UNEVEN IRRIGATION AND ECONOMIC INEQUALITIES: EXPLORING THE CONNECTION

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ABSTRACT

Irrigation development is widely recognised as a key instrument to boost livelihoods and food security, particularly in rural developing areas. While improved water supply can help reduce average poverty levels, uneven access to sufficient and reliable irrigation water can also result in aggravated economic disparities. Using a combination of qualitative and quantitative analyses, this article explores the impact that uneven irrigation water supply has on two smallholder irrigation schemes in southern Tanzania. The results reveal that inequality of water supply is a major concern for most irrigators and that farmers who receive inadequate water supply are affected in a number of ways. These include reduced crop yields, greater uncertainty, worsened working conditions, inability to cultivate their own land, higher risk of land turning unproductive and higher financial losses. While Tanzania's water and irrigation national legislation mandates equity of water supply, the problem persists within smallholder systems due to a complex combination of issues, including inability to measure water supplies, poor infrastructure maintenance and lack of adequate regulations at local levels.

Keywords: Crop yields, Irrigation schemes, Poverty, Economic inequality, Tanzania, Water distribution.

1. INTRODUCTION

Irrigation development is widely agreed to be an effective tool to fight rural poverty. However, it is also necessary to know if the benefits of irrigation are equitably shared among the population. Previous studies in south-Asia (Bhattarai et al. 2002) have theorised that uneven water distribution could aggravate income inequalities, yet the mechanism linking both types of inequalities had not been identified.

This article investigates the connection between water supply and economic inequalities in Tanzania, using two smallholder irrigation schemes as case studies. The research method consists of a combination of qualitative and quantitative approaches, including descriptive summaries, statistical significance tests and spatial analyses. The data were collected between May and July 2015through personal interviews with 155 farming households.

This paper contributes to the existing literature by providing further evidence of the link between irrigation water supply and economic inequalities, within the context of sub-Saharan Africa. The findings show that irrigators suffering from inadequate water supply are affected in a number of ways that hamper their ability to cultivate and secure a livelihood from irrigated agriculture. In addition to lower crop yields, they tend to suffer from higher risk of unproductive land, greater financial losses, higher uncertainty and worsened farming conditions.

While the two case studies are representative examples of smallholder irrigation in Tanzania, the lessons learnt are relevant within a much wider context. In fact, equity

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of irrigation water supply has been highlighted as a critical issue across developing areas in Africa (Makombe et al. 1998), south-America (Saldias et al. 2013), south-Asia (Bhattarai et al. 2002) and south-east Asia (Collins et al. 2014).

2. BACKGROUND

Despite its importance, equity of water supply remains a significant challenge, particularly within traditional irrigation systems. One of the main issues is the lack of measuring systems. In Tanzania, the lack of data on volumes is a major obstacle for water allocation and management because it is only in large-scale, highly-controlled systems that volumes can be sufficiently known and manipulated (van Koppen et al. 2004).

Within the two schemes of this study, the Irrigators' Associations (IA) - the local organisations managing the irrigation schemes - are responsible for water supply scheduling, but they lack the means to systematically monitor and keep records of deliveries across the systems. Furthermore, the poor level of infrastructure maintenance (e.g. collapsed canal banks and broken control structures) results in high water losses and impeded canal operability, thus hindering possible estimations of water distribution. As a result, there is no objective, consistent measure of the volumes or timing of the water deliveries within the schemes.

Furthermore, regulations addressing (equity of) water distribution in Tanzania are not adequately formulated to address issues at small scales. A number of policies mandating equity of irrigation water supply exist at national level(e.g. 2002 National Water Policy, 2009 Water Resources Management Act and 2013 National Irrigation Act), but they do not provide any details on how equity of water distribution should be implemented, monitored or enforced.

3. METHODOLGOY

3.1. Site description

In Tanzania, agriculture provides livelihoods for three-quarters of the population (out of a total of 45 million) and accounts for almost a third of the country's GDP (The United Republic of Tanzania 2013). Despite Tanzania's steady growth, the percentage of people living below the poverty lines is still considerably high: 38% in rural areas and 16% to 24% in urban centres(The United Republic of Tanzania 2009). This article is based on data collected from two smallholder irrigation schemes, Kiwere and Magozi, located in the Southern Highlands region of Tanzania. These schemes were selected following two scoping exercises (Pittock et al. 2013 ; Rhodes et al. 2014)on the basis of their desirable characteristics: institutional capacity, ability to improve agricultural practices, accessibility and the interest of local agencies in collaboration.

Both schemes are located in the Rufiji River Basin and are supplied from the Little Ruaha River through a network of earth and concrete-lined open channels. This kind of schemes is very common in Tanzania. The schemes vary in size and number of members (Table 1) with an average household landholding of 0.95 ha in Kiwere and 1.62 ha in Magozi. This reflects the characteristics of the agricultural sector in Tanzania, where over 80% of the agricultural landholdings are smallholder farms, with an average plot size of 0.9 ha (FAO 2005)

Table 1. Characteristics of the irrigation schemes

Site features	Kiwere	Magozi
Total area (ha)	189	939
Number of plots	248	760
Average plot size (ha)	0.76	1.24
Number of registered households	199	578
Average household landholding (ha)	0.95	1.62
Surveyed households	79	76
Main crops	Horticultural produce, maize	Rice

3.2. Data collection and analysis

The data used in this study was collected between May and July 2015 through 155 household interviews - 79 in the Kiwere scheme and 76 in Magozi. Participating households were selected using a stratified sampling approach based on their economic level and gender of the household head. A representative member of each household (usually the head) was interviewed following a structured list of questions regarding water supply, economic inequality and crop production.

The research approach used in this study is a combination of quantitative and qualitative methods. Questions regarding objective, measurable factors, such as crop production or size of cultivated land, are studied using a quantitative approach. Conversely, aspects related to farmers' perceptions and opinions are addressed through qualitative (descriptive) questions. These include close-ended questions using Likert-type rating scales, as well as open-ended questions providing narrative answers that were later synthesized into common themes.

Water supply could not be estimated using quantitative figures (e.g. volumes) because of the total lack of measuring devices and water supply records. Instead, irrigators were asked to rate, on a scale from 1 to 5, their level of satisfaction with water supply, considering volumes, timing, reliability, etc. Thus, farmers' perceptions were used as a proxy measure for water supply. Understanding how people perceive their problems is a crucial factor for developing strategies to improve their lives and the environment they depend on (Quinn et al. 2003).

4. RESULTS AND DISCUSSION

This section comprises two parts addressing the question of how unequal water supply impacts economic inequalities. The first part uses data from both schemes applying a qualitative approach. The second part, focuses on the Magozi scheme to conduct statistical and spatial analyses.

4.1. The impact of water supply on economic inequality

Water supply and economic inequalities are recognized by farmers in both schemes to be important issues. In fact, the vast majority of interviewees believe that neither water (69%) nor wealth (90%) are equitably distributed among the members of their irrigation community. It is also widely agreed (83%) that improving the distribution of irrigation water could potentially help reduce the existing economic disparities through a number of linking mechanisms (Table 2).

Table 2. How can equitable water distribution help reduce the wealth gap?

Issues raised to the respondents	% Responses		
	Kiwere (n=79)	Magozi (n=76)	Combined (n=155)
Benefit the poor the most	19	16	17
Improved farming conditions	18	12	15
Opportunity to expand irrigated area	6	21	14
Increased yields	13	11	12
Higher certainty of supply	10	7	8
Ability to irrigate own land	-	13	6
Other	8	14	11
Water won't help reduce the wealth gap	27	8	17

When farmers were asked to explain how a more equal water distribution could help reduce the wealth gap, the most common answer (17%) was based on the idea that the poorest irrigators are the ones who suffer the most from inadequate water supply. This is believed to be one of the main reason why disadvantaged farmers remain trapped in poverty, while the rest are able to profit more from irrigation and its multiplying effects. Second, water distribution would have an equalising effect by improving their working conditions (15%).

Currently, farmers who receive inadequate supply have conflict with other more advantaged farmers and spend significant amounts of time being vigilant and quarrelling about water, instead of concentrating on cultivation and other non-farming activities. Moreover, in Magozi, the delay in the optimal irrigation schedule results in low quality rice and harvest too later in the season. Because the rice is of poorer quality and only reaches the market when this is already oversupplied, water-disadvantaged growers can only sell their rice for a very low price compared to those who can irrigate at the optimal time. In Kiwere, 65% of the interviewees reported that strong competition for water supply during the day forces them to cultivate late in the evenings. Female irrigators, in particular, reported this was a major concern for them, as they are kept away from their traditional home duties and also become in danger of being attacked when working in the field alone at dark.

Increasing crop production, either through expansion of the irrigated area (14%) or higher crop yields (12%), was also frequently stated as a factor that could help narrow the economic gap. Higher certainty of timing and volumes was also perceived as a critical factor (8%), as it would allow irrigators to better plan their activities and provide a greater incentive for poor farmers to invest in irrigated agriculture. Furthermore, 13% of the sampled farmers in Magozi believed that a more equal distribution would give the poor the ability to irrigate their own land instead of having to rent or work for someone else. One interviewee explained that "rich irrigators skew the water distribution towards their plots so downstream farmers cannot cultivate their own land. Then, the only options we have are to work as labourers, rent land or borrow money from them. But they offer very low pay, expensive rent and high interest rates."

4.2. Water supply and rice production

This section uses quantitative measures of crop production to investigate the influence of uneven water supply. In the Kiwere scheme, farmers grow a wide variety of crops, which are harvested at different times during the year. Such heterogeneities make it very cumbersome to obtain a measure of farm output that allows an accurate comparison across the entire scheme. Moreover, the direct impact of water on crop production is difficult to assess, as there are many other influencing factors such as fertilizer use, seasonality, horticultural practices, etc. Conversely, in the Magozi

scheme, rice is the only irrigated crop, it is cultivated without chemical fertilizers (Rhodes et al. 2014), is harvested once a year and is highly susceptible to water availability. Given its relative homogeneity, rice production in the Magozi scheme was used to evaluate the influence of water supply.

In relation to the latest irrigation season (December 2014-May 2015), Magozi farmers were asked to provide information on the rice output (kg), the size of the land they had cultivated and the size of the land they had harvested. A number of farmers were unable to harvest the entire area they had cultivated because it became (partially or totally) unproductive due to insufficient water supply. Consequently, many irrigators suffered from financial losses resulting from investments made in early preparation (seeding, weeding, levelling, etc.) of land that later turned unproductive. Hence, in order to assess the impact of water supply, three measures were used: rice yield (kg/ha of harvested land), percentage of unproductive land (ha of unproductive land/ha of cultivated land) and financial losses due to lack of water (losses in Tanzanian shillings/ha of cultivated land).

Irrigators rated their level of satisfaction with their water supply on a scale from 1 to 5. However, for ease and clarity of analysis, the five-point Likert scale was converted into a binary scale, grouping answer into “not satisfied” and “satisfied or neutral”. Non-parametric tests of statistical significance, Wilcoxon rank-sum (WRS) and Kolmogorov-Smirnov (KS), were used to analyse differences between the two population subgroups.

The results of the statistical analyses (Table3) show there are significant differences (p<0.01 and p<0.05) between both subgroups. On average, irrigators who are not satisfied with their water supply tend to experience lower rice yields (-25%) compared to those who are satisfied or neutral. Moreover, they are more exposed to land unproductivity. Out of 50 “not satisfied” irrigators, 10 were totally unable to cultivate, as a result of inadequate water supply. On average, 45% of their land resulted unproductive, as opposed to only 15% of the “satisfied/neutral” group. Also, “not satisfied” irrigators suffered financial losses that were, on average, 2.3 times greater compared to the “satisfied/neutral” group.

Table3. Rice production statistics by level of water supply satisfaction

Particulars	n		Mean		Median		Wilcoxon rank-sum test	Kolmo-gorov-Smirnov test
	Not-Satisfied	Satisfied /Neutral	Not-Satisfied	Satisfied /Neutral	Not-Satisfied	Satisfied /Neutral	p	p
Rice yield (kg/ha)	40	26	1,751	2,344	1,897	2,347	0.0012***	0.017**
% Unproductive land	50	26	45	15	45	0	0.0009***	0.002***
Financial losses (‘000 TZS/ha[1])	50	26	296	129	254	0	0.0001***	0.000***

The values are statistically significant at ***1% and **5%, [1]1,000 TZS = 0.46 USD

Using geospatial analysis tools, the differences in water supply satisfaction, rice yields, unproductive land and financial losses were displayed in the form of thematic maps (Figure 1).

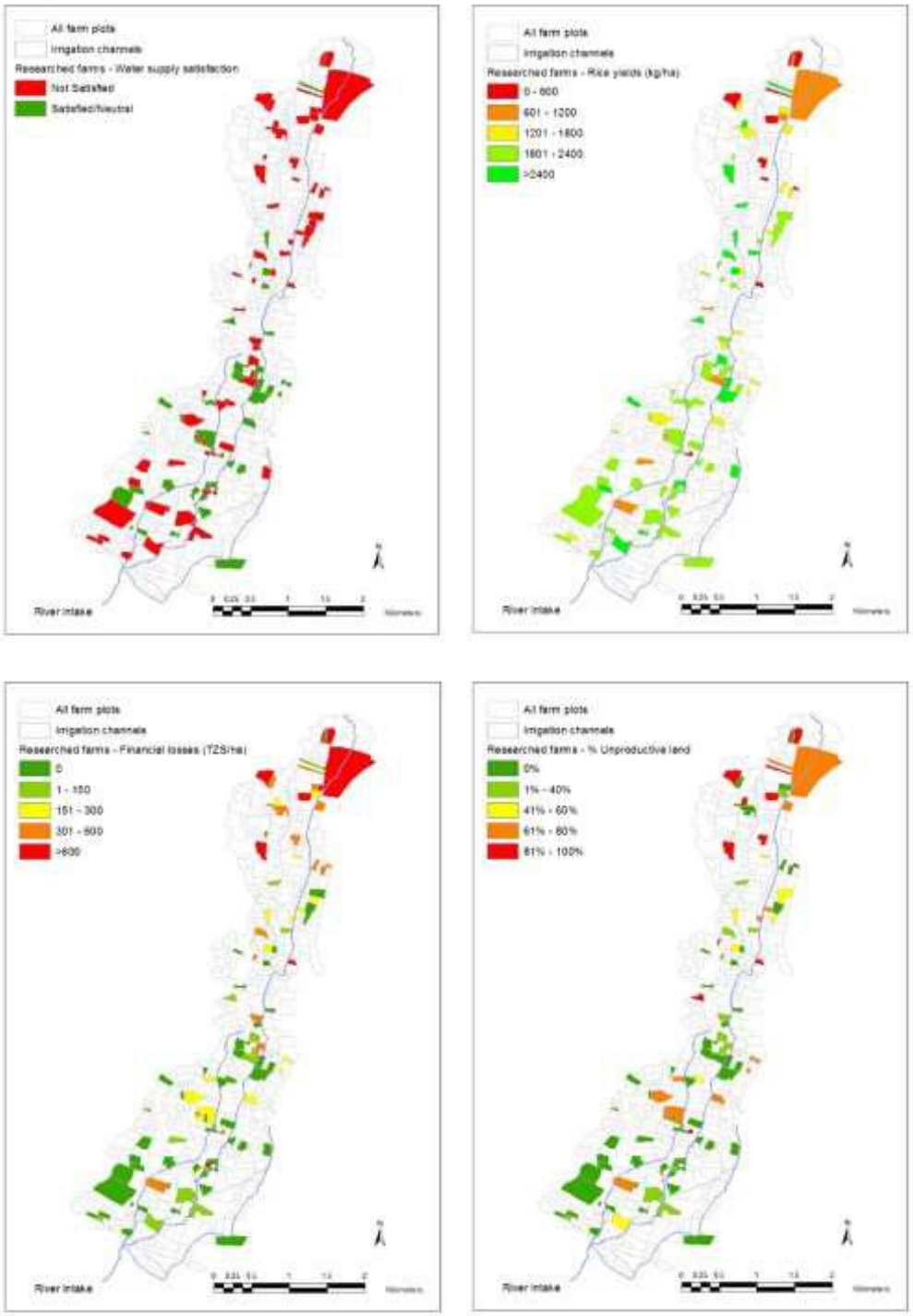

Figure 1. Spatial representation of water supply satisfaction, rice yields, financial losses and % of unproductive land

Through observation of the maps, it becomes evident that farmers who are satisfied/ neutral with their water supply tend to be located closer to the intake. Moreover, those plots situated further downstream (towards the middle and tail-end of the canal system) tend to obtain rice yields, which confirms what had been previously found (Collins et al. 2014) regarding the connection between lower crop yields and greater distance from the water source. In addition, downstream plots suffer greater losses in

terms of land production and financial investments, as a result of insufficient water supply.

4.3. Rules regarding equity of water supply

Despite the obvious and serious disparities across the irrigation scheme, the rules of the Irrigators' Association mandate that all farmers must pay equal fees for their water (per ha), regardless of the adequacy of the supply. This creates a negative loop whereby irrigators who are most affected by inadequate water supply may not be able to afford the mandatory supply fees, which places even more pressure on their financial situation.

Although equity of water supply is a desirable objective which most irrigators agree about, it is not reflected in the Irrigators' Associations by-laws. Instead, only a brief mention is made about farmers' rights to use irrigation resources, their obligation to follow rules and the applicable fines. However imposing monetary fines fails as a deterrent for wealthier individuals, as they can easily afford the penalties, which in some cases are offset by the benefits of having extra water. In the Magozi scheme, for example, sanctions for braking water rules represent 1% to 4% of the average yearly earnings of families in the top quintile, but up to 60% of the revenues of households in the bottom quintile. Prosecution in court is also ineffective, given that the regional court is located far away from the villages. The need to attend several hearings and the deficient public transport system become major impediments for farmers to pursue legal action when water distribution rules are broken.

5. CONCLUSIONS

Based on two smallholder irrigation schemes in Tanzania, it was investigated how unequal water supply may impact economic inequalities within the irrigation community. This paper has analysed qualitative and quantitative data collected in May-July 2015 through personal interviews with 155 farmers regarding their water supply, crop production and wealth inequality.

Despite the lack of objective measures of water supply, qualitative answers provided by farmers revealed that irrigation water was not equally distributed within the schemes (agreed by 69% of interviewees). The vast majority (89%) believed that more equal water distribution could potentially help alleviating wealth inequalities, through a number of ways. These include direct benefit for the poorest irrigators, improved farming conditions, higher yields, opportunity to expand their irrigated area, greater certainty of supply and ability to irrigate their own land instead of renting or labouring.

Focusing on rice production in one of the irrigation schemes (Magozi), the statistical analyses showed that farmers who are not satisfied with their water supply obtain 34% lower rice yields, suffer three times more from poor land productivity and experience financial losses that are more than double compared to irrigators who are satisfied/neutral with their supply. Such differences are also spatially reflected, with GIS maps evidencing that plots at the tail end of the system are more severely affected by the issues derived from inadequate water supply.

Despite being mandated by national polices, equity of water supply within small holder irrigation schemes in Tanzania remains a significant challenge given the lack of systematic measuring tools and adequate regulations at local levels. Therefore, strategies addressing water distribution within traditional schemes must target factors that can be directly influenced by farmers, such as keeping manual records of irrigation schedules, empowering less-advantaged irrigators and defining rules that can be effectively enforced by the local Irrigators' Associations.

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