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153

Gender Aspects of Small-scale Private Irrigation in Africa

Barbara van Koppen, Lesley Hope and Willem Colenbrander

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Project

The AgWater Solutions Project was implemented in several countries in Africa and Asia between 2009 and 2012. The objective of the project was to identify investment options and opportunities in agricultural water management with the greatest potential to improve incomes and food security for poor farmers, and to develop tools and recommendations for stakeholders in the sector including policymakers, investors, non-governmental organizations (NGOs) and smallholder farmers.

The leading implementing institutions were the International Water Management Institute (IWMI), the Food and Agriculture Organization of the United Nations (FAO), iDE, the International Food Policy Research Institute (IFPRI) and the Stockholm Environment Institute (SEI).

For more information on the project or for detailed reports, please visit the project website (http://awm-solutions.iwmi.org/) or contact the AgWater Solutions Project Secretariat (AWMSolutions@cgiar.org).

Contents

Summary

This paper analyzes gender dimensions of the adoption of small-scale private irrigation technologies in Ghana and Zambia. Continental and national policies promote gender equality also in the domains of agriculture and irrigation. Yet, evidence on the gender dimension of irrigation adoption processes in sub-Saharan Africa is rare and assumptions diverge. Either men or women can be seen as being the drivers of agricultural technological innovation. This paper aims to inform such opposite assumptions by evidence generated from three gender-disaggregated variables in the quantitative farm household surveys, which were carried out under the AgWater Solutions Project in Ghana and Zambia. The variables are: headship of household, labor provision and plots as intra-household production sub-units.

It was identified that female-headed households (FHHs) adopted irrigation at a rate that is at least two-thirds of that of male-headed households (MHHs). However, FHHs adopted manual irrigation technologies such as buckets more often, while MHHs favored motor pumps and river diversions. Men generally provided more labor for irrigation activities. Women in FHHs provided least labor: only 35% of total household labor. Having an own plot of land encouraged female heads of households to adopt irrigation more often than overall adoption rates for female-headed households. Married women with their own plots of land had the highest rates of irrigation adoption out of all the categories in one site in Zambia, but adoption rates were lower than overall rates in two other sites. Women's decision-making appeared to be somewhat stronger on irrigated plots than on rainfed plots. The conclusion is that the mode of agricultural growth that was found, and is triggered by irrigation and in which both genders engage, is a historically unique 'dual irrigation culture'. Better implementation of gender equality policies will remove the structural obstacles that women still face, and contribute to both more gender equality and to faster irrigation adoption for accelerated agricultural growth.

INTRODUCTION

Background and Aim of the Study

Many high-level policy forums in sub-Saharan Africa, including the African Ministers' Council on Water (AMCOW), have adopted gender equality as their main goal (AMCOW 2011). National constitutions, African gender protocols and United Nations agreements, such as the Convention on the Elimination of All Forms of Discrimination against Women (CEDAW), back these efforts (UN 1979). These policies are also applicable for access to land and public agricultural water management (AWM) support to small-scale farmers, such as AWM technologies, loan facilities, inputs, extension and market access. Researchers and program managers did some work on gender in public irrigation schemes, where they, in particular, identified gender inequalities in irrigated land allocation and gaining membership of water user associations (WUAs) (Meinzen-Dick and Zwarteveen 1998; van Koppen 2002; Peterman et al. 2011). Equal public support should also hold for the focus of this paper: small-scale private irrigation development. However, public recognition, let alone support to private irrigation, is still piecemeal. Gender issues have hardly been raised at all. Due to these factors, assumptions and stereotypes prevail, which are even opposite. This paper seeks to move beyond such assumptions through evidence from gender disaggregated farm surveys on small-scale private irrigation adoption.

At the one end is the assumption that men specialize in technology adoption for improved productivity, so that they can better provide for their wives and children with their 'household income'. Their wives can then fully specialize in domestic work and child care. Gender relations entail a division of labor that is for the benefit of all. In this view, the goal is to alleviate women's agricultural labor. Targeting of public support is only warranted for female heads of households. Empirically, Boserup (1970) found this pattern in the historical 'plough cultures' in Europe and in many parts of Asia and Ethiopia. Here, men propel agricultural growth, in general, and are supposed to provide for their families. With growing wealth, women become housewives, while landless male and female wage workers take over women's agricultural labor (Boserup 1970).

The opposite assumption on gender in small-scale private irrigation development builds on what Boserup (1970) empirically found for the 'hoe cultures' of sub-Saharan Africa. As many other scholars confirmed after Boserup (1970), women in the African 'hoe cultures' have done, and continue to do, most of the cropping (Rogers 1980; Safilios-Rothschild 1994; Doss 1999; FAO, IFAD and ILO 2010). Men specialize more in livestock, hunting and warfare. Since long, both men and women are expected to be economic providers. Matrilineal land inheritance was most common. After the - still largely unexplained - shift of matrilineal land tenure to patrilineal land tenure in parts of the continent, the patrilineal clans of husbands became responsible for allocating land to their wives (Holden and Mace 2003). Women and men continue to have their own plots, crops and incomes. In particular, high-value vegetable crops have remained as women's crops to be used for consumption and for women's income. Colonization and western religion introduced the notion of the man as head of the household, provider and, therefore, the acclaimed beneficiary of public land improvements and other assets (Boserup 1970).The assumption, then, is that stagnating agricultural productivity is largely due to the wrong assumptions made by colonizers and current professionals about gendered production relations in sub-Saharan Africa. This would also be the case for private small-scale irrigation technologies. Irrigation is for high-value crops, which are women's domains. Therefore, women would be the lead in private small-scale irrigation adoption. Women's control over own income is in the interest of her dependents, as women tend to spend a higher proportion of their incomes on household welfare than men (Quisumbing

2003). A higher income allows women to alleviate their domestic labor, for example, by paying for fuelwood instead of collecting and mechanized grinding of corn. In this view, the question is not about women's labor alleviation, but about rendering women's labor more productive for an income that they control themselves, as men do. Thus, any public support for agriculture should primarily be targeted to both female heads of households and to married women. For the sake of gender equality, support can also be targeted to men, but productivity gains are unlikely as men are hardly involved in cropping.

The aim of this paper is to inform these two diametrically opposite assumptions by providing empirical evidence on the question of women's and men's engagement in the adoption of (largely) private small-scale AWM technologies in Ghana and Zambia. Both countries are examples of the ancient 'hoe cultures' (Boserup 1970) and still have some matrilineal societies. However, ploughs have been introduced in the past century and other societies are patrilineal. We will derive recommendations from the findings for agricultural productivity and gender equality policies.

Conceptualization and Methodology

The method consisted of a gender differentiated analysis of existing datasets of quantitative surveys on the adoption of AWM technologies in Ghana and Zambia. These studies were conducted under the AgWater Solutions Project, led by the International Water Management Institute (IWMI), in collaboration with the Food and Agriculture Organization of the United Nations (FAO), iDE, the International Food Policy Research Institute (IFPRI) and the Stockholm Environment Institute (SEI). The studies carried out were related to the cropping season of 2008/2009 or 2009/2010. The detailed study questions and approaches slightly differed because there was no a priori intention to compare across countries.

We conceptualized and operationalized 'gender' in a farm household in three ways. First, the farm household was the unit of analysis for technology adoption rates, technologies adopted, and rainfed and irrigated farm sizes. This analysis was differentiated by the gender of the household head: male-headed households (MHHs) and female-headed households (FHHs). There were very few unmarried men, so MHHs usually consisted of a couple. The definition of de jure FHHs was quite straightforward: households led by unmarried women. The de facto FHHs were households in which women were the main providers, due to their husbands being sick or handicapped or otherwise unable to provide. Moreover, they included households whose husbands had migrated. Headship of household is a common variable in farm surveys. The findings of this analysis in Ghana are presented in the section, *Ghana: Survey Findings on Technology Adoption*, and the findings from Zambia are presented in the section, *Zambia: Survey Findings on Technology Adoption*.

Second, the individual household member was the unit of analysis for labor provision for irrigation activities among adopting MHHs and FHHs. Findings of the analysis from both Ghana and Zambia are presented in the section, *Ghana and Zambia: Gendered Labor Provision for Irrigation*.

Farm surveys often lose gender-disaggregated data collected in the interviews during the analysis phase, when information is aggregated to the gender-blind category of 'the household'. Gender analysis keeps this information gender-disaggregated.

Third, we analyze adoption rates and changes in gendered decision-making under irrigation adoption for 'intra-household production sub-units', in both MHHs and FHHs, in Zambia. The findings of this analysis are presented in the section, *Zambia: Intra-household Production Sub-*

units. These variables are differentiated by the gender of its manager, distinguishing male- and female-managed production sub-units. An intra-household production sub-unit is an enterprise, managed by an adult household member who also has the major say over the output. Unlike the assumed unitary household, in which all activities, assets and resources are pooled under the custodianship of the male head of the household, a more realistic concept is to recognize households as domains of cooperation and conflict. Adult members manage their own enterprises and bargain about the allocation of labor, assets and benefits. While there are intricate forms of exchange and mutual help, each adult member tries to 'get the best deal out of it'. Ownership of land and other assets, cultural labor obligations for women, marital status, age, and stage of the household cycle and other factors determine the outcomes (Safilios-Rothschild 1988).

The identification of intra-household production sub-units warrants more detailed data collection and analysis. In our case, a male- or female-managed plot appeared as a good proxy for a production sub-unit. The section, *Zambia: Intra-household Production Sub-units,* also presents findings on the impact of better targeting of support for small-scale private irrigation to women.

A methodological caveat in the farm surveys is warranted for the gender of the respondent of the survey. In these farm surveys, the enumerators were instructed to interview the 'head of household'. They typically interpreted the 'head' to be a man. Women were heads of household by default. In MHHs, the enumerators mainly spoke with men (81% of all respondents in both MHHs and FHHs in Ghana; 95% of all MHHs in Zambia). So, most findings presented below about MHHs represent men's views. Women's ownership, decision-making and labor provisions are likely to be underreported.

Sample Selection

In both country studies, the site selection focused on regions where adoption rates of AWM technologies were known to be high. Three or four regions were selected to ensure diversity in ecological and socioeconomic contexts. In these purposively selected regions a 'hut-to-hut' census was conducted among adopters and non-adopters in selected adjacent areas. This census served as a framework in the selection of representative samples for household surveys, either covering every household in adjacent areas (Ghana) or in randomly selected households from the list (Zambia). Ghana's data come from the household survey; Zambia's data are both from the census and the household survey.

An important difference in the study designs concerned the technologies studied. In Ghana, the focus was only on lift irrigation but all combinations of these technologies were investigated. In Zambia, four regions were chosen to ensure that all technologies were represented: river diversions (Mpika), motor pumps (Chibombo), conservation agriculture (Monze) and a public irrigation scheme (Sinazongwe). The survey revealed other technologies as well. Only the main technology of households was assessed. Table 1 gives an overview of these study designs.

TABLE 1. Overview of the study designs.

Country and regions	Focus and selection criterion for region	Sampling procedure and sample
Ghana Ashanti Greater Accra Volta	Focus on all private water-lifting technologies and more lifting technologies per household. Purposive selection of regions with highest prevalence of private lift irrigation.	Hut-to-hut census among 12,620 households in five regions. Hut-to-hut household survey among 494 households from 44 communities in 17 districts.
Zambia Mpika Chibombo Monze Sinazongwe	Focus on all smallholder technologies and only the main technology per household. Purposive selection of districts with highest prevalence of river diversions, motor pumps, conservation agriculture or public irrigation schemes.	Hut-to-hut census among 1,935 households. Household survey among 240 representative households, randomly selected from the census.

Demographically, the following proportions of FHHs were found. In Ghana,10% of the households in the sample were headed by females. Between 31% and 47% of these were de facto FHHs, in which men were out-migrants mainly to neighboring cities. This underlines the importance of this type of FHH.

In Zambia, the proportions of FHHs in three districts were 22-25% (both de jure and de facto FHHs). Mpika was an exception with only 15% of FHHs.

GHANA: SURVEY FINDINGS ON TECHNOLOGY ADOPTION

Adoption Rates

The adoption rates of any water-lifting device were high for both MHHs and FHHs, ranging from 56% for FHHs in the Ashanti region and up to 93% for MHHs in the Greater Accra region. As shown in Table 2, adoption rates are consistently higher for MHHs (average 80%) than for FHHs (average 63%). The gap was smallest in the Volta region, where 81% of the adopters were MHHs and 73% were FHHs.

TABLE 2. Adoption rates by type of household and region (percentage).

	Ashanti (%)		Greater Accra (%)		Volta (%)		Total (%)	
	MHH	FHH	MHH	FHH	MHH	FHH	MHH	FHH
	(N=156)	(N=16)	(N=108)	(N=18)	(N=181)	(N=15)	(N=445)	(N=49)
Adopters	71	56	93	61	81	73	80	63

One factor that may have contributed to the lower adoption rates of FHHs was their generally smaller household size. This was confirmed. In all cases, except for MHHs in Greater Accra, the household size of adopters was larger than for non-adopters (see Table 3).

TABLE 3. Average household size for adopters and non-adopters by type of household and region.

	Ashanti		Greater Accra		Volta		Total	
	MHH (N=156)	FHH (N=16)	MHH (N=108)	FHH (N=18)	MHH (N=181)	FHH (N=15)	MHH (N=445)	FHH (N=49)
Adopters	6.52	6.75	6.99	5.92	6.88	6.00	6.81	6.16
Non-adopters	5.98	4.71	7.33	-	6.08	4.50	6.06	4.63

Technologies Adopted

Among the total of 397 farm households that adopted water-lifting devices, FHHs adopted a bucket (55%) more often than MHHs (39%). For petrol pumps (without and with buckets), adoption rates were virtually similar. For mechanized irrigation, the difference was that FHHs hardly adopted electric pumps, while 21% of MHHs did adopt electric lifting devices (see Table 4). With approximately half or more of the adopting farm households moving to mechanization, it was clear that mechanized irrigation had taken off in these regions.

TABLE 4. Adoption rates by technology, type of household and region (percentage).

Technology	Ashanti (%)		Greater Accra (%)		Volta (%)		Total (%)	
	MHH (N=111)	FHH (N=9)	MHH (N=100)	FHH (N=18)	MHH (N=148)	FHH (N=11)	MHH (N=359)	FHH (N=38)
Bucket only	35	33	50	66	39	55	39	55
Treadle pump only*	0	11	0	0	0	0	0	3
Bucket and treadle pump	0	0	0	0	1	0	0.8	0
Petrol only	23	11	3	8	16	36	15	16
Petrol and bucket	41	45	41	25	2	0	24	23
Electric only	0	0	1	0	30	0	14	0
Electric and bucket	0	0	5	0	12	9	7	3
Bucket/electric/treadle pump	1	0	0	0	0	0	0.2	0

Note: * Treadle pumps are excluded in the further analysis.

Farm Sizes of Rainfed and Irrigated Areas

Irrigation was mainly carried out in the dry season. The majority of irrigators also cultivated rainfed plots in the rainy season. The mean size of rainfed plots (of adopters and non-adopters) is given in Table 5. The Table also gives the mean size of irrigated land. Both MHHs and FHHs cultivated larger areas in the rainy season than in the dry season. The difference between rainfed and irrigated farm sizes was largest for the MHHs and FHHs in Ashanti region. Here, the rainfed areas were more than double the areas irrigated. This is because the Ashanti region often grows rainfed tree crops on relatively large areas of land. In this matrilineal society, FHHs cultivated larger rainfed farmlands than MHHs. Elsewhere, both the rainfed and irrigated areas in MHHs were always larger than those of FHHs.

TABLE 5. Mean area under rainfed and irrigated farming (aggregated adopters and non-adopters) (hectares).

Mean land size	Ashanti		Greater Accra		Volta	
	MHH	FHH	MHH	FHH	MHH	FHH
Irrigated	1.01 (N=195)	0.72 (N=20)	1.36 (N=176)	1.29 (N=33)	1.00 (N=266)	0.71 (N=19)
Rainfed	3.46 (N=133)	3.84 (N=14)	2.32 (N=90)	1.53 (N=18)	2.69 (N=168)	2.2 (N=15)

The irrigated farm size was related to the technology adopted, as shown in Table 6. This confirms that FHHs had somewhat lower sizes of rainfed plots than MHHs. The irrigated area for FHHs was about half that of MHHs for petrol and bucket irrigation. However, for combined mechanized irrigation and bucket irrigation, which is often carried out by hired labor, FHHs had larger plots than MHHs.

TABLE 6. Average farm size of rainfed and irrigated plots, by the technology adopted and type of household (hectares).

Water application methods	Type of Household	N value	Area (hectares)
Rainfed	MHH	N=86	2.82
	FHH	N=11	2.52
Bucket only	MHH	N=147	0.92
	FHH	N=21	0.43
Petrol only	MHH	N=54	1.41
	FHH	N=6	0.79
Petrol and bucket	MHH	N=86	1.01
	FHH	N=9	1.16
Electric only	MHH	N=50	0.94
	FHH	N=0	0.00
Electric and bucket	MHH	N=25	1.10
	FHH	N=1	1.40

Conclusions

Both MHHs and FHHs in the Ashanti, Greater Accra and Volta regions actively took up the opportunities of private lift irrigation and half or more moved into mechanization. However, there was a gender gap. With smaller household size and rainfed and irrigated land sizes, FHHs were, overall, less often adopters of technology than MHHs. Their choice of technology was somewhat more biased to manual lifting. However, the differences were small and there were exceptions. On the one hand, the differences confirm the relevance of differentiation by headship of household in research. On the other hand, these findings confirm that FHHs are also adopting irrigation at substantive scales.

ZAMBIA: SURVEY FINDINGS ON TECHNOLOGY ADOPTION

Adoption Rates

In Zambia, a similar pattern was found for adoption rates by headship of households. Here, we studied all relevant small-scale AWM technologies. The household survey revealed that 71% of the MHHs had adopted AWM technologies. Adoption rates for FHHs were 55% (see Table 7). Dis-adoption rates of households who took up irrigation but abandoned it were substantive and similar for MHHs and FHHs (21 and 22%, respectively). Very few MHHs were non-adopters (8%). Among FHHs, this proportion was higher: 22% (see also Table 15 for adoption rates by district, as found in the census).

TABLE 7.Adoption, dis-adoption and non-adoption rates by type of household (percentage).

		Adopters (%)	Dis-adopters (%)	Non-adopters (%)	Total (%)
MHH	N=191	71	21	8	100
FHH	N=49	55	22	22	100

As for the Ghana study, FHHs had smaller average households (4.73) than MHHs (6.37). The household survey found that adopter households had a larger average household size (6.35) than the non- and dis-adopter households (5.40). So, in Zambia, smaller farm sizes of FHHs might have also contributed to the lower adoption rates of FHHs.

Technologies Adopted

The census asked adopters about the main AWM technology that they had adopted (Table 8). All districts mentioned buckets as the main AWM technology adopted, except for Mpika, where river diversions were used by 50% of the MHHs; only 39% of those MHHs used buckets. For the FHHs in Mpika, buckets were still more important (65%), but river diversions came in second place (23%). River diversions are largely private. In Mpika, 10% of both MHHs and FHHs used wetlands.

Motor pumps were only found in Chibombo, a district just 20 kilometers (km) from Lusaka's fast-expanding vegetable markets. After buckets, motor pumps were the most important, used by 31% of adopter MHHs. Adoption rates of motorized pumps by adopter FHHs were lower at 15%. The treadle pump was only used by 4 or 5% of the households, and was, therefore, not considered further here.

Conservation agriculture was only used by 8% of the MHHs and 3% of the FHHs in Monze. Since Monze was selected because of its relatively high adoption rates of conservation agriculture, adoption rates of this technology elsewhere in Zambia are likely to be even lower.

The findings in Sinazongwe also show the importance of buckets and other private irrigation compared to public interventions. The public irrigation scheme only served 17% of the MHHs and 13% of the FHHs. Private wetlands were used more frequently by FHHs (32%) than MHHs (18%).

TABLE 8.Technology adopted by type of household and by district (percentage).

District	Type of household	N value	Technology adoption rates (%)								
			Bucket	River diversion	Irrigation scheme	Public Motor pump	Wetland	CA[1]	Treadle pump	Other	Total
Mpika	MHH	N=256	39	50		0	10	1	0		100
	FHH	N=31	65	23			10			3	100
Chibombo	MHH	N=559	64			31			5		100
	FHH	N=151	81			15			4		100
Monze	MHH	N=139	81			2		8		9	100
	FHH	N=37	92					3		6	100
Sinazongwe	MHH	N=149	62		17		18	1	1	2	100
	FHH	N=31	55		13		32				100

Note: [1] CA = Conservation agriculture.

Farm Sizes of Rainfed and Irrigated Areas

As shown in Table 9, the mean farm size of the total irrigated area per household is much smaller than the mean farm size of all rainfed plots within the total sample of adopters, non-adopters and dis-adopters.

TABLE 9. Mean farm size of total plots under irrigation or rainfed cultivation of adopter, dis-adopter and non-adopter households (n=1,935).

District	Total area of plots under irrigation mean (hectares)	Total area of plots under rainfed mean (hectares)	Ratio of sizes of rainfed plots/ irrigated plots
Mpika	0.47	1.32	2.8
Monze	0.16	2.17	14
Sinazongwe	0.38	0.94	2.5

Note: no data for Chibombo.

Conclusions

In sum, the patterns of technology adoption by type of household were quite similar to those found in Ghana. FHHs did adopt technologies, but they did slightly less often than MHHs. Moreover, the adopter FHHs adopted the less labor-intensive river diversions and motor pumps only half as often as MHHs. This was the opposite for labor-intensive technologies. FHHs cultivated wetlands twice as often as MHHs. FHHs used buckets more often than MHHs in three districts, but, in Sinazongwe, MHHs used buckets more often. While the household size of FHHs was also smaller than MHHs, FHHs were more inclined to spend their labor for agriculture than MHHs. As in Ghana, irrigated farm sizes were considerably smaller than rainfed farm sizes.

These differences in adoption rates and technologies between FHHs and MHHs in both Ghana and Zambia imply that gender differentiation by headship of households is an important factor to be considered in future research. Further, policies and interventions should explicitly target FHHs, especially in accessing the labor-saving irrigation technologies, provided that they fit the smaller farm sizes.

Headship of household is certainly not the only gender variable. Over 75% of the households have married couples. This warrants intra-household analysis in both FHHs and MHHs, which is the focus of the remainder of this paper.

GHANA AND ZAMBIA: GENDERED LABOR PROVISION FOR IRRIGATION

Ghana: Findings

Labor required to apply the new technologies is an important variable. It entails time and skills of varying complexity to improve productivity. Labor provision also reflects cultural acceptability. In the plough cultures of India, for example, strong taboos exist against women even touching a plough (Agarwal 1994). Most importantly, labor provision is related to say over the fruits of labor, although this relationship is considerably less strong for women (and children) than for (adult) men.

The Ghana survey assessed three main types of labor: household, hired and exchange labor. Household labor is labor provided by members of the household. Hired labor is paid labor provided by people outside the household. This can be on temporary or permanent basis. Exchange labor does not involve payment of money, but farmers work on each other's farm to complete a specific task. Table 10 presents findings on the person-days per year of labor provided for irrigation, differentiated by male and female working days for different types of labor, the technology adopted and the type of household.

Table 10 shows that bucket irrigation alone required the most labor per hectare (278 and 165 days for MHHs and FHHs, respectively). FHHs spent less total irrigation labor than MHHs. This was only partly due to their smaller irrigated plot sizes: labor contributions per hectare were also, on average, two-thirds of MHHs. Only the six FHHs using petrol pump irrigation spent more time. While FHHs spent somewhat less household labor days on irrigation than MHHs, they engaged especially less in hired labor or exchange labor.

Looking at the gendered labor contributions within MHHs and FHHs, men spent more time on irrigation for all three types of labor: household, hired and exchange labor. Hired and exchange labor were considerably more male-dominated than household labor. For household labor, women in MHHs provided a higher proportion (30/70 = 43%) of the total of men's and women's household labor than women in FHHs, who provided 35% (20/57) of total household labor. The type of technology does not seem to matter in MHHs; there was no systematic difference between women's and men's relative contributions to household labor for bucket irrigation and mechanized irrigation. However, in FHHs, men mainly contributed labor for mechanized irrigation. Women's labor prevailed in bucket irrigation.

Zambia: Findings

The Zambian survey measured household labor contributions to irrigation only by the type of technology according to four categories: male, male and female, female and children. For bucket irrigation, there was no gender bias. Labor for canal irrigation was slightly biased towards men, but this bias was strongest for motor pumps. In 54% of the households adopting pumps, men alone provided labor. In the other half of the cases, women and children were also active (see Table 11).

TABLE 10. Gendered labor provided for irrigation by technology adopted, type of labor and type of household (person-days per year).

AWM techno-logy	Type of house-hold	N value	Hired labor in person-days		Unpaid labor in person-days				Total labor days		Total labor days	labor days per hectare
					Household labor		Exchange labor					
			Male	Female	Male	Female	Male	Female	Male	Female		
Bucket	MHH	N=147	72	52	64	41	22	5	158	98	256	278
	FHH	N=21	-	-	11	60	-	-	11	60	71	165
Petrol	MHH	N=54	27	16	18	18	13	-	58	34	92	65
	FHH	N=6	22	3	30	8	4	4	56	15	71	90
Petrol and bucket	MHH	N=86	47	1	41	19	20	3	108	23	131	130
	FHH	N=9	14	-	13	14	-	8	27	22	49	42
Electric and bucket	MHH	N=25	140	-	36	40			176	40	216	196
	FHH	N=1	-		94	-			94		94	67
Average of all four techno-logies	MHH	N=312	72	17	40	30	14	2	125	49	174	188
	FHH	N=37	9	1	37	20	1	3	47	24	71	120

Note: 50 MHHs using electric pumps are excluded.

TABLE 11. Intra-household gendered labor provision for irrigation by technology.

Technology		Household labor provision for irrigation by technology (%)				
		Male	Male and female	Female	Children	Total
Bucket	N=81	16	51	31	2	100
Canal and river diversion	N=24	17	67	8	8	100
Motor pump	N=13	54	31	8	8	100

Conclusions

Both men and women provided labor for irrigation. For bucket irrigation, contributions were pretty similar, except for FHHs in Ghana where women did much more work than men. With mechanization, there was no clear pattern in Ghana. In Zambia, men's contributions to mechanized irrigation were more articulated. Yet, in neither country did we find cultural taboos, monopolization of mechanized technologies or men categorically taking over from women in the labor for irrigation of high-value cropping. The equal capacity building of men and women in irrigation skills is socially acceptable and should also be promoted by interventions.

Labor provision per se does not say much about the control over the fruits of labor. Yet, control over those fruits is the main incentive for farmers to decide to invest in the technologies for higher productivity. We explore findings about this relationship from the survey carried out in Zambia in the final section of this paper.

ZAMBIA: INTRA-HOUSEHOLD PRODUCTION SUB-UNITS

Adoption Patterns

In the section, *Conceptualization and Methodology*, we defined intra-household production sub-units as the production activities or enterprises that are managed by an adult household member. While there can be considerable mutual consultation and exchange, one adult tends to be the ultimate decision-maker over access to land, crop choice and investments in the production process, including investments in irrigation and control over the output. For assessing gendered adoption processes and changes in decision-making, the question is: which adult decides to adopt irrigation for whose production sub-unit?

The household survey questions went down to plot level, including both rainfed and irrigated plots. This appeared a reasonable proxy for a production sub-unit. Table 12 illustrates the relationship between plot ownership, management and control over the produce for the case of an irrigated plot, and the decision-making over the income gained from sales.

TABLE 12. Gendered decision-making on the income from sales by the owner of an irrigated plot (percentage of households).

Owner of irrigated plot	N value	Decision-making on the income gained from sales (%)		
		Female head or wife	Husband	Others
Female household head	N=14	93	-	7
Husband in MHH	N=90	24	57	19
Wife in MHH	N=13	69	15	15

Almost all female household heads owning plots controlled the income from sales (93%). When wives owned plots, they controlled the money in 69% of the cases. This is higher than when husbands were owners and the husbands only controlled the income in 57% of the cases. In 24% of the cases, their wives had the stronger say.

For assessing irrigation adoption rates by production sub-unit, we focused on households with women-managed plots, and compared adoption rates by women on their own plots with the overall adoption rates for all households. However, not all households had women-managed plots.

Table 13 first shows the proportion of households that had women-managed plots, whether irrigated, rainfed or both. Expectedly, women in 70 to 95% of the FHHs had their own plot(s). That percentage is lower in MHHs. In Mpika, women had their own plot in only 34% of the MHHs. It is noted that plot ownership is a complex concept in this matrilineal society. If land is being cleared for shifting cultivation, it is referred to by the name of the man. During cultivation and with regard to the produce, the plot is referred to by the name of the woman. As most respondents were men, there may have been a bias towards ownership claims by men. On the other hand, if a household claims to have a plot owned by a woman, it may actually refer to the main household field. In patrilineal Monze and Sinazongwe, almost half of the MHHs (44-47%) have women managing their own plots.

TABLE 13.Proportion of households with women-managed plots and women-managed irrigated plots, and overall adoption rates by type of household and district.

District	Type of household	N value	Proportion of households with women-managed plots (rainfed, irrigated or both) (%)
Mpika	MHH	N=346	34
	FHH	N=61	87
Monze	MHH	N=205	44
	FHH	N=57	95
Sinazongwe	MHH	N=191	47
	FHH	N=56	70
Total		N=916	100

Table 14 focuses on households with women-managed plots, and shows the percentage of households with women-managed plots in which that plot was irrigated, and compares that adoption rate with the overall adoption rates by household headship and by district. This Table further differentiates Table 7 in that it also provides details by district. It repeats that FHHs had adoption rates that were two-thirds or more of those of MHHs.

TABLE 14. Comparison between adoption rates by women on women-managed plots, and overall adoption rates by type of household and district.

District	Type of household	Households with women-managed plots (N)	Adoption rates on women-managed plots (%)	All households (N)	Adoption rates of all households (%)
Mpika	MHH	N=118	49	N=346	63
	FHH	N=53	42	N=61	41
Monze	MHH	N=90	29	N=210	53
	FHH	N=54	52	N=58	45
Sinazongwe	MHH	N=85	85	N=216	54
	FHH	N=39	69	N=61	38
Total		N=439		N=952	

Note: no data for Chibombo.

Table 14 shows that the adoption rates by female heads of households, managing their own plot, were higher than the average adoption rates in FHHs in that region. So self-management increased adoption of irrigation in FHHs.

For MHHs, an even stronger relationship between women's self-management and adoption of AWM technologies was found in Sinazongwe. When women in MHHs had their own plot, they irrigated in 85% of the cases. This is considerably higher than the average of MHHs adopting irrigation, which is 54%. Women with own plots in MHHs irrigated even more often than women with own plots in FHHs, who irrigated their own plots in 69% of the cases.

In the MHHs in Monze and Mpika, women's self-management of plots was inversely related to irrigation adoption. Especially in Monze, adoption rates on women-managed plots were still more than half of the average adoption rates of MHHs.

In sum, women-managed plots occurred in between one-third and half of the MHHs, and in 70 to 95% of the FHHs. In FHHs, such self-management led to higher than average adoption rates. For MHHs, there was no clear pattern. In two regions, women-owned plots in MHHs were less often irrigated. However, women with own plots in Sinazongwe had the highest adoption rates of all households interviewed in the four districts of Zambia. Further research into the reasons for these patterns will highlight how the land rights of women and men in both matrilineal and patrilineal societies are interlinked to adoption of irrigation technologies. Interventions for more equal land rights may well appear to boost irrigation adoption too.

Gendered Decision-making on Irrigated and Rainfed Plots

Further, the household survey explored the important question of how intra-household decision-making changed under technology adoption. Does irrigation adoption imply that (a) husbands increase their own decision-making at the expense of their wives, moving towards the gender relations of the plough culture; or (b) does irrigation offer an opportunity for women to strengthen their relative say in farm decision-making according to the gender relations in the hoe culture? We compared decision-making on rainfed plots of adopters and non-adopters with decision-making on irrigated plots. The variable selected for this analysis was decision-making on the use of the produce of a plot, i.e., whether to sell it or use it for household consumption. As numbers are small and regional differences substantive, much more research is needed to establish causes and effects. Yet, Table 15 gives an indication.

In MHHs, the decision-making of married women on their own and their husbands' irrigated plots tended to be slightly stronger than that on their husbands' and own rainfed plots. Husbands decided in 70% of the cases of their own male-managed plots, both on their rainfed and irrigated plots. Unlike the decision above on the use of the income gained from sales of the produce from an irrigated plot in Table 12, wives hardly decided about the use of the produce of their husbands' rainfed plots: just 4 to 6%. However, this increased to 13% on the irrigated plots managed by their husbands.

On their own plots, wives were also more often decision-makers on their irrigated plots than their rainfed plots. The proportion of wives' irrigated plots with husbands deciding on the produce was only 20%. Among adopters, husbands decided about the produce of their wives' rainfed plots in 33% of the cases. Among non-adopters, this proportion was even higher: husbands decided in 43% of their wives' rainfed plots. Overall, men had a stronger say over the use of the produce of women-owned plots than women had over the produce of their husbands' plots. However, the difference was less for irrigated plots than for rainfed plots.

When female household heads were owners, they decided in 80 to 100% of the cases. However, the lowest say of female heads in 80% of the cases was on their irrigated plots.

In sum, in MHHs, wives' decision-making on the use of the produce from both their plots and male-owned plots is relatively stronger on irrigated plots than on rainfed plots. In FHHs, others had somewhat more influence than women on irrigated plots compared to rainfed plots. This debunks the assumption that irrigation adoption marginalizes women to housewives of the plough cultures. Private small-scale irrigation empowers women. The question to explore in future research is whether men and women prefer irrigation development on separate self-managed plots or on male-managed or genuinely jointly-managed plots. Answers will not only depend on women's land rights and access to other assets, but also on whether the technology is divisible, as in the case of buckets, or indivisible, as in the case of motor pumps.

TABLE 15. Gendered decision-making on the use of produce by plot ownership for rainfed and irrigated plots among adopters and non-adopters, and by type of household.

Owner of plot	N=240	Type of plot	Decision-maker on the use of the produce (%)				
			Husband	Wife	Female household head	Others or not applicable	
MHH:	N=41	NON-ADOPTER rainfed plot	71	4	-	24	100
Husband	N=103	ADOPTER rainfed plot	71	6	-	24	100
	N=109	ADOPTER irrigation plot	69	13	-	19	100
MHH:	N=7	NON-ADOPTER rainfed plot	43	43	-	14	100
Wife	N=6	ADOPTER rainfed plot	33	50	-	17	100
	N=15	ADOPTER irrigation plot	20	60	-	20	100
FHH:	N =16	NON-ADOPTER rainfed plot	-	-	94	6	100
Female	N=21	ADOPTER rainfed plot	-	-	100	0	100
household head	N=20	ADOPTER irrigation plot	-	-	80	20	100

Note: Non-adopters include dis-adopters.

Targeting Support

Coming back to the policies of equal treatment at the start of this paper, the Zambia census survey also sheds some light on the issue of equal targeting of public support to women and men. Well-targeted support in favor of motor pumps in Chibombo appeared to reach women more equally than private adoption processes of pumps.

Table 16 shows that the majority of FHHs who adopted motor pumps in Chibombo (78%) had access to pumps that are owned by groups. For MHHs, that is only 29%. Most of the MHHs (62%) owned motor pumps individually. This high proportion of group ownership among FHHs was the result of an intervention that explicitly targeted women in Chibombo District in 2007. Here, World Wide Fund for Nature (WWF), supported by Southern African Development Community (SADC)-Danish International Development Assistance (Danida), provided 30 motor pumps free of charge to mixed and women's groups and to a few groups of male farmers. The census found 50 MHHs and 18 FHHs that benefited from this project. The proportion of 26% (18/68) of beneficiary FHHs was virtually similar to the general ratio of FHHs, which is 25% in Chibombo area. Thus, targeting women's or mixed groups with the provision of free pumps was an effective way to reach FHHs, at least proportionately to their demographic ratio. During a field visit in 2010, respondents indicated that 22 men and 11 women of these group members had bought their individual pumps. It is unknown whether these women were female heads of households or wives in MHHs. Nevertheless, the purpose of targeting women through group ownership appeared to be a more effective stepping stone to both men and women adopting motor pumps rather than no such intervention taking place.

TABLE 16. Motor pump ownership in Chibombo by type of household.

Type of household	N	Group ownership to WWF pumps N (%)	Owned by other groups and rental N (%)	Owned by individuals N (%)	
MHH	178	50 (29%)	18 (10%)	110 (62%)	100%
FHH	23	18 (78%)	3 (13%)	2 (9%)	100%
Total	201				

CONCLUSIONS AND RECOMMENDATIONS

The systematic gender disaggregation of rather standard farm survey variables: de jure and de facto headship of household; intra-household labor provision; intra-household plot-level analysis; and project's target group analysis, is a first step to fill the knowledge gap on gender. With the caveat of the bias towards male respondents and the relatively small samples, we can start tracing the implications of these findings for the two opposite assumptions on the role of gender for agricultural technology development.

Above all, the findings debunk the assumption that private small-scale irrigation adoption in sub-Saharan Africa is a process primarily propelled by male household heads, in which women rapidly lose any independent farm productivity and become housewives as 'plough cultures' (Boserup 1970) entail. Instead, the 'hoe culture' in both countries kept influencing adoption. Both female heads of households and married women continued their traditional roles in the cultivation of high-value crops, and adopted irrigation for higher productivity. The Zambia study, which analyzed intra-household relations in further depth, found that the decision-making of married women on irrigated plots, of those owned by themselves and those of their husbands, tended to be stronger than on rainfed plots. For female heads of households and married women, it appeared to be an incentive to have their own plot. Women had their own plots in 70-95% of FHHs and in 34-47% of the MHHs. Their irrigation adoption rates were higher than average for FHHs, while married women with their own plots in Sinazongwe had the highest adoption rates of all respondents in Zambia. However, adoption rates of married women on their own plots were lower than average in other sites. This link between women's land rights and technology adoption warrants further attention. Gender equality in land rights may well contribute to equality in technology adoption.

Focusing on the 10 to 25% of FHHs, they had adoption rates that were at least two-thirds of the adoption rates of MHHs. FHHs adopted the labor-intensive buckets or wetlands more often, while MHHs adopted motor pumps and river diversions more often. These two differences may be related to the smaller household and farm size of FHHs. However, the demand for motor pumps among FHHs appeared to be higher than the private adoption processes met. This was also the case in the site with the highest motor pump adoption, Chibombo in Zambia, where a project met this demand by implementing the policy intention of equal treatment and vesting the assets of motor pumps in both genders.

While women did take the new opportunities in their domains, male heads of households moved into irrigated high-value crop cultivation at a somewhat more significant scale. Men's household labor contributions in MHHs and even in FHHs tended to be equal or slightly more than women's labor contributions in Ghana. This was the case for manual and motorized technologies alike. Among hired laborers, the dominance of men was most articulated. There was a stronger influence of the technology in Zambia than in Ghana: men were exclusively performing irrigation in half of the cases. More training of women in mechanized irrigation can address this bias.

Men can move more easily into irrigation than women, because their traditional workloads in crop cultivation are often less than women's, and they hardly have any domestic chores to be carried out. Men also tend to have better access to public support, and to private agricultural equipment and input stores, fuel stations, electricity companies, finances, transport and (in Zambia, but less in Ghana) markets. Women's equal access to these assets would accelerate irrigation adoption even further.

With both genders adopting small-scale private irrigation at significant scales, irrigation is becoming an even more important trigger for agricultural growth in sub-Saharan Africa. This mode of agricultural growth is unprecedented. Unlike the stagnating productivity of the women-dominated hoe culture, it enhances women's productivity. It also overcomes the colonial and post-colonial failures to impose the alien male-dominated plough culture by effectively pulling men into the cultivation of high-value crops. Spouses may prefer separate plots or to collaborate on joint plots. A 'dual irrigation culture' is emerging. In this pattern of growth, productivity and gender equality mutually reinforce each other. Agricultural support agencies will achieve both goals by better addressing women's structural disadvantages: access to high-performing irrigation equipment, land, technical training, and forward and backward linkages. This fully aligns with the intentions of sub-Saharan Africa's policies towards gender equality.

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