Income inequality within smallholder irrigation schemes in sub-Saharan Africa

Ana Manero

Crawford School of Public Policy, Australian National University, Canberra, Australia

School of Commerce, University of South Australia, Adelaide, Australia

ana.manero@anu.edu.au

1 This is an Author’s Original Manuscript of an article published by Taylor & Francis in International Journal of Water Resources Development on 02 March, 2016, available online: http://dx.doi.org/10.1080/07900627.2016.1152461
Income inequality within smallholder irrigation schemes in sub-Saharan Africa

Equitable income distribution is recognised as a critical element to achieve poverty reduction, particularly in developing areas. Most of the existing literature in this field is based on region or country-wide data, yet fewer empirical studies exist at community levels. This paper examines income disparities within six smallholder irrigation schemes in Zimbabwe, Tanzania and Mozambique. Gini coefficients were used to compare local and national levels of inequality. By-group and by-source decompositions served to identify the factors that most contribute to income disparities. The results across the six schemes present significant contrasts both between schemes and compared to national figures. The results suggest that, inadvertently, some national strategies may overlook high levels of income inequality within small communities. Rural development strategies should recognise the importance of income inequality within the specific areas of intervention and target growth within the activity sectors that have the greatest potential to reduce poverty and inequality.

Keywords: income inequality, agriculture, poverty, Gini coefficient, Theil index

Introduction

It is estimated that 1.2 billion people across the world live in extreme poverty, making this a priority area in international development (UN, 2013). Alongside with growth, mitigating socio-economic inequalities is widely recognised as a key component of effective poverty reduction strategies (Groll & Lambert, 2013; Kabubo-Mariara, Mwabu, & Ndeng’e, 2012). Kuznets (1955) argued that growth may lead to an initial rise in income inequality, but in the long-term, as the economy develops, inequality would eventually decline. Nevertheless, without adequate redistribution interventions, the benefits of development rarely spread spontaneously from the rich to the poor. Instead, excessive economic disparities often entail serious, long-lasting issues such as persistent poverty (Ravallion, 1997), violent crime (Hsieh & Pugh, 1993), corruption
(Khagram, 2005), political instability (Alesina, 1996), worsened health (Kawachi & Kennedy, 1997) and low education levels (De Gregorio & Lee, 2002).

The interconnection between growth, poverty and inequality is particularly crucial in rural areas, home to 70% of the developing world’s extremely poor (Ferreira, 1996; Ortiz & Cummins, 2011; Watkins, 2013). Sabates-Wheeler (2005) argues that understanding this relationship is most critical in Sub-Saharan Africa (SSA), where limited empirical work and data exist. Most of the existing inequality literature is based on national or regional investigations, yet fewer studies exist within smaller areas, such as villages or rural communities (Silva, 2013). One of the reasons for this data gap is that broad studies are frequently based on readily-available governmental census surveys, whereas localised research requires detailed data collection processes. Given this gap in the literature, Ostry and Berg (2011) point to the need to further understand the poverty-inequality nexus within small communities, in order to define more effective and robust growth strategies.

This study investigates socio-economic inequalities within six smallholder irrigation schemes in SSA. First, income inequality will be calculated at a local level and then compared to national figures. Second, income inequality will be decomposed by economic activity – solely agricultural or diversified incomes - to assess the relative importance of the between and within-group components. Finally, an analysis by four different sources of income will determine which are the components that most contribute to total inequality and which ones have a (un)equalising effect. Lessons learnt from this investigation will serve to understand how income inequalities within smallholder agricultural communities compare to country-wide disparities and whether commonly accepted strategies would be applicable within local contexts.
**Growth, poverty and inequality in sub-Saharan Africa**

Between 1995 and 2013, SSA experienced a steady increase in economic activity with an average annual GDP growth of 4.5%, accompanied by a nine percent drop in the poverty headcount ratio (The World Bank, 2014a). Nevertheless, the benefits have not reached all, as the sub-continent is still home to 30% of the world’s extreme poor and undernourished population. Following the global trend, income disparity in the region has risen compared to 1980’s levels. Cogneau et al. (2007) indicate that SSA is the second most unequal subcontinent in terms of income, after Latin America and the Caribbean. Out of all SSA countries, Lesotho, South Africa and Botswana are the most unequal, with Gini coefficients above 0.63. On the other hand, Niger and Ethiopia have the lowest incomes disparities, with Gini coefficients below 0.35 (CIA, 2014).

Zimbabwe ranks among the ten most unequal SSA countries, with a Gini coefficient of 0.50 in 2006 (CIA, 2014). Part of Zimbabwe’s economic disparities are derived from its agrarian socio-economic situation, which still reflects the legacy of the colonial era, the civil war and the reforms of the late 20th century. Throughout the 1980’s and 1990’s, Zimbabweans’ livelihoods deteriorated significantly, as a result of repetitive droughts and issues associated with its land reform (Government of Zimbabwe, 2010; Kinsey, 2010; Mazingi & Kamidza, 2011; Schleicher, 2012).

Tanzania is one of the four most income equal countries in SSA, with a Gini coefficient of 0.38 in 2007 (CIA, 2014). Its economy is largely dependent on rural activities, with agriculture, hunting and forestry accounting for 27% of GDP, only second to the service sector (48%) (NBS, 2013). During the 1980s and early 1990s, Tanzania experienced significant economic growth, which brought poverty reduction (14% drop in poverty headcount), but also an increase in economic inequality. In fact, while the poor benefited from growth, the rich captured a much greater share of economic improvement (The World Bank, 2011). Over the first decade of the 2000s, the
country experienced an average annual GDP growth of seven percent and a the national HDI was lifted from 163rd to 151st position, on a world rank of 189 countries (UNDP, 2011). At the national level, the poverty headcount ratio is still over 28%, while in rural areas it is considerably higher at 38% (Ministry of Planning and Economic Affairs, 2009; The World Bank, 2014b).

In Mozambique, income inequality is relatively high, with a 0.46 Gini index, above the median of 0.43 across SSA. Between 1995 and 2003, agriculture was the second largest contributor to GDP growth (1.7% out of 8.6%) and the main driver of poverty reduction. Over this period, agriculture experienced an average annual growth of 5.2%, yet this mainly represented a recovery after the 1977-1992 war, with production returning to pre-conflict levels, rather than resulting from innovation and investment (Virtanen & Ehrenpreis, 2007). In 1999, the Ministry of Agriculture launched the first phase of a large-scale reform program, the Agricultural Sector Public Expenditure Program, towards a market-based agriculture with improved public support and more effective use of natural resources (The World Bank, 2013). Since then, the national poverty rate has declined by one-third, although it is still high at 55%.

Worldwide, Mozambique is the tenth least developed nation, with a HDI of 0.393 in 2013 (UN, 2014).

Research methodology

Data collection

This study is based on six smallholder irrigation schemes in Zimbabwe, Tanzania and Mozambique. The schemes range in size from 10 to 1,200 hectares and each of them has between 30 and 1,300 farms. Irrigation water is supplied through gravity-fed channels and serves to produce a variety of crops, as detailed in Table 1. In addition,
many irrigators also engage in other farming activities (e.g. rainfed crops and livestock) and non-agricultural businesses, for example through labour and self-employment.

Table 1. Characteristics of the irrigation schemes and surveys undertaken

<table>
<thead>
<tr>
<th>Country</th>
<th>Irrigation scheme, District</th>
<th>Area (ha)</th>
<th>Number of farmers</th>
<th>Major crops</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total</td>
<td>Surveyed</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>Mkoba, Vungu</td>
<td>10</td>
<td>75</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>Silalabuhwa, Insiza</td>
<td>442</td>
<td>212</td>
<td>100</td>
</tr>
<tr>
<td>Tanzania</td>
<td>Kiwere, Iringa</td>
<td>145</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Magozi, Iringa</td>
<td>1,200</td>
<td>1,300</td>
<td>100</td>
</tr>
<tr>
<td>Mozambique</td>
<td>Associacao de 25 Setembro, Boane</td>
<td>80</td>
<td>38</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Khanimambo, Magude</td>
<td>16</td>
<td>27</td>
<td>9</td>
</tr>
</tbody>
</table>

*Source: Rhodes, Bjornlund, and Wheeler (2014)*

For the purpose of this study, the household was used as the unit of analysis. This is justified because the irrigation schemes are subdivided into farms, each of which is cultivated by one family, with some families having more than one farm. Given the association between farm and household, and not farm and individual, the data collection process was designed using households as the basic unit. The survey consisted of 65 structured and semi-structured questions, regarding the family members (sex, age, education, health and occupation), farm characteristics (type of crops, yield), food security (frequency and type of foods consumed), asset ownership, revenue and expenses, among other questions.

The surveys were conducted between May and July 2014 with some variation from country to country. The sampling methods depended on the size of the population in each scheme. In the three smallest schemes, those in Mozambique, and Mkoba in Zimbabwe final samples were close to 100% of the defined population. For the three largest schemes, those in Tanzania and Silalabuhwa in Zimbabwe, the population was sampled using a stratified approach. Irrigators were categorised according to gender of
the household head and wealth category (poor, medium and well-resourced) and then randomly sampled (Moyo, Moyo, & van Rooyen, 2014).

Data used in this study includes household revenues and expenditure over the 12-month period prior to the interview. These figures were reported in each country’s local currency, i.e. US dollar in Zimbabwe (USD), shilling in Tanzania (TSH) and metical in Mozambique (MZN). The data was collected according to the source of revenue and type of expenditure, and was then aggregated into on-farm and off-farm categories, following the classification in Table 2.

Table 2. Revenue and Expenditure categories used in household survey

<table>
<thead>
<tr>
<th>Revenue</th>
<th>Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfed crops</td>
<td>Crop inputs</td>
</tr>
<tr>
<td>Irrigated crops</td>
<td>Harvesting/transport</td>
</tr>
<tr>
<td>Livestock sales</td>
<td>Livestock inputs</td>
</tr>
<tr>
<td>Milk sales</td>
<td>Hired labour</td>
</tr>
<tr>
<td>Other</td>
<td>Irrigation</td>
</tr>
<tr>
<td></td>
<td>Other</td>
</tr>
<tr>
<td>On-farm</td>
<td></td>
</tr>
<tr>
<td>Agricultural labour</td>
<td>Food</td>
</tr>
<tr>
<td>Non-agricultural labour</td>
<td>Education</td>
</tr>
<tr>
<td>Regular employment</td>
<td>Health</td>
</tr>
<tr>
<td>Off-farm</td>
<td></td>
</tr>
<tr>
<td>Business/self-employment</td>
<td>Social events</td>
</tr>
<tr>
<td>Remittances</td>
<td>Housing</td>
</tr>
<tr>
<td>Seasonal work</td>
<td>Personal transport</td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

Analytical framework

Economic inequality can be defined in many ways, but it is typically considered to be the uneven distribution of wealth, income and/or assets among individuals of a group, or between groups of individuals (McKay, 2002).

While the literature is consistent in affirming that there is no ideal unit of measurement for wealth, money-metrics, i.e. income or consumption expenditure, tend to be the preferred indicators of poverty and living standards (Sahn & Stifel, 2003). Alternative non-monetary measures of poverty and inequality exist, such as those based on asset ownership (Filmer & Pritchett, 2001; McKenzie, 2005) and the Multidimensional Poverty Index, defined by a combination of education, health and
living standards indicators (Alkire & Santos, 2010; Kovacevic & Calderon, 2014). In this paper, monetary indicators were used so as to evaluate how various income sources contribute to total inequality.

There are a number of methods and indices to estimate economic inequality. The section below presents a brief summary of the most common ones.

**Gini coefficient**

The Gini coefficient measures the extent to which the distribution of wealth within a group deviates from a perfectly equal distribution (The World Bank, 2011). It is the most commonly used inequality measure and is typically applied to income and expenditure. Its advantages include being relatively easy to calculate; having a visual representation and allowing for comparison between different size populations.

It can be estimated based on the representation of the Lorenz curve, plotting cumulative income vs. cumulative population. The Gini coefficient can also be mathematically calculated as follows:

$$ G = Cov(y, F(y)) \frac{2}{\bar{y}} $$

(1)

where Cov is the covariance between income levels $y$ and the cumulative distribution of the same income $F(y)$ and $\bar{y}$ is average income (Bellù & Liberati, 2006b).

Lerman and Yitzhaki (1985) developed a method to decompose the Gini coefficient as the sum of the inequality contribution of each income source. This is obtained as a product of its own inequality, its share of total income and its correlation with total income. Hence, the Gini coefficient for total income, $G$, can be formulated as follows:

$$ G = \sum_{k=1}^{k} R_k G_k S_k $$

(2)
where, $S_k$ is the share of income source $k$ in total income, $G_k$ is the Gini coefficient of income source $k$ and $R_k$ is the Gini correlation of income from source $k$ with the distribution of total income.

By calculating partial derivatives of the Gini coefficient with respect to a percent change $e$ in income source $k$, it is possible to estimate the percent change in total inequality resulting from a small percent change in income source $k$:

$$
\frac{\partial G}{\partial e} = \frac{R_k G_k S_k}{G} - S_k \tag{3}
$$

This property is particularly useful when identifying which sources of income have an “equalising” or “un-equalising” effect on total income (López-Feldman, 2006).

**Theil Index**

The Theil is a specific case of the generalised entropy indices (Bellù & Liberati, 2006a). Its lower value is zero (perfect equality) and it has no upper limit. The index is defined as follows:

$$
T = \frac{1}{n} \sum_i \left( \frac{y_i}{\bar{y}} \right) \ln \left( \frac{y_i}{\bar{y}} \right) \tag{4}
$$

where $y_i$ is the $i$ observation and $\bar{y}$ is the average income.

The Theil index has certain key advantages such as being decomposable and additive into groups, thus allowing distinction of between and within sub-group inequality components. Assuming $m$ groups, the Theil Index is decomposed as follows:

$$
T = \sum_{k=1}^{m} \left( \frac{n_k \bar{y}_k}{n} \right) T_k + \sum_{k=1}^{m} \frac{n_k}{n} \ln \left( \frac{\bar{y}_k}{\bar{y}} \right) \tag{5}
$$

where the first term of the equation is the within component, and the second term is the between component. Similarly to by group analysis, the Theil index can be decomposed by source of income, following the expression for $m$ sources:

$$
T = \sum_{k=1}^{m} \frac{1}{n} \sum_{i=1}^{n} \left( \frac{y_{ik}}{\bar{y}} \right) \ln \left( \frac{y_i}{\bar{y}} \right) \tag{6}
$$
In this study, the decomposition of the Theil index in *between/within sub-groups* and *by income source* was calculated by computing equations (5) and (6).

The Theil Index has also some drawbacks, such as, not having an intuitive representation and not being suitable to compare populations of different sizes. Also, it does not support non-positive values, as \( \log x \) is undefined if \( x < 0 \). As explained by Bellù and Liberati (2006a) and Vasilescu, Serebrenik, and van den Brand (2011), this limitation can be overcome by replacing zeros with very small values \( \epsilon > 0 \), such that 

\[
I_{\text{Theil}}(x_1, \ldots, x_{n-1}, 0) \equiv I_{\text{Theil}}(x_1, \ldots, x_{n-1}, \epsilon).
\]

In this paper, \( \epsilon \) was taken equal to \( 10^{-10} \).

**The Atkinson index**

Atkinson (1970) developed inequality measures based on the concept of Equally Distributed Equivalent (EDE) income. EDE is that level of income that, if obtained by every individual in the income distribution, would enable the society to reach the same level of welfare as actual incomes (Bellù & Liberati, 2006c). The Atkinson index is, hence, a welfare-based measure of inequality that can be used to address questions around transfers of income from better-off to poorer sections of the population.

In this study, the Atkinson index will not be used as welfare considerations specific to each of the six communities are out of the scope of this paper. Therefore, cross-regional inequality comparisons and income decomposition analysis will be carried out using the Gini coefficient and the Theil index.

**Negative incomes and measures of inequality**

In agricultural economies, two common measures of income are net cash income and net farm income. The former compares cash receipts to cash expenses (Schnepf, 2012), while the latter is a value of production including cash and non-cash transactions, such as value of commodities consumed or stored by the household, depreciation or
inventory changes (Edwards, 2013). In this study, net cash income has been chosen as the measure of household income.

Across the six irrigation schemes, 30% of the households reported higher on-farm expenses than on-farm revenues, thus resulting in negative net (farm) cash incomes. This poses a major constraint in the study of inequality given that the most robust and commonly used tools, such as the Gini coefficient and Theil index, are not defined for negative values. This issue had been discussed in the literature with different authors adopting different approaches.

Walker and Ryan (1990) and Möllers and Buchenrieder (2011) note the existence of negative incomes in their data, yet neither discuss the method of calculation of household incomes or ways of dealing with non-positive incomes.

Schutz (1951) and Stich (1996) indicate that negative incomes are usually excluded from the measurements of income inequality. This approach can be found, for example, in Cowell (2009). Cribb, Hood, Joyce, and Phillips (2014) and Sanmartin et al. (2003).

Nonetheless, disregarding households with negative net (farm) cash incomes is not ideal in this study as it would ignore almost one-third of the households in the sample. This is in line with the consideration made by Rawal, Swaminathan, and Dhar (2008, p. 232): “Such (negative incomes) exclusion not only narrows down the database but also misses out on a key feature of household incomes”. Moreover, Allanson (2005) argues that negative incomes cannot be ignored in the analysis of agricultural redistribution policies given that it is normal for farms to record losses.
A modified Gini coefficient can be calculated including zero and negative values, based on the geometric properties of the Lorenz curve, yet its values are no longer limited between 0 and 1. Chen, Tsaur, and Rhai (1982) reformulated the Gini coefficient to correct this issue, yet this alternative measure still has major limitations, such not allowing for an accurate decomposition by income source (Mishra, El-Osta, & Gillespie, 2009).

The Australian Bureau of Statistics (ABS, 2006) notes that negative incomes are not necessarily a good indicator of economic inequality and that it is inappropriate for them to have a disproportionate influence on summary inequality measures. It is argued that negative incomes often reflect the households’ business and investment arrangements or, in other cases, incomes may be accidentally or deliberately underreported. Thus, another common method of handling negative incomes is through a process referred to as *equivalisation*, by which the individual components of market income showing negative values are set to zero before computing the total income of each household (OECD, 2014). The process of *equivalisation* has been defined by the OECD and is used by government agencies such as the Australian Bureau of Statistics (ABS, 2006) and the UK Department for Work & Pensions (2014).

A similar approach was adopted by Seidl, Pogorelskiy, and Traub (2012) who truncated their data in a way that negative incomes were reported as zeros. Bray (2014, p. 443) also used this technique in a comparison with four other treatment methods, thus showing that, when negative incomes are set to zero, the resulting Gini coefficients were consistent with the figures obtained through the alternative methods.

When it comes to adopting one method or another, Deaton (1997, p. 140) notes that the choice between various inequality measures is sometimes made on the grounds
of practical convenience and others on the grounds of theoretical preference. Similarly, Smeeding, O'Higgins, and Rainwater (1990, p. 11) state that “each researcher is left to deal with zero and negative incomes as he or she sees fit”.

Given the preference to maintain all households in the sample and the choice of Gini and Theil measures of inequality, the author deemed that the most suitable approach to deal with negative incomes is adopt the *equivalisation* process described above. Thus, negative farm incomes were converted to zero, before being added to other income components to obtain the total.

In order to test the adequacy of the chosen method, a sensitivity analysis was conducted (see Appendix A). The levels of income inequality calculated using the *equivalisation* method are coherent with those obtained through alternative approaches, such as excluding households with negative incomes.

**The use of non-parametric tests**

Non-parametric tests of statistical significance were used to analyse differences in the distribution of incomes in different population sub-groups. This choice is justified by the fact that commonly used parametric tests make assumptions on parameters characterising the population’s distribution, which was not possible given the data in this study.

The Wilcoxon rank-sum test (hereafter WRS, and also known as Wilcoxon-Mann-Whitney) is a non-parametric test analog to the independent samples t-test that can be used when the variables are not normally distributed (UCLA). In addition, the two-sample Kolmogorov-Smirnov (hereafter KS) is another non-parametric test that can be used to test the hypothesis that two populations have the same distribution. The KS
test is sensitive to any differences in the distributions (e.g. shape, spread or median) and has more power to detect changes in the shape, whereas WRS tests on location and shape, and has more power to detect a shift in the median (GraphPad Software, 2015).

Limitations

This study has two major limitations. First, the populations of study consist only of members of irrigation schemes, but not the entire agricultural communities. This is due to the fact that the data used in this study was collected as part of a research project focusing on increasing irrigation water productivity (ACIAR, 2013). Given the nature of this research, the population of study was limited to irrigation farmers and, hence, did not include other members of the rural community, such as dryland farmers and non-farmers. Studying income inequality across the entire community would not have been possible because there is no comprehensive list of all its members that would allow adequate probability sampling. Conversely, Irrigation Organisations keep up-to-date lists of all their members, from which population samples were drawn. Future research could be extended to analyse income and inequality within the entire rural community and also investigate the potential differences between irrigators a non-irrigators.

The second limitation is the large proportion of households reporting negative farm incomes. As previously discussed, this entails difficulties in the study of inequality analysis, as most analysis tools are restricted to positive values. It is possible that during the interviews, farm incomes were underreported and expenses overreported, either accidentally or deliberately. Therefore, an improvement to this study could have been identifying negative farm income during the interviews to then question farmers about their financial losses. This method would have improved the accuracy of the records and also would have provided greater insight into why certain households experience negative incomes.
Results and discussion

Income inequality at scheme and national levels

This section describes the levels of expenditure and income inequality within six smallholder agricultural communities and compares them to their respective national figures.

As shown in Table 3, inequalities measured by expenditure are smaller than by income. This tendency is quite common (Aguiar & Bils, 2011; Finn, Leibbrandt, & Woolard, 2009; Krueger & Perri, 2006) and is mainly a result of consumption expenditure being more evenly distributed than income.

Table 3: Inequality at scheme and national levels

<table>
<thead>
<tr>
<th>Scheme level</th>
<th>National level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumption expenditure Gini</td>
<td>Income Gini</td>
</tr>
<tr>
<td>Mkoba</td>
<td>0.54</td>
</tr>
<tr>
<td>Silalabuhwa</td>
<td>0.47</td>
</tr>
<tr>
<td>Kiwere</td>
<td>0.54</td>
</tr>
<tr>
<td>Magozi</td>
<td>0.39</td>
</tr>
<tr>
<td>Ass.e 25 Setembro</td>
<td>0.59</td>
</tr>
<tr>
<td>Khaminambo</td>
<td>0.55</td>
</tr>
</tbody>
</table>

Source: author’s computations for scheme level and CIA (2014) for national levels.

Except for Silalabuhwa (Zimbabwe), income inequalities at scheme level are higher than at national levels. The greatest difference is in Tanzania, where Gini income coefficients within the agricultural communities (0.56 in Magozi and 0.60 in Kiwere) are in the order of 50% to 60% higher than at the national scale (0.38).

The Tanzanian Ministry of Planning and Economic Affairs (2009) argues that, given the country’s relatively low levels of inequality, redistribution of incomes is not likely to be effective in achieving significant reductions in poverty. Instead, it suggests that continued high rates of economic growth over the long-term will be required. By contrast, the results of this study show that significant income inequalities exist at
smaller scales (e.g. irrigation schemes), which are currently being overlooked by country-wide statistics.

**Income dualism between agricultural and diversified sources**

In rural developing areas, non-agricultural earnings represent an important part of households’ incomes (Barrett, Reardon, & Webb, 2001; Escobal, 2001; Reardon, 1997). While this can contribute to improved living standards, entry barriers to non-farm activities may result in a greater divide between those who are able to diversify and those who are not.

The aim of this section is to analyse income differences between and within two households groups: i) those earning incomes exclusively from agriculture (Ag), including farm incomes and agricultural labour; and ii) those having diversified income sources (Div), including non-agricultural labour, regular, seasonal or self-employment, business, remittances or other. Statistical significance tests were used in the comparisons between agricultural and diversified income households.

In Zimbabwe, the vast majority of households have diversified incomes, while in Tanzania and Mozambique, only half obtain earnings outside of agriculture. One common characteristic to all six communities is that households who make a living exclusively from agriculture had consistently lower mean and median incomes than those with diversified incomes. The results of the WRS and the KS tests (Table 4) conclude that the distribution of income is not the same in both groups and that exclusively agricultural households rank lower in the overall income distribution. The WRS test \(p<0.10\) indicated that the null hypothesis that incomes of agricultural households are not different from diversified-income households could be rejected. Similarly, the KS test concluded that \(p<0.10\) the hypothesis that both groups have the same distribution was also rejected in all schemes, except for Magozi (Error!)
Reference source not found.). Caution should be taken when interpreting the results from the Mozambican schemes, since the power of statistical significance tests is low when applied to such small samples (n<50).

Table 4: Income statistics by type of income

<table>
<thead>
<tr>
<th>Scheme</th>
<th>n</th>
<th>Mean HH Income*</th>
<th>Median HH Income*</th>
<th>Wilcoxon rank-sum test</th>
<th>Kolmogorov-Smirnov test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ag</td>
<td>Div</td>
<td>Ag</td>
<td>Div</td>
<td>Z</td>
</tr>
<tr>
<td>Mkoba</td>
<td>6</td>
<td>62</td>
<td>179</td>
<td>1,098</td>
<td>-2.52</td>
</tr>
<tr>
<td>Silalabuhwa</td>
<td>20</td>
<td>80</td>
<td>411</td>
<td>940</td>
<td>-3.55</td>
</tr>
<tr>
<td>Kiwere</td>
<td>56</td>
<td>44</td>
<td>1,006</td>
<td>2,026</td>
<td>-3.29</td>
</tr>
<tr>
<td>Magozi</td>
<td>48</td>
<td>51</td>
<td>1,500</td>
<td>2,905</td>
<td>-1.79</td>
</tr>
<tr>
<td>As. 25 Setembro</td>
<td>14</td>
<td>11</td>
<td>40,634</td>
<td>187,707</td>
<td>-2.63</td>
</tr>
<tr>
<td>Khanimambo</td>
<td>4</td>
<td>5</td>
<td>5,250</td>
<td>177,610</td>
<td>-2.49</td>
</tr>
</tbody>
</table>

M: male-headed household; F: female-headed household

* Mkoba, Silalabuhwa in USD; Kiwere, Magozi in ‘000 TSH; As. 25 Setembro, Khanimambo in MZN,

Despite the remarkable contrast between agricultural and diversified income households, the Theil index decomposition reveals that disparities within these two groups are actually the main contributor to overall inequality (Table 5). The only exception is Khanimambo, yet statistics from this scheme are subject to a very small sample size.

Table 5. Household income analysis and decomposition by activity group

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Percentage of Ag HH</th>
<th>Gini</th>
<th>Theil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ag</td>
<td>Div</td>
</tr>
<tr>
<td>Mkoba</td>
<td>9%</td>
<td>0.59</td>
<td>0.58</td>
</tr>
<tr>
<td>Silalabuhwa</td>
<td>20%</td>
<td>0.49</td>
<td>0.45</td>
</tr>
<tr>
<td>Kiwere</td>
<td>56%</td>
<td>0.59</td>
<td>0.69</td>
</tr>
<tr>
<td>Magozi</td>
<td>48%</td>
<td>0.55</td>
<td>0.59</td>
</tr>
<tr>
<td>As. 25 Setembro</td>
<td>56%</td>
<td>0.64</td>
<td>0.43</td>
</tr>
<tr>
<td>Khanimambo</td>
<td>44%</td>
<td>0.56</td>
<td>0.54</td>
</tr>
</tbody>
</table>

Ag: exclusively agricultural income household; Div: diversified income households

The results of this section suggest that promoting agricultural households to diversify their income sources could potentially have a poverty reduction effect, as households with a variety of incomes are consistently better-off.
Relative importance of income sources in total inequality

An extensive literature review undertaken by Senadza (2011) concluded, that to better understand the effects of income on inequality, it is important to distinguish between the various components of non-farm income. Hence, this section is dedicated to analysing the effect on total inequality derived from four distinct income sources: i) Agricultural, including on-farm income and agricultural labour; ii) Wages, including non-agricultural labour, regular employment and seasonal work; iii) Business and self-employment and iv) Other, including remittances and other unspecified sources.

The results in Table 6 show the relative importance of each source in terms of its contribution to the scheme’s combined income and to its total income inequality. In Tanzania, agriculture is the most important source of income, accounting for three-quarters of total earnings and circa 80% of inequality. Conversely, Zimbabwean schemes rely more heavily on remittances and other sources, which also drive the largest portion of the schemes’ income disparities. In Mozambique, incomes and inequalities are mainly split between agriculture and wages.

Table 6: Income and inequality decomposition by source

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Agriculture</th>
<th>Wages</th>
<th>Business and self-employment</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Share of Income</td>
<td>Share of Inequality</td>
<td>Share of Income</td>
<td>Share of Inequality</td>
</tr>
<tr>
<td>Mkoba</td>
<td>19%</td>
<td>2%</td>
<td>15%</td>
<td>23%</td>
</tr>
<tr>
<td>Silalabuhwa</td>
<td>34%</td>
<td>14%</td>
<td>17%</td>
<td>42%</td>
</tr>
<tr>
<td>Kiwere</td>
<td>79%</td>
<td>83%</td>
<td>7%</td>
<td>6%</td>
</tr>
<tr>
<td>Magozi</td>
<td>66%</td>
<td>43%</td>
<td>9%</td>
<td>15%</td>
</tr>
<tr>
<td>As. 25 Setembro</td>
<td>46%</td>
<td>10%</td>
<td>47%</td>
<td>86%</td>
</tr>
<tr>
<td>Khanimambo</td>
<td>52%</td>
<td>48%</td>
<td>43%</td>
<td>47%</td>
</tr>
</tbody>
</table>

As noted by Shariff and Azam (2009), ‘A key rational for studying decompositions by source is to learn how changes in particular income source will affect overall inequality. What impact does a marginal increase in a particular income
source have on inequality? In order to answer this question, a Gini decomposition following equations (2) and (3) was carried out for each of the six irrigation schemes.

For each income source, the results summarised in Table 7 indicate the marginal impact in total inequality due to a 1% increase in that particular source, whilst holding income from all other sources constant. The direction and magnitude of the marginal impact are given by the % Change. A negative sign indicates a tendency of that particular component to reduce total inequality, while a positive sign reveals an un-equalising effect. Logically, the larger the absolute value, the greater marginal the impact.

Table 7: Gini decomposition by income source

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Agriculture</th>
<th>Wages</th>
<th>Business and self-employment</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gini</td>
<td>% Change</td>
<td>Gini</td>
<td>% Change</td>
</tr>
<tr>
<td>Mkoba</td>
<td>0.76</td>
<td>-0.07</td>
<td>0.93</td>
<td>0.02</td>
</tr>
<tr>
<td>Silalabuhwa</td>
<td>0.68</td>
<td>-0.07</td>
<td>0.94</td>
<td>0.10</td>
</tr>
<tr>
<td>Kiwere</td>
<td>0.66</td>
<td>0.01</td>
<td>0.94</td>
<td>0.00</td>
</tr>
<tr>
<td>Magozi</td>
<td>0.57</td>
<td>-0.09</td>
<td>0.95</td>
<td>0.02</td>
</tr>
<tr>
<td>As 25 Setembro</td>
<td>0.54</td>
<td>-0.13</td>
<td>0.90</td>
<td>0.13</td>
</tr>
<tr>
<td>Khanimambo</td>
<td>0.61</td>
<td>-0.06</td>
<td>0.69</td>
<td>0.06</td>
</tr>
</tbody>
</table>

In five out of six schemes, agriculture has an equalising effect. In fact, the distribution of agricultural income is skewed towards the bottom, meaning that poorer households rely more heavily on farming and would benefit the most from growth in this sector. The exception to this trend is Kiwere, in Tanzania, where even the highest income households (top two quintiles) earn a significant portion (80%) of their incomes from agriculture.

Wage incomes have an un-equalising effect across the six schemes, while the effect of business and self-employment is mixed, i.e. equalising three scheme (one in each country), yet unequalising in the rest. Unequalising effects could be explained by low wages received by poor famers and entry barriers preventing poorer households from venturing into entrepreneurship. The fact that neighbouring schemes experience
contrasting effects reveals the existence of significant intra-country and even intra-region differences. The policy implication is that one same strategy targeting growth in a certain activity sector could have a positive, equalising effect in some groups, yet the exact opposite (unequalising) in other nearby communities.

**Conclusions**

This paper analyses income inequality within six smallholder irrigation schemes in Zimbabwe, Tanzania and Mozambique using household survey data from 2014. The Gini and Theil indices are used to measure income inequalities and decompose inequalities by gender and source.

The results indicate that income inequalities within the irrigation communities are considerably higher (20% to 60%) than their respective country-wide figures. Comparisons between agricultural and diversified income households showed that those relying exclusively on farming activities earn consistently lower incomes than their counterparts. In five out of six schemes, agricultural income was found to have an equalising effect, i.e. a marginal increase in agricultural income will lead to decrease in overall inequality. Conversely, a marginal increase in wages would lead to an increase in inequality in all schemes, while the impact of business and self-employment was mixed across the three countries.

These findings have important policy implications. First, it is crucial to recognise the existence of significant levels of income inequality at small scales. Therefore, broad-based strategies should be carefully examined before being applied within local contexts, as they could overlook existing disparities and thus perpetuate, or even worsen, economic inequalities. Policies incorporating income distribution considerations would be more effective in achieving substantial and long-lasting poverty reduction, rather than those targeting only economic growth.
Second, strategies aimed to lessen inequality levels within smallholder irrigation schemes should be two-fold. On the one hand, lifting incomes from sources having equalising effects (e.g. agriculture) could act as a poverty reduction intervention at the same time as it would reduce income inequality. On the other hand, it is also important to create new opportunities for poor households to diversify into more gainful activities (e.g. skilled employment or entrepreneurship), rather than relying exclusively on agricultural incomes.
Acknowledgments

I thank my PhD supervisors, Henning Bjornlund, Sarah Wheeler, Quentin Grafton and Jaime Pittock for their advice and insightful comments. This study is based on data collected through a large research project funded by the Australian Centre for International Agricultural Research. I kindly thank my research colleagues Andre van Rooyen, Martin Moyo, Nuru Mziray, Makarius Mdemu, Paiva Munguambe and Wilson de Sousa for their efforts in collecting the data used in this study.
References


Appendix A

This Appendix provides the results of a sensitivity analysis using various methods of estimating income inequality. The purpose of this appendix is to verify that results obtained through the chosen methodology are consistent with the other possible alternatives.

Income Gini coefficients for the six communities are summarised in Table A1 following four different methods. The first column reflects the method used in this study, which consists of converting negative farm incomes to zero, before being added to the rest of household income components. The second column represents HH income Gini coefficients excluding those households with negative farm incomes. The third column reflects HH income, excluding households with negative incomes. The fourth column indicates the values of the Gini coefficients for household earnings, without taking into consideration farm expenses. The last column indicates modified Gini coefficients including negative incomes, which are calculated based on the geometric properties of the Lorenz curve. The differences shown in this sensitivity analysis are a result of the different calculations methods and are consistent with previous studies (Bray, 2014) also comparing various approaches to treat negatives incomes.
Table A 1: Gini coefficient sensitivity analysis

<table>
<thead>
<tr>
<th></th>
<th>Income Gini Adjusting for negative farm incomes</th>
<th>Income Gini Excluding HHs with negative Farm Income</th>
<th>Income Gini Excluding HHs with negative HH income</th>
<th>Gini for HH Revenue (without considering farm expenses)</th>
<th>Modified income Gini including negative incomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mkoba</td>
<td>0.60</td>
<td>0.51</td>
<td>0.58</td>
<td>0.57</td>
<td>0.63</td>
</tr>
<tr>
<td>Silalabuhwa</td>
<td>0.48</td>
<td>0.44</td>
<td>0.46</td>
<td>0.42</td>
<td>0.52</td>
</tr>
<tr>
<td>Kiwere</td>
<td>0.60</td>
<td>0.52</td>
<td>0.52</td>
<td>0.53</td>
<td>0.93</td>
</tr>
<tr>
<td>Magozi</td>
<td>0.56</td>
<td>0.55</td>
<td>0.55</td>
<td>0.51</td>
<td>0.66</td>
</tr>
<tr>
<td>As. 25 Setembro</td>
<td>0.65</td>
<td>0.62</td>
<td>0.62</td>
<td>0.64</td>
<td>0.85</td>
</tr>
<tr>
<td>Khanimambo</td>
<td>0.58</td>
<td>0.55</td>
<td>0.59</td>
<td>0.57</td>
<td>0.59</td>
</tr>
</tbody>
</table>

As discussed in this paper, methods that exclude households with negative incomes (Columns 2 and 3) tend to underestimate income inequalities as the bottom part of the distribution is not taken into account. The exception is the Khanimambo scheme where there are no households with negative incomes. Estimating economic inequality based only on revenue (Column 4) also provides lower Gini coefficients, which indicates that gross revenue (earnings without considering expenses) is more evenly distributed than net income (revenue minus farm expenses). Finally, modified Gini coefficients including negative incomes are consistently higher than those treating negative incomes.

Similarly to the Gini coefficient sensitivity analysis, Table A 2 summarises the results of the Theil index sensitivity analysis.

Table A 2: Theil index sensitivity analysis

<table>
<thead>
<tr>
<th></th>
<th>Income Theil Adjusting for negative farm incomes</th>
<th>Income Theil Excluding HHs with negative and zero Farm Income</th>
<th>Income Theil Excluding HHs with negative and zero HH income</th>
<th>Theil for HH revenue (without considering farm expenses)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mkoba</td>
<td>0.64</td>
<td>0.45</td>
<td>0.58</td>
<td>0.55</td>
</tr>
<tr>
<td>Silalabuhwa</td>
<td>0.41</td>
<td>0.31</td>
<td>0.35</td>
<td>0.27</td>
</tr>
<tr>
<td>Kiwere</td>
<td>0.63</td>
<td>0.47</td>
<td>0.46</td>
<td>0.46</td>
</tr>
<tr>
<td>Magozi</td>
<td>0.60</td>
<td>0.56</td>
<td>0.58</td>
<td>0.46</td>
</tr>
<tr>
<td>As. 25 Setembro</td>
<td>0.89</td>
<td>0.73</td>
<td>0.74</td>
<td>0.66</td>
</tr>
<tr>
<td>Khanimambo</td>
<td>0.66</td>
<td>0.17</td>
<td>0.31</td>
<td>0.36</td>
</tr>
</tbody>
</table>
Calculations excluding households with negative and zero incomes (Columns 2 and 3) provide lower values of the Theil index. However, it should be noted that the Theil index does not allow direct comparisons across populations of different sizes. Lastly, Theil indices calculated based on earnings are lower than those based on net income, as in the case of the Gini coefficients.