Messica case study

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1. Case study context:

Furrow irrigation systems in Manica, Mozambique

In the mountainous areas of Manica Province, close to the border with Zimbabwe, numerous smallholder producers initiated irrigation systems by diverting permanent mountain streams into earth furrows that channel water to their fields, often over considerable distances. This type of furrow irrigation has a long history, some dating back to the beginning of the 20th century, and maybe even earlier (Bolding et al., 2010).

Characteristically, several furrow systems take water from one stream, sometimes additionally capturing water from side streams, springs or neighbouring catchments. These system are interlinked and may present a picture of a hydrologically interconnected water network (Van der Zaag et al., 2001; Bolding et al., 2010), rather than a series of discrete irrigation systems.

Although the 2003 census recorded only 986 ha of smallholder irrigation in the two central Mozambican Provinces of Sofala and Manica (DNHA, 2003), more recent work in 2010 identified 9,500 ha of existing smallholder irrigation in just 7 Districts (Beekman, 2011:22). Subsequent work suggests even this was an underestimation, with 1000 ha identified in Messica in 2011 where the 2010 study found only 340ha.

The area cultivated using furrow systems contracts and expands during multi-year cycles of droughts or above-average rainfall (Schippers, 2008) and also as a result of continual social interaction and re-organisation (Bolding et al., 2010).

Case study communities

The communities of Chirodzo and Ruaca are situated in Bandula (*localidade*), in Messica District (*Posto Administrativo*), about 40km from the Zimbabwe frontier in the Manica province of Mozambique. The communities are located next to each other on the eastern side of a mountain ridge. Agriculture is practised on gentle slopes leading down into the Messica river valley. Producers sell mostly at Godi market (in Ruaca), the local district market in Messica (about 30 minutes by dirt road from Ruaca) on the main Beira-Harare highway or in Chimoio, the Provincial capital (a further 30 minutes by car on the main road). Either the traders come to producers' fields or the farmers themselves sell their products in the market. Other incomes derives principally from charcoal and small livestock (chickens, goats).

There are three growing seasons. The wet season from December till March, with mainly rainfed maize cultivation. The dry and cool 'winter' season (April till July), in which production is mainly focussed on irrigated horticultural crops. And the dry and hot 'summer' season (August till November), also used for irrigated production but with greater difficulty because of water shortage.

Irrigation water is obtained from small perennial streams flowing down from the mountain to the Messica river. Weemstra et al. (2014) estimated precipitation to be 1224 mm/year, potential evapotranspiration 14562 mm/year, actual evapotranspiration 949 mm/year and discharge an

equivalent of 266 mm/year. Differential gauging showed that groundwater contributes to streamflow in downstream reaches, and that this assumes increasing importance as the dry season progresses. Although varying along the course of the streams, baseflow appears stable during the year with no great variations between the wet and dry season (from a maximum of 70 l/s to 40 l/s). However, rainfall events are followed by a sharp increase in discharge quickly followed by a return to base flow. The average discharge of the Godi stream between December 12th 2012 and August 12th 2013 was approximately 115 l/s or 0.9 mm/day. The discharge achieved by diverting the stream into earth canals (or 'furrows') in the Godi catchment is between 1 and 10 litres per second but some even dry up during the dry season. During the rainy season, lower-lying fields may become waterlogged and farmers seek to increase drainage.

The community of Chirodzo has six streams with a total of at least 41 canals. The community of Ruaca has only one permanent stream with approximately twelve canals.

Figure 1. Regional Location of case study

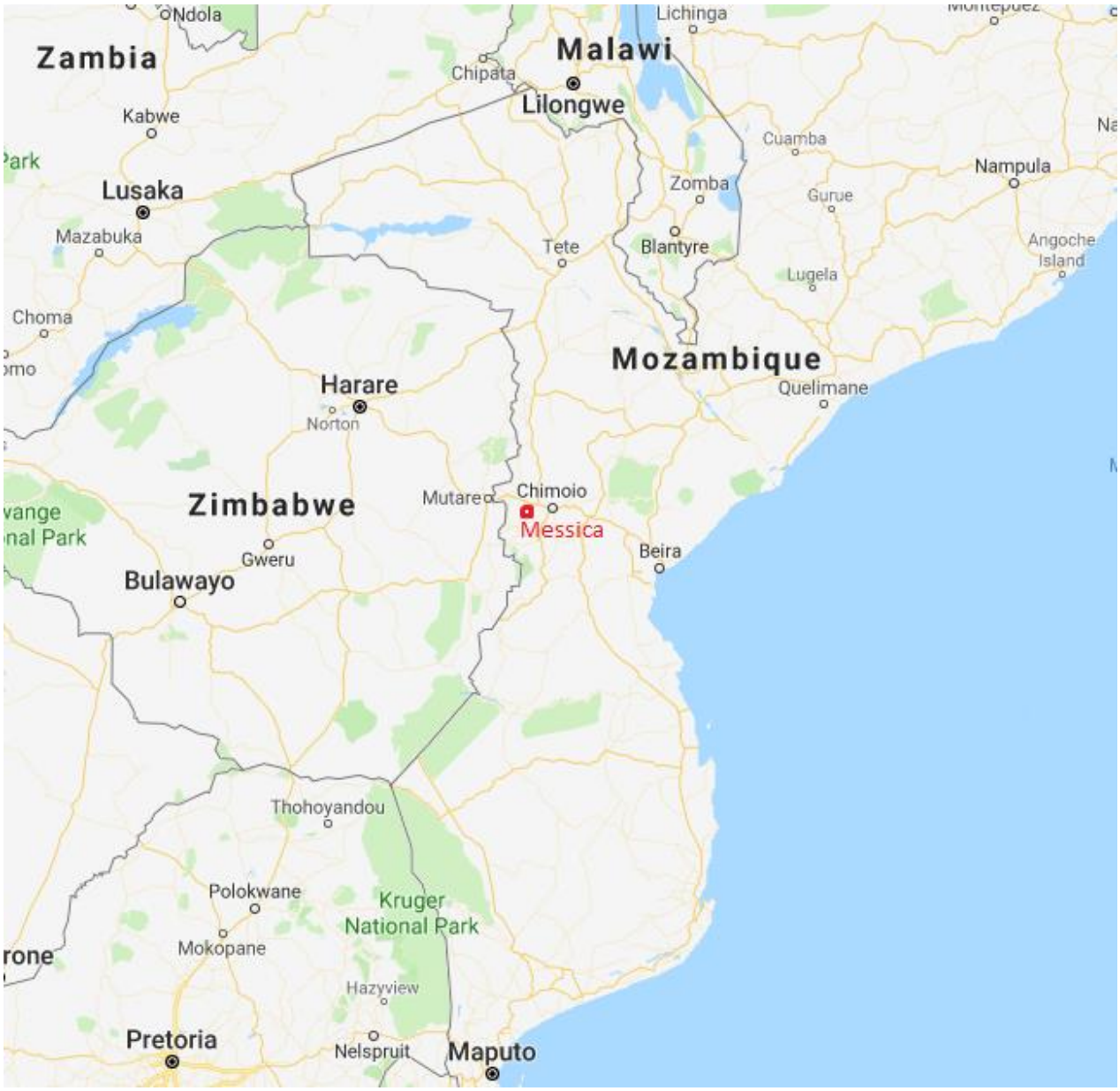
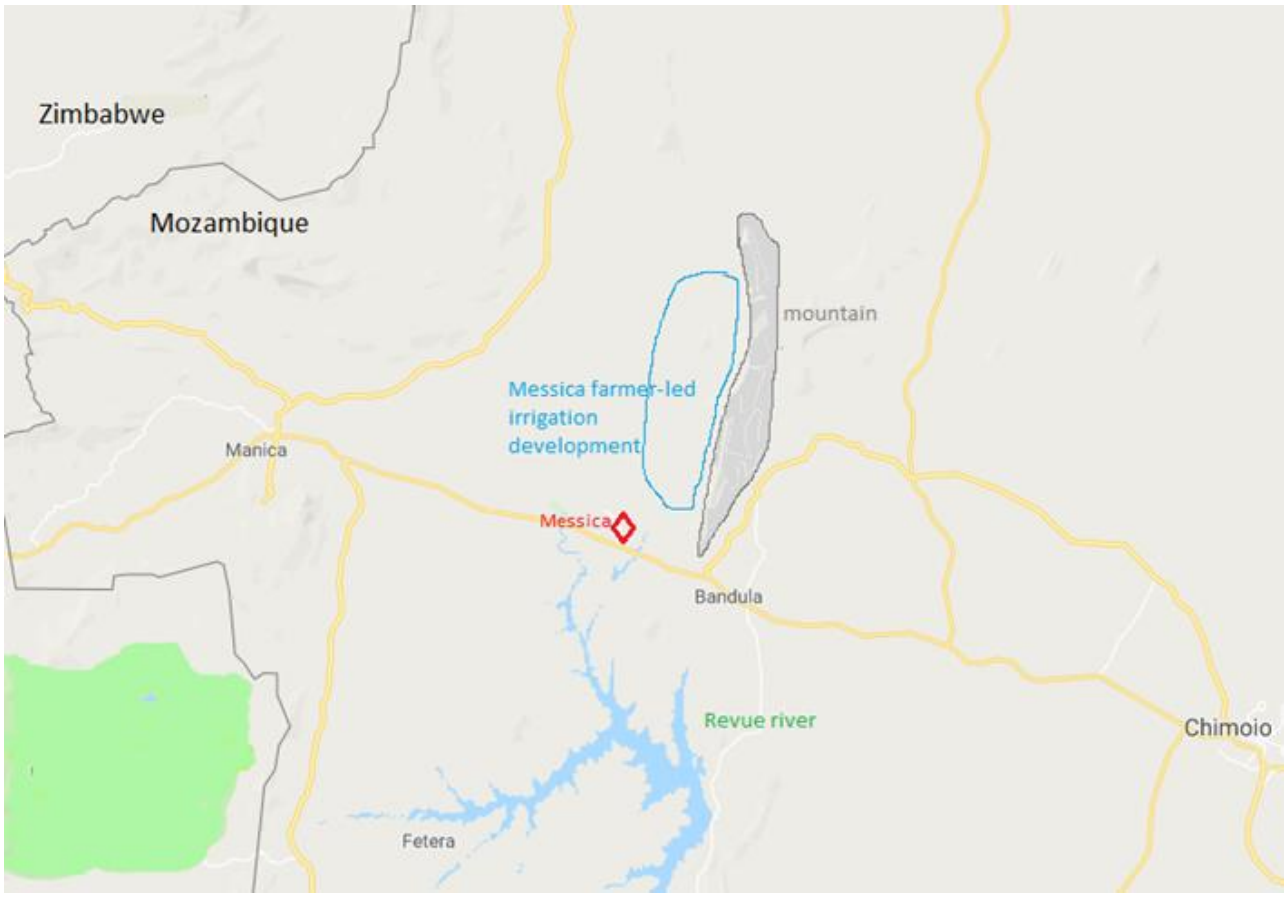


Figure 2. Location of farmer-led development of irrigation in Messica District



2. History of irrigation development

Colonial period (till 1975)

Irrigation was first developed by Portuguese settlers who established farms in the area. Africans working on these farms learned the techniques but were not allowed to open irrigation canals of their own. All the land in Chirodzo was farmed by the settler Amaral. The area known as Ruaca was occupied by Salvador and between the two lay the land of Costa. Downstream, on the bank of the river Messica, was the farm of Pereira, now occupied by a Mozambican farmer, Paulo Chirenje.

Salvador had 2 irrigation canals to irrigate a citrus orchard and other crops. Amaral, an employee of Companhia de Açucareira de Moçambique, had three canals that he used to irrigate citrus orchards, tomatoes and potatoes, and sugar cane as feed for his oxen and other animals.

Between independence and the beginning of the civil war (1975-1977)

After independence, the settlers abandoned the area and African cultivators took over the fields organized in community cooperatives with the help of a government-appointed extension worker.

Civil war (1977-1992)

Insurgency arising initially from the Zimbabwean war of Independence intensified in 1982 when RENAMO fighters occupied the area and most of the population fled. Agricultural production remained severely constrained during the following decade.

Post-war (1992 =>)

Following the general peace agreements in 1992 the area was rapidly re-settled by those who had

left during the war, but also by those whom the war had displaced (e.g. military veterans). The arrival of war returnees, especially those who had taken refuge in the Republic of Zimbabwe and had gained experience in irrigated agriculture, brought new momentum to agricultural development in the area. A Mozambican, Mr. Cristovão, took over the 750 ha area previously operated by the settler Salvador and rehabilitated the two canals. Contestation from the neighbouring population resulted in his land title (DUAT) being reduced to 250 ha. From 2001 new irrigation canals were opened, on the initiative of individuals who are locally recognised as having taken a leading role. Examples are the role of Sr Francisco Solomon Pedro (aka Chadzuka) in rehabilitating a canal in Ruaca and Sr. Tobias Sixpence (aka Dzandiwandira) who similarly rehabilitated a canal in Chirodzo. The rehabilitation of canals has attracted more farmers to seek access to irrigation water and canals have been further extended.

Since 2007 private traders operating from the main vegetable market in Chimoio have promoted contracts for tomato production. Traders provided inputs to the farmer (on credit) in exchange for the right to buy whole tomato crop. The production of tomato under contract met with competition from the foreign-owned Companhia de Vanduzi, whose arrival in 2014 somewhat displaced tomato production with contracts to produce baby corn and piripiri for export to the UK. Although similar to the tomato contracts (supply of inputs on credit in return for exclusive right to purchase the harvest) these contracts were more formal: individual producers had to be registered as members of a farmers' association and contracts had to be witnessed by association leaders. However, the Companhia de Vanduzi discontinued contracts with farmers in Messica in 2017.

Beyond these commercial arrangements, external official intervention has been slight. Agricultural producer associations in both communities were started in 2011, mainly to share agricultural knowledge and practices. At this time Micaia Foundation and ITC facilitated the organization of farmers and their applications for DUATs (formalisation of land tenure). In 2012 the Messica Irrigation Pilot Project (MIPP) did participatory assessments of bottlenecks to development of irrigated agriculture and supported groups of farmers in improving canal intakes and institutional strengthening (elaboration and formalisation of rules and regulation at canal and stream-level). MIPP lasted two years. During this period, eight canals were improved in the two communities, two in Ruaca and six in Chirodzo.

3. Current Irrigation dynamics

Infrastructure/Technical characteristics

The dominant technical characteristics of the furrows in Messica are: a distribution network of earth canals, a temporary diversion weir as intake structure and water distribution within the fields using furrow irrigation. The diversion weirs are usually made of stones, branches, bags of sand, etc. and can therefore be easily modified but require frequent maintenance.

Measurements on the water distribution in such systems showed that for most of the year water availability is relatively abundant and that only during some weeks per year some farmers in the tail-end areas have to irrigate at night in order to obtain enough water for their crops. However, large variation in water availability from year to year means that in some years water shortages are more severe. This work also confirmed that the mountain stream is quickly replenished by groundwater seepage below each diversion weir, possibly reinforced as a result of return flows from the diverted water.

The past 20 years has seen an increase in use of water resources in the area. This is due not only to further construction of canals to distribute river water shared by multiple users, but also due to cultivation of wetlands (drained in the rainy season) and also irrigation using sprinklers (knowledge from Zimbabwean influences) in combination with water reservoirs (basin), some motorised pumps and bucket irrigation.

Institutional/ organisation aspects

The person who took the initiative to open a canal becomes the *dono do canal* (owner of the canal), assuming the full right to use the water in the canal. In order to avoid any competing claims to such primary water rights, the *dono do canal* may often prefer to pay wage labourers to undertake the initial excavation of the canal rather than enlisting neighbouring farmers to help. In this way, the *dono do canal* secures prior rights for himself alone and other potential irrigators have to request his permission to use water from the canal. In general, water availability has been sufficient for permission to be granted in most cases with new canal users establishing their rights through an initial investment: by paying a fee to join the canal 'group' or by extending the canal to reach new areas. In practice ideas of "fairness" and "giving others a chance", sharing water between neighbours and allowing new user into the system or allowing new furrows to be constructed (Bolding et al., 2010; Schippers, 2008). These rights are maintained by investment in operation and maintenance, and non-compliance could lead to exclusion of farmers from water (Bolding, 2007; Schippers, 2008; Bolding et al., 2010). There exist two different types of maintenance. The yearly regular maintenance, e.g. after rainy season: renewal and reconstruction of the canals and intakes. Besides this sometimes some more immediate repairs are needed, e.g. after a very heavy rain event. Farmers usually maintain the canal from the intake until their own fields. Both men and women gather together to mark out with a shovel the course of the channel and allocate among them the work to be undertaken.

The *donos do canal* have a certain influence on the use of water in the canal. Generally, during the dry season, when the river flow reduces and limits water availability, especially for the plots in the tail-end are of the canal. They (try to) dictate the rules and in the time of water shortage between the months of September to January, the rules imposed by the canal owners will certainly affect the production activities of other users.Especially in the hot dry season (August - November) there is a water shortage. During those times most follow a irrigation scheme. The divide the different users of the canal over the morning and the afternoon. Mostly in the morning the downstream users get time to irrigate because the evapotranspiration in the afternoon is more and water is more unlikely to enter the fields of the downstream users. In between the two groups a further subdivision is established in order to get all the fields irrigated. Conflicts do arise during the hot dry season. Some farmers easily don't stop irrigating until they finished all their fields although their time following the irrigation scheme is much shorter. Because of short distance the downstream user will warn his neighbour or simply send someone to take care of the intake during the time being. If needed they sit together with the whole group to make new appointments but sometimes there is simply nothing you can do (this counts especially for the downstream users).

During the rainy season (December - March) and the winter dry season (April - July) less conflicts take place because more water is available in the area. So an irrigation schedule is only applied when needed. There are less strict rules. Because of the short distances they can easily communicate. E.g. they wait till the other has finished irrigating.

Some examples of night storage were found in the area, including one farmer who during the night fills his own reservoir (estimated $10m^2$) excavated from earth and uses this water to water his fields during the day while avoiding competition for water with others.

Conflicts are generally dealt with through consultation.. Conversations are often started by *the dono do canal* or even the community leader but other people can ask them to initiate a meeting, for instance when they need to ask permission to use the water from a canal. Community leaders (*regulos*) play an important role and are the most respected authorities in these communities. Three tiers (*escalões*) of *regulos* are locally recognised and each tier performs a certain activity in territorial administration and resolution of interpersonal and group conflict in the community. They also assign land to individuals for agriculture and housing and enforce local rules to regulate use and

conservation of natural resources by local communities, for example with respect to the manufacture of charcoal, cultivation of plots close to the spring heads and the opening of new canals.

Some farmers refer to water management committees and rules and regulations formally documented for the canals where MIPP worked. Most arrangements seem to have remained informal however and distribution issues are rather settled pragmatically on case-by-case basis, involving community leaders to arbitrate when individuals or groups are unable to resolve problems between them.

Nonetheless, farmers with tail-end plots - often immigrants to the area – accuse *regulos* of favouring local cultivators of head-end plots (nearer the canal intake from the stream) when the latter restrict water flow to the tail end of the canal in times of water shortage.

People who do not have access to irrigated plots sometimes benefit in different ways from the developments in the area, by working on others' fields during the harvest, engaging in trade of agricultural produce, and/or doing paid work in the maintenance and rehabilitation of canals. Despite this, farmers without access to irrigated plots have seen that those who practice irrigated agriculture are financially better-off (see data below) and look to the public irrigation project PROIRRI for investment to extend the irrigated area and make it available to those who are currently non-irrigators.

The contract farming arrangements for export crops introduced by the Companhia de Vanduzi imposed a a greater degree of formality to agricultural production with explicit requirements of access to irrigation. However, the relationship between the company and its contract farmers was not an easy one. Producers complained they did not receive copies of contracts, prices were low and baby corn and piripiri crops were frequently rejected on grounds of inadequate quality while the company prohibited their sale to alternative buyers. Moreover, farmers accused company staff of not making their concerns known to the company managers. Some farmers continued to produce tomatoes on a small scales to spread their risk, maintaining that tomatoes have a higher profit compared to piri piri and baby corn, but the latter have a more guaranteed market. In 2017 the Companhia de Vanduzi withdrew from contracting small-scale growers in Messica, focusing on its own estate production and contracts with outgrowers in the neighbouring Vanduzi District.

4. Social and economic aspects of irrigation development.

Descriptive statistics relating to the households surveyed in 2016-17 are set out in tables 1 and 2. The survey was based on a randomised sample drawn from household lists held by village authorities (*régulos*) in Ruaca and Chirodzo. The data discriminate between irrigating and non-irrigating households and between female-headed (where the head of household was identified by interviewees as female) and male-headed households. Irrigating households made up 62 percent of the sample. The female-headed households represented a small minority (11%) of the sample, and were much less frequent (8%) among irrigating households than among those who were not irrigating (18%). This small sample size, particularly among female-headed households using irrigation should be borne in mind.

Household size and assets

Table 1 shows households that are irrigating are, on average, larger, with one or two more working-age adults than non-irrigating households. The small size and higher proportion of dependent children and older people is apparent for female-headed households who are not irrigating. These households appear disadvantaged on a number of measures in these data. Female heads of

households are on average older than male-headed households, reflecting the high preponderance (82%) of those female household heads that are widows.

The data in table 1 identify a series of advantages of households that irrigate compared to those that do not: higher levels of education achieved by a household member; larger areas of land farmed, higher levels of livestock ownership (including oxen, the main source of farm mechanisation); greater likelihood of their house having metal roofing and glass windows; and fewer months of food shortage. This last is particularly marked among female-headed households, and may reflect differences in the use of irrigation from male-headed households (see below).

All groups of households show a greater likelihood of having grandparents with links to the local area than parents who do so. This is consistent with the decade of insecurity when many families took refuge elsewhere, and also shows that around half of the households surveyed had grandparent links with the local area. Conversely, households with no prior links (parents or grandparents) with the local area made up a larger proportion of those without irrigation, suggesting barriers to acquisition of irrigable land for immigrants. The gendered dimension of access to irrigation is further suggested by the very low proportion of irrigating female-headed households with no prior links to the area.

Female-headed households are more likely to be receiving remittances of money from family members working elsewhere, although the proportion of households receiving remittances is relatively low (<20%).

The crucial role of irrigation in driving improvements in households' economic position is indicated by the data showing that a half or more than a half of total household income is derived from sale of irrigated crops for 85 percent of male-headed and 73% of female-headed households that are irrigating.

Table 1. Demographic and livelihood data for surveyed households in Messica (Ruaca and Chirodzo)

	Non-irrigating		Irrigating	
	Female-headed	Male-headed	Female-headed	Male-headed
N	17	76	11	141
Mean Age of household head	51.7	41.3	50.6	45.5
Mean no. of household members	4.6	6.3	7.5	8.1
Mean number of working age (age 16 to 64)	2.1	2.8	4.1	3.5
Mean number of dependents (age 0 to 15 and 65 plus)	2.5	3.5	3.4	4.6
Mean dependents per working age adult	1.7	1.5	0.9	1.5
Mean maximum years of education within household	6.9	7.8	8.5	9.0
Grandparents from local area (%)	47	51	64	54
Parents from local area (%)	12	11	18	12
No family history in local area (%)	41	37	18	34
% receiving remittances	11.8	5.3	18.2	12.1
Average oxen owned per household	0.71	1.26	1.73	2.16
Average livestock index per hh	0.83	1.68	2.50	3.01
Mean total Land farmed per household (ha)	2.53	4.83	5.73	6.45
Months of food shortage	2.82	2.84	1.27	2.07
Irrig crops contribute >half income	-	-	55	61
Irrig crops contribute half income	-	-	18	24
Irrig crops contribute < half income	-	-	27	15
Housing quality index	4.88	4.62	4.36	5.28
Frequency of metal roof	29.4	32.9	36.4	55.3
Frequency of glass windows	5.9	14.5	9.1	19.9

Table 2. Crop production statistics in surveyed households in Messica (Ruaca and Chirodzo)

Households:	Non-irrigating		Irrigating	
	Female-headed	Male-headed	Female-headed	Male-headed
N	17	76	11	141
Mean total Land farmed per household (ha)	2.53	4.83	5.73	6.45
Mean harvested area of irrigated crops (ha) per household	0	0	2.49	2.87
Mean harvested area of rainfed crops (ha) per household	1.67	4.47	2.26	2.70
Mean area of land irrigated acquired via market (rent or purchase) ha	0	0	0.41	0.77
Mean gross income from all crop sales (USD/year/hh) [1]	2.1	57	715	1157
Mean gross income from non-irrigated crops (USD/year/hh)	2.1	57	157	59
Mean gross-income from irrigated crops (USD/year/hh)	0	0	558	1098
Mean net income from crop sales (USD/year/hh) [2]	1.5	49	453	677
Mean net income per ha rainfed (USD/ha)	0.92	13.0	83.1	20.2
Mean net income per ha irrigated (USD/ha)	0	0	160	331
Total value of harvest (USD/hh)	140	289	1456	1496
Percent of irrig harvest sold	-	-	63.1	69.7
Percent of non-irrig harvest sold	2.7	18.5	17.6	10.4
Employ farm labour (%)	12	25	18	44
Rainfed crops				
Ploughed with oxen (%)	76.5	81.7	68.2	67.8
Purchased fertilizer (%)	0.0	1.3	9.1	5.7
Improved seed (%)	9.8	20.2	13.6	12.6
Irrigated crops				
Ploughed with oxen (%)	-	-	88.6	82.3
Purchased fertilizer (%)	-	-	59.1	62.3
Improved seed (%)	-	-	32.3	45.7
Mean rainfed maize yield kg/ha	874	730	633	834
Mean irrigated maize yield kg/ha	-	-	1080	355

[1] crops valued by the sales price and quantity reported in questionnaire survey

[2] net income is estimated as the gross sales value of crops less the cost of fertilizer, seed, pesticide and labour.

Crop Production

Table 2 shows the huge difference in income from crop sales between irrigating and non-irrigating households. The data show female-headed households who are irrigating have much lower average incomes from crop sales than male-headed households but much higher than either male-or female-headed households who are not irrigating. The gap between male and female-headed households appears also in the area farmed and area irrigated.
Male-headed households are more likely to hire farm labour and irrigating households also hire more farm labour, so that the proportion hiring labour approaches half of male-headed irrigating households.

The data also show farmers' much higher investment in inputs on irrigated land, with fertiliser being purchased for about 60 percent of irrigated crops compared to less than 20 percent of non-irrigated crops. Moreover, farmers who use irrigation are more likely to apply fertilizer to their rainfed crops. Similarly, use of improved seed for irrigated crops is at least double that for rainfed crops, although the difference between rainfed crops of irrigating and non-irrigating households is less marked.

There was no recorded use of tractors in this sample of farmers but, in contrast, the role of ox-drawn ploughs is critical. Over 80 percent of irrigated crops were on plots ploughed with oxen. For the rainfed crops of non-irrigating households the use of oxen was similar, although among female-headed households the use of oxen was slightly lower, at 75 percent. The use of oxen was slightly lower, at 68 percent, for the rainfed crops of households using irrigation, possibly indicating a prioritisation of using oxen on irrigated crops, or a relative shortage of oxen when timing is critical at the start of the rainy season.

The strong market-orientation of irrigated crop production is demonstrated by the high percentage (>60%) of irrigated production that is sold, rising to an average of nearly 70 percent for male-headed households. This compares to sales of less than 20 percent of the value of rainfed harvests. The twenty-fold difference in gross sales value between irrigating and non-irrigating households is therefore due to both the much higher value (x 5 at least) of irrigated crops (mostly vegetables) and the much higher proportion (x 3 at least) that is sold.

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