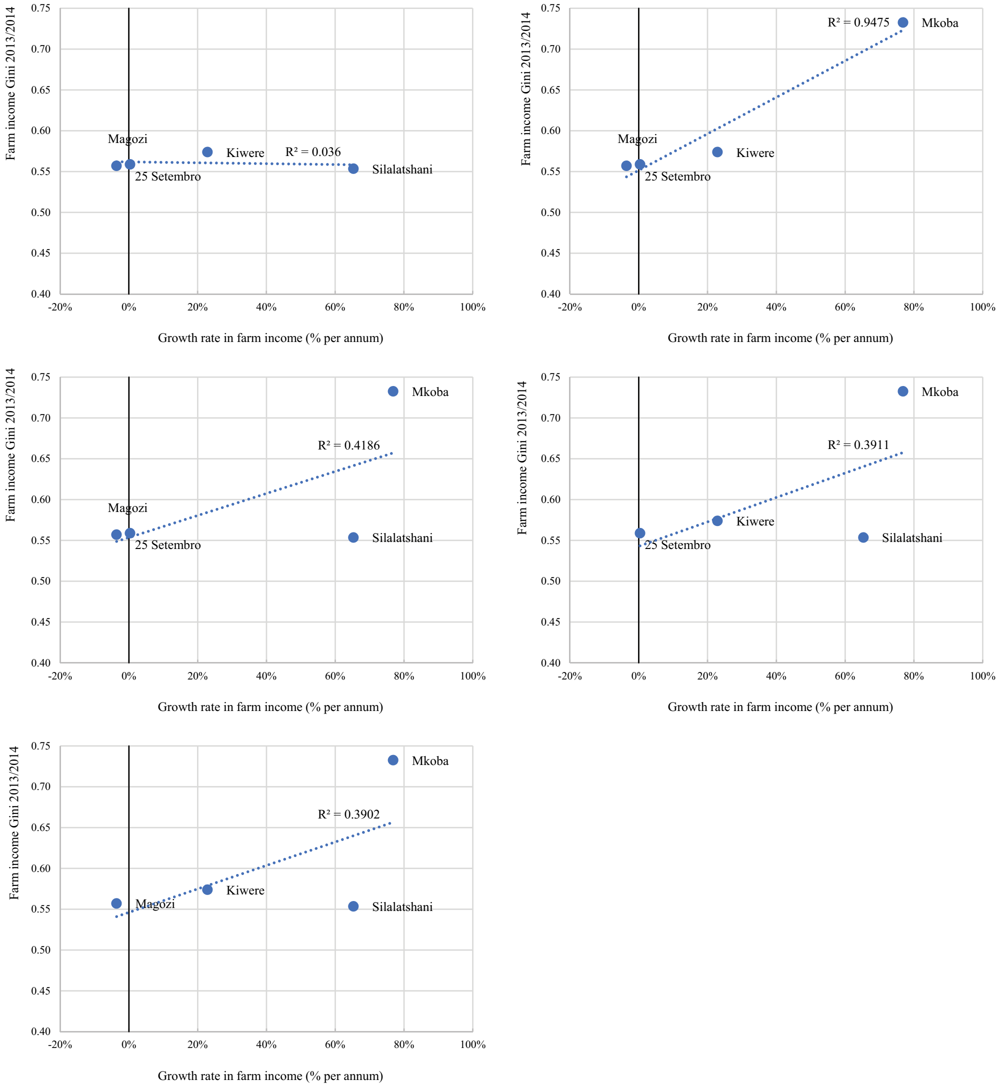

Figure A1. Sensitivity tests on initial inequality and growth rates.