SMALL SCALE FARM MECHANIZATION

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Abstract

Increasing agricultural productivity is central to the development agenda. Mechanization is one tool that has the potential to achieve farm labor productivity growth and spur structural transformation. However, the adoption of mechanization in developing countries is very limited. Using a randomized controlled trial, we examine the impact of demand-side and supply-side interventions within the small-scale mechanization sector in Ethiopia on the take-up of farm machinery services. On the demand-side, we offer subsidies for mechanization services. On the supply side, we offer service providers a training workshop and subsidies for mechanical maintenance support. Among service providers, we examine the impact of the interventions and find suggestive (but imprecise) impacts of the training workshop on firm survival, service diversification, and changes to pricing strategies. Among households, we find vouchers are more impactful among female-headed households. We find little evidence of changes to adult farm labor, but using female reports, find evidence of reductions in child farm labor that are larger in female-headed households.

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1 Introduction

Improving agricultural productivity is key to achieving economic development (Gollin, Parente and Rogerson, 2002). Mechanization can play a critical role in improving agricultural productivity and facilitating the reallocation of labor towards the non-agriculture sector (Manuelli and Seshadri, 2014; Caunedo and Kala, 2021). However, low adoption of mechanization is a persistent challenge in developing economies, and policymakers are increasingly considering various interventions to increase the provision and adoption of mechanization. In this paper, we examine the extent to which supply side and demand side interventions facilitate the adoption of small-scale mechanization services, and the effect of mechanization on smallholder farmer's time allocation.

While mechanization can improve agricultural productivity and save labor, most large-scale machinery, such as combine harvesters, are likely to be more profitable for larger farms (Foster and Rosenzweig, 2017). Furthermore, lack of access to capital in rural settings makes the ownership of even smaller machines prohibitively expensive for smallholder farmers. Hence, in this project, we focus on factors that determine the adoption of machines and modalities that are more suitable for smallholders that are central to agricultural production in developing economies. In particular, we examine demand and supply side factors that affect the take up of rental services for Two Wheel Tractors (2WTs), which are provided by small-scale service providers to smallholder farmers.

We conduct a two-stage randomized controlled trial, whereby we first randomize 2WT mechanized service providers to a comprehensive training workshop treatment and then randomize households to receive subsidized vouchers (varying the size of the voucher) within communities in which the firms were already operational. Our focus is on expanding adoption rather than expanding access into newer areas where 2WT provision was not yet available. Among firms, we find that the training had suggestive impacts on firm survival, and pricing and payment strategies, but that it took time for these impacts to be realized. Among households, we find that the voucher-recipient households do adopt

mechanization. Vouchers were more effective in inducing adoption among female-headed households and among households that had never used mechanization services previously. The value of the voucher, 1,000 Birr vs 1,500 Birr, did not appear to make a difference in the level of mechanization adoption. We do not find evidence that crop-related farm labor among voucher-recipient households was impacted by the intervention. Our survey data elicits farm labor reports by both a male adult and a female adult, where possible, within the household. The findings are consistent regardless of who is reporting, although we do find that men report lower female crop labor on average in general.

In contrast to the adult crop labor results, we do find impacts of the voucher subsidy program crop-related farm labor of children (aged 10-18). But our results are conflicting depending on who the respondent is. Using male reports we find that child crop-related farm activities increased in response to the voucher; but among female reports the reverse is true. Overall reported child farm activity is higher among the men, and take together with the lower disparity between female and male reports of male labor, we think the female reports are likely more accurate. These disparate results do highlight the importance of who the respondent is. Male reports of child crop activity suggest increases in child labor on the farm in male-headed households, and declines in female-headed households; while female reports of child crop activity imply decreases in child farm labor both in male and female-headed households, albeit with larger declines in female-headed households. Thus, it seems that the biggest beneficiaries regarding time allocation appear to be children.

As with any new technology, there could be a myriad of factors that are potential obstacles to the provision of mechanization services by service providers or the take up of these services by smallholders. On the demand side, farmer's lack of knowledge about the potential benefits of mechanization, credit constraints, and costs of services have been suggested as potentially key obstacles to mechanization. Caunedo and Kala (2021) show that subsidized vouchers increased the take of agricultural equipment rental services. On the supply side, factors such as limited access and cost of finance, lack of maintenance

skills and services, lack of market knowledge, and inadequate entrepreneurial skills are potential constraints (Karedza et al., 2014). Our paper builds on and contributes towards the active and vast literature on agricultural technology adoption.[1] Many constraints limit adoption including frictions in financial markets resulting in credit, liquidity and insurance constraints (Karlan et al., 2014). Information (including peer learning) and behavioral constraints also play a key role in limiting technology adoption (Conley and Udry (2010), Duflo, Kremer and Robinson (2011) and Hanna, Mullanaithan and Schwarzstein (2014). Much of this literature has focused on relaxing one constraint, or multiple constraints on the same side of the market. However, the constraints rural communities face can be independent and simultaneously relaxing multiple constraints may be more effect in foster improvements in agricultural productivity (Ambler, de Brauw and Godlonton, 2018; Gebresilasse, 2021).

We build on this literature by relaxing constraints on both the demand and supply-side simultaneously in the context of mechanization adoption. The contribution of this study is twofold. First, unlike many studies looking at one side of machinery services, here the analysis considers both supply-side and demand-side interventions where both service providers and service using smallholder farmers are supported to stimulate markets for small mechanization services in wheat and maize-based systems. Second, it explores the role of demand and supply side interventions separately, and in subsequent drafts will also examine their interaction effects.

Finally, our findings also relate to the literature on agricultural labor markets. Labor is highly seasonal in agriculture, and households experience periods of both excess labor supply and a shortage of labor supply. Our paper may shed light on whether farm mechanization can help smooth the provision of and demand for agricultural labor. Moreover, we hope to contribute to understanding the intra-household responses to mechanization adoption and the potential gendered impacts on household labor, particularly concerning the reduction of drudgery.

[1] Magruder (2018) offer recent reviews of this literature.

2 Background and Research Design

2.1 Farm Mechanization in Ethiopia

The agriculture sector in Ethiopia accounts for around 35% of the country's GDP (World Bank, 2025). Smallholder farmers dominate the sector and account for more than 90 percent of the cultivated area and output (Bachewe et al., 2015). According to CSA (2021), more than 19 million farm households are operating a total of 22.8 million ha of crop land using animal draft power and human muscle as main farm power sources. At the same time, agricultural productivity continues to be relatively low. In 2018, the global average cereal yield was 4,071 kg per hectare while it was only 2,935 kg per hectare for Ethiopia (World Bank, 2025).

While the importance of farm mechanization in agricultural development has been recognized by successive governments since the 1960s, the commitment to increase the mechanization of smallholder production both from a policy and technical standpoint, has been minimal. Recently, however, a more serious commitment to farm mechanization has been recognized within Ethiopia which led to the formulation of an agricultural mechanization strategy and formulation of a mechanization technical working group. Commitment to this strategy is visible, as the current government lifted all import tariffs levied on farm machinery and equipment with the aim of improving the affordability and accessibility of farm machinery to farmers and entrepreneurs buying farm machinery and providing services to smallholder farmers.

Private owners of large agricultural machinery and the government-owned Agricultural Mechanization Service Enterprise (AMSE) has been providing machinery services mainly for land preparation, planting, harvesting, and threshing operations in wheat-based systems of the country. Farmers using these services usually have larger land parcels and better access to road networks. However, smallholder farmers operating on smaller plots, with limited road networks and growing diversified crops are still depending on draft power and human muscle for almost all farm operations. For instance, less than 1%

of agricultural plots in Ethiopia are plowed with a tractor (Berhane et al., 2017). Though nascent, there are emerging small-scale machinery service providers in rural areas providing threshing (for *teff* and wheat) and shelling (for maize) services to smallholder farmers. These services are limited to areas where projects supported the demonstration of small-scale farm machinery development and pocket areas where innovative entrepreneurs purchased 2WT-based machinery and providing these services.

The existing literature and the findings from our service provider screening survey suggest that there are various factors, both on the demand and supply side, that may be hindering the expansion of small-scale mechanization services in Ethiopia. Given the relative suitability of small-scale mechanization services for smallholder farmers in rural settings, it is essential to explore the factors that could help to improve the provision and take-up of these services.

2.2 Experimental Design and Data

We conduct a two-stage randomized controlled trial, whereby we first randomize 2WT mechanized service providers to the broad-based training treatment, and then randomize households to receive subsidized vouchers (varying the size of the voucher) within communities in which the firms were already operational. Our focus is on expanding adoption rather than expanding access into newer areas where 2WT provision was not yet available.

2.2.1 Supply-Side: 2WT Firms

Firm selection: Using a list of all sales records of 2WTs sold by Adama Agricultural Machinery Industry (AAMI) in the period 2017 through 2020 we constructed a census of firms offering 2WT mechanized services. AAMI was the primary distributor of 2WT machines during this period. Based on this sales data, firms are spatially distributed across the country, see Figure 4. We restrict our focus to the East Shewa and South West Shewa zones in the Oromia region motivated by the density of providers, the share of 2WT providers that had phone numbers available in conjunction with agricultural productivity, crops culti-

vated and average parcel size using data from the Annual Agricultural Sample Surveys conducted by the Central Statistical Agency of Ethiopia. Figure 1 and 2 show the spatial distribution of the 2WTs sold by METEC. Due to concerns regarding ongoing conflicts, districts in the peripheries of the Oromia region were excluded.[2] To determine the appropriate firm-level intervention we conducted a screening survey with the selected firms and elicited the list of kebeles in which they had ever worked, thus populating the list of eligible kebeles.

Firm intervention: The firm level intervention has two components: 1) a 5-day training workshop; and 2) a subsidy voucher for mechanical repair services. A screening survey conducted with the firms identified inadequate maintenance of their 2WTs as a key challenge to their current operations. They also cited limited repair skills and unavailability of maintenance mechanics. Both interventions on the supply-side aim to directly address these issues. The training workshop included training on appropriate machinery operation, machinery handling, and safety, as well as training modules covering financial literacy, and financial management of business operations. Successful 2WT entrepreneurs outside of our sample were also invited to discuss their personal experiences operating their business. All of the training modules were developed by CIMMYT in partnership with the Melkassa Research Center at the Ethiopian Institute of Agricultural Research. All firms within our area of operation that were contactable by phone, were randomly assigned to treatment stratified on zone (East Shewa/South West Shewa) and an indicator variable for whether they were below/above the median distance to the woreda town. Distance from the woreda town would likely exacerbate some of the cited concerns regarding maintenance. While understanding the value of each of the training components might be valuable, we did not have the power to test each component of the training separately. The subsidy voucher for mechanical repair services was offered 2 years later, and the vouchers are redeemable until March 2024.

[2]Our sampling decisions were influenced by information at the time regarding the spatial distribution of conflict, however, throughout the project, the intensity and spatial distribution of conflict varied considerably necessitating phone-based surveys in certain locations at certain times.

Firm surveys: In June 2021, we conducted a screening survey with potential 2WT service provider operators. In the screening survey, we contacted all 212 unique individuals who purchased a 2WT from METEC between 2017 and 2020, provided a phone number at the time of purchase, and listed East Shewa and South West Shewa as their home resident zone. The modal number of kebeles service providers work in is 2 (average: 3.5). Out of the 134 firms that provided tractor services in 2020, 80.6% reported offering only threshing and/or shelling services. The screening survey serves as the basis for the supply-side randomization. In June 2022 and June 2023, we conducted follow-up surveys with all the listed service providers from the screening survey as well as any additional firms that had started operations within the sample site. To expand the list of firms, we consulted the local Agricultural Officers. Thus, our sample of firms both expands in coverage, and shrinks as firms shut down operations. We observe 283 distinct firms operational for at least part of the period 2017 to 2024. Firm-level surveys asked extensive questions regarding their operations including information about their business (registration, etc), firm related asset purchases, breakdowns and repairs, pricing and marketing related questions.

Notably, for the purposes of this analysis we restrict the sample to the original sample of firms, but future work will expand the broader market dynamics in this sector. Table 1 presents balance tests for the firm-level random assignment using data collected from the screening survey. Firms in the treatment and control group are similar with respect to when they first started their business [3], whether they were still offering services at the time, how far they were from the closest town, as well as the reach of their services as measured by the number of kebeles served.

2.2.2 Demand-Side: Farming Households

Household selection: We restrict the sample to kebeles located within the existing market area of service providers. Using the full roster of kebeles the firms reported ever working in, we compiled a list of kebeles. In each kebele we selected up to 16 male-headed and

[3] 2010 in the Ethiopian calendar is approximately 2018 in the Western calendar.

female-headed farming households.

Demand side intervention: To encourage demand for mechanized services, we provided a once-off first use subsidy. We offered a high (1,500 ETB, approx. 26 USD) and a low (1,000 ETB, approx. 18 USD) incentive amount to encourage adoption. Farmers were issued the voucher with a 4-month expiration date. Farmers could use the voucher for any mechanized service with a 2WT. The size of the voucher is approximately equal to one-third and one-half of the median mechanization costs incurred by households who utilized any mechanization services in the meher season prior to the baseline survey. The low subsidy is similar in size to that used by (Caunedo and Kala, 2021) as a proportion of total average costs by farmers and provides a useful benchmark. These are meaningfully sized vouchers but also require households to chip in to use the level of services most appropriate for their farm.

Figure 6 provides an example of the back side of the vouchers distributed. Vouchers included information about service providers who have worked in their kebele. Thus, the voucher both provides information and subsidises usage. Households were issued vouchers in a community meeting to which they were invited to attend. At the meeting, the process for redeeming the vouchers was clearly explained, and ID verification was conducted before issuing the vouchers. Each voucher contained a unique identifier that was tied to a specific household ID. To increase power, randomization of households to receive the subsidies was implemented at the household level stratified on kebele and the sex of the household head. To ensure we can measure the independent and complementary effects of the two intervention, prior to the household randomization, kebeles were determined to have treated firms and non-treated firms, based on this kebeles were randomized into either receiving the demand side intervention or not. Table 1 presents the balance tests for the household-level randomization. We find that, across a range of characteristics including farm size and prior mechanization usage households assigned to receive the treatment subsidy are similar to those who were assigned to the control group.

Household surveys: The baseline survey includes modules on socioeconomic character-

istics, time use of household members, farm mechanization knowledge and adoption and other employment-related information by household member. During the 2023 follow-up survey, a similar survey was conducted as well as a component eliciting labor, decision-making, and mobility questions for up to two respondents per household. In each household, both the primary respondent and an adult of the opposite sex was selected to be interviewed. A second follow-up survey will be conducted in 2024, that will elicit information on the persistence of mechanization adoption. In each follow-up survey we elicit labor on crops and livestock of all household members (10 or older). We measure these variables to capture changes both in the extensive margin (whether any hours are spent on the activity) and the intensive margin (the number of hours/days spent on the activity during the agricultural season).

3 Empirical Approach and Results

The analysis is organized into two distinct parts. We begin by examining the impact of the training workshop on the firms across time. Then, we turn to examine the direct impact of household subsidies on mechanization adoption and impacts on labor. Once the second phase of the supply-side intervention is completed, we will also examine the interplay between the demand and supply side interventions.

3.1 Service Provider Impacts

To examine the impact of the interventions on service providers we estimate the following regression:

$$Y_{st} = \alpha + \beta_1 Supply_s + \tau Y_{s0} + \gamma X_{s0} + \delta_s + \varepsilon_{st} \quad (1)$$

where Y_{st} is an outcome measure for service provider s measured at time point t. $Supply_s$ is an indicator variable that takes the value of 1 if the service provider was assigned to the supply-side intervention group. We also control, when possible, for the

baseline value of the outcome variable, Y_{s0} and include stratification cell fixed effects (δ_s). Baseline variables come from the screening survey conducted in 2021 which was a very short survey and aimed at understanding constraints to growth rather than current operations. Outcomes are measured at three points in time: after the training (2022), after the household subsidies expired (2023), and after the mechanic subsidies expired (2024). For this draft only focus on the first two rounds of data collection. We also present treated on the treatment impacts, using the random assignment to instrument for whether or not the service provider attended the training.

Table 2 presents our main results. Follow-up one was conducted after the training but before the household intervention. We find that firms assigned to the treatment group, do report being significantly more likely to have received an invitation to attend the training (52.4 percentage points), and much more likely to have attended the training. Panel A presents the intention to treat estimates, while Panel B presents the treatment on the treated impacts. We find suggestive evidence that firms exposed to the treatment were more likely to be operational (although this is not statistically significant). Across outcomes, we find suggestive results of an impact of the training, yet they are imprecise. Service providers in the treatment group are more likely to keep financial records of their business, are less likely to experience a breakdown of their machine, and experience more days of operation. This pattern exists for both the ITT and TOT results. Panels C and D utilize data from the second follow-up survey, that took place after households received the subsidy vouchers. Here we observe a similar pattern of results, and find stronger results, despite being further constrained by power due to fairly significant attrition of firms from the sample. Attrition is not selective based on treatment (Column 1).

In Table 3 we explore additional business practices related to the range of services, and engagement with customers. We observe no impact on the number of services offered in the short term (Panels A and B), but do see evidence of service expansion over a longer-term horizon (Panels C and D). Buying new equipment and finding customers for new services may take time to establish. We also observe suggestive results that treated firms

serve more customers, and are less generous in extending credit to their customers for services rendered, and in the second follow-up they seem to charge a higher price for their threshing services. The higher price is meaningful, as it translates into a 10% higher rate than that charged by controls when considering the ITT estimate.[4] Here we focus on the threshing price charged as most firms offer this service. Consistent across these findings is that it appears to take time for the firms to respond to the training.

3.2 Household Impacts

To examine the direct and independent impact of the subsidies, we estimate the following regression:

$$Y_{hk} = \alpha + \beta_2 Demand_h + \tau Y_{h0} + \gamma_k + \varepsilon_{hk} \quad (2)$$

where $Demand_h$, is an indicator variable equal to 1 if the household was assigned to receive the demand side treatment. As before, where possible we control for the baseline value of the outcome variable $Y_{h0,}$, and control for kebele fixed effects γ_k and a household head sex indicator variable to control for the stratification cell fixed effects. We then turn to examine differences by the sex of the household head. Finally, we explore the difference in impacts for the different level of subsidies. This analysis is restricted to kebeles in which we implemented the subsidies.

3.2.1 Mechanization Adoption

Table 4 presents information from the administrative records on the issuance, and redemption of the voucher program. Households had to attend a meeting to collect their vouchers. Both female and male headed households received their vouchers at consistently high rates (approximately 90%). Redemption rates and out-of-pocket spending paired with the voucher were higher among male-headed recipient households. The high and low vouchers were redeemed at similar rates.

[4]Due to high attrition, albeit not differential by treatment status, future drafts will implement bounding exercises to assess the robustness of this result.

We examine the impact of the vouchers on the adoption of mechanized services in Table 5. We find that vouchers did stimulate demand, households receiving the vouchers were 15 percentage points more likely to use any mechanized service, equivalent to a 30% increase in usage (Panel A, column 1). We also observe a higher adoption rate of mechanization among female households, despite the lower overall redemption rate (Panel B, column 1). Female-headed households are less likely to have adopted mechanization, and are 4 percentage points more likely than male-headed households to adopt mechanization due to the voucher. We further find that increased adoption of hired mechanization services does not crowd out the use of own mechanization services. In addition, to the extensive margin effects, we also find impacts on the intensive margin: households use mechanized services for more days, and expand the number of services adopted.

From the administrative records, we did not observe large differences in the redemption of the vouchers by the size of the vouchers. We explore this further in Table 6. When pooling male- and female-headed households (Panel A) we do not observe a statistically significant differences between the two voucher sizes on the adoption of mechanized services either on the extensive or intensive margin. In Panel B, we explore whether this differs when accounting for the gender of the household head, and similarly find no difference in adoption among male- and female- headed households of the low relative to high-valued vouchers. For the remainder of the household analysis, we therefore pool the vouchers and only consider whether a household received any voucher.

We observe clear evidence of the adoption of mechanization services among treated households. However, the intention behind the vouchers was to encourage adoption exceeding the value of the voucher. We examine this in Table 7. All expenditures are transformed using the inverse hyperbolic sine transformation, however, all control means are expressed in expenditures in Birr. In columns (1) through (3), we examine the impact on all mechanized service expenditures (this includes the voucher amount), all out-of-pocket expenditures on mechanized services, and finally expenditures on threshing. We focus on threshing as it is the most commonly adopted mechanized service. Broadly, we find

strong evidence that voucher recipient households increased their own expenditure in a meaningful way. For example, the overall increase in out-of- pocket expenditures is approximately 66%. Consistent with our previous findings we do not find significant differences across households receiving the high relative to the low voucher; but we do see larger and significant differences in the increase in expenditure on mechanized services by female-headed voucher recipients as compared to male-headed recipients. While this was a gender-neutral policy it does seem to have favored women, at least concerning increasing the adoption of such services, whether adoption persists into the following year will be important to observe in determining the overall efficacy of this intervention.

In columns (4) through (9), we further examine how these impacts differ across households that had ever used mechanization relative to those who had never used such services, to understand whether the vouchers are primarily inducing farming households to increase usage of a technology they are familiar with or whether it induces new consumers into the market. We find much larger treatment impacts on the total out-of-pocket expenditures among households who had never used mechanized services. Notably, the level of expenditures in the control mean among never users at baseline is significantly lower (albeit it not zero), as compared to the control mean among those that had used it at baseline. Thus, in addition, to the increased adoption of mechanized services in response to the vouchers, the kebeles also witnessed an overall increase in the adoption of such services.

The heterogeneity of the results by prior usage has a distinctly gendered pattern. Overall, female-headed voucher recipient households respond more to the treatment on their out-of-pocket expenditure, but, there are stark gendered differences in these patterns by their previous usage. Female-headed treated households with no prior experience adopting mechanized services spend more than female-headed control households, but the estimated treatment impact on out-of-pocket expenditures relative to male-headed households. The reverse is true among households with experience with mechanized services: female-headed treated households respond more than male-headed households in terms of their out-of-pocket expenditures if they have prior experience with mechanized services.

3.2.2 Labor Impacts

Voucher-recipient households increased their adoption of mechanized services, treatment effects on the adoption of mechanization services was greater among female-headed households. They primarily did so, by increasing their adoption of threshing services. Next, we turn to examine the impact of the adoption of this technology on the allocation of labor to farming activities and how this varies within the household. From our baseline survey, we observe distinct patterns of men and women in how they spend their time across different agricultural activities. Men spend a greater share of their agricultural-task time on land preparation; whereas, women spend more time on weeding, threshing, and shelling. Given our findings that the vouchers increased primarily the use of threshing services, we might expect gendered treatment effects on time allocation.

To explore this we examine several measures of agricultural labor. Results are presented as reported by an adult male and an adult female in the household. To ensure a consistent sample across panels we restrict analysis to households for which we have both a male report and a female report. The pattern of results is consistent in the unbalanced panel. We find very limited evidence in Table 8 that time spent on crop-related activities by adults was impacted by the voucher-recipient households. The reported number of hours worked varies based on the identity of the respondent. We do find that female report of male hours is more similar to male reports of male hours; whereas male reports appear to systematically under-report female hours spent on crop activities. These results also stand in stark contrast to those in (Caunedo and Kala, 2021). In their setting, in India, they find that mechanization reduces labor use by male family members and male hired workers by 0.13 and 0.425 workers per acre over the season, respectively.

Intriguingly, we find disparate results on measures of child labor spent on agricultural related activities. When relying on male-reports, child labor on the farm appears to increase, whereas when using female reports we find the opposite, child labor on agricultural activities decline. Notably, we also observe higher prevalence of child labor on agricultural activities reported in general by female respondents. Based on the adult-reporting

differences, the female reports are likely correct.

Given that female-headed voucher recipient households were more responsive to the vouchers, we also explore the heterogeneity of crop-related labor by the sex of the household head. There are two key insights from this analysis (Table 9 and Table 10) that mirror the previous findings. First, we do not find strong evidence of large changes to the time spent by adults (male or female) using either the male or female reports, in male or female-headed households. Second, we stark and contrasting results for children. Male reports of child crop activity suggest increases in child labor on the farm in male-headed households, and declines in female-headed households; while female reports of child crop activity imply decreases in child farm labor both in male and female-headed households, albeit with larger declines in female-headed households. Thus, it seems that the biggest beneficiaries regarding time allocation appear to be children. Future work will examine whether this translates into increased schooling enrollment and attendance which may help reconcile the male vs female reporting differences.

4 Discussion and Conclusion

We conduct a two-stage randomized controlled trial, whereby we first randomize 2WT mechanized service providers to be invited to a training workshop and then randomize households to receive subsidized vouchers (varying the size of the voucher) within communities in which the firms were already operational. Our focus is on expanding adoption rather than expanding access into newer areas where 2WT provision was not yet available. Among firms, we find that the training had suggestive impacts on firm survival, and pricing and payment strategies, but that it took time for these impacts to be realized. Among households, we find that the voucher-recipient households do adopt mechanization. Vouchers were more effective in inducing adoption among female-headed households and among households that had never used mechanization services previously. The value of the voucher, 1,000 Birr vs 1,500 Birr, did not appear to make a difference on the

adoption of mechanized services. We do not find evidence that crop-related farm labor among voucher-recipient households was impacted by the intervention. Our survey data elicits farm labor reports by both a male adult and a female adult, where possible, within the household. The findings are consistent regardless of who is reporting, although we do find that men report lower female crop labor on average in general.

In contrast to the adult crop labor results, we do find impacts of the voucher subsidy program crop-related farm labor of children (aged 10-18). However, our results are conflicting depending on who the respondent is. Using male reports we find that child crop-related farm activities increased in response to the voucher, but among female reports the reverse is true. Overall reported child farm activity is higher among the men, and taken together with the lower disparity between female and male reports of male labor, we think the female reports are likely more accurate. These disparate results do highlight the importance of who the respondent is. Male reports of child crop activity suggest increases in child labor on the farm in male-headed households, and declines in female-headed households; while female reports of child crop activity imply decreases in child farm labor both in male and female-headed households, albeit with larger declines in female-headed households. Thus, it seems that the biggest beneficiaries regarding time allocation appear to be children. Our results stand in contrast to previous work that documents impacts on male adult labor, such as that of (Caunedo and Kala, 2021) in India, thus providing complementary evidence in a new setting. There are many differences between this setting and the one they study. This is a diffuse market with many different providers, and the adoption of mechanized service here is primarily threshing. Future work will continue to examine the interaction of the supply-side and demand-side interventions in this context.

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5 Tables

TABLE 1: Balance tests

	Year business started (ET calendar) (1)	Offer 2WT services (2)	Offers threshing (3)	Intends to offer 2WT services next year (4)	Distance to town (in km) (5)	Number of kebeles serviced (6)
Panel A: Firm Balance Tests						
Treatment Mean	2010.309	1.000	0.879	1.000	10.088	3.580
Control Mean	2010.114	1.000	0.938	0.986	11.864	3.500
Difference	0.193	0.000	-0.056	0.015	-1.533	0.130
	(0.173)	(.)	(0.046)	(0.014)	(1.342)	(0.450)
Panel B: Household Balance Tests						
	Subsidy Mean	No Subsidy Mean	p-value of difference			
Respondent Characteristics						
Age	47.802	48.875	0.263			
No education	0.241	0.204	0.166			
Completed primary	0.237	0.210	0.280			
Household Head Characteristics						
Age	48.290	49.589	0.208			
Is female	0.416	0.398	0.580			
Household Characteristics						
Household size	5.081	4.843	0.152			
Land Cultivated	9.208	8.430	0.109			
Used mechanized services last season	0.352	0.380	0.551			

Note: Robust standard errors in parentheses.

TABLE 2: Impacts on Firms: Training, Record keeping, Operations

	Completed survey	Still operational	Training: Received invitation	Training: Attended training	Keeps financial records	Machine broke down	Number of Days offering: Any service	Number of Days offering: Threshing
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Followup survey 1, ITT								
Supply Side Treatment	0.042	0.056	0.524***	0.373***	0.049	-0.008	-9.042	0.070
	(0.052)	(0.068)	(0.073)	(0.071)	(0.102)	(0.469)	(9.008)	(6.543)
N	139	124	124	124	100	100	100	100
Control Mean	0.892	0.806	0.379	0.250	0.530	2.410	76.080	64.130
Panel B: Followup survey 1, TOT								
Attended Training		0.149			0.112	-0.018	-20.646	0.160
		(0.179)			(0.229)	(1.071)	(20.581)	(14.940)
N		124			100	100	100	100
Control Mean		0.806			0.530	2.410	76.080	64.130
Panel C: Followup survey 2, ITT								
Supply Side Treatment	0.023	0.076	0.423***	0.346***	0.134	-0.265	17.932	7.932
	(0.080)	(0.083)	(0.095)	(0.094)	(0.121)	(0.734)	(10.961)	(9.534)
N	139	106	83	83	76	76	76	76
Control Mean	0.597	0.717	0.313	0.265	0.474	3.263	106.026	102.026
Panel D: Followup survey 2, TOT								
Attended Training		0.221			0.348	-0.688	46.546*	20.589
		(0.236)			(0.311)	(1.884)	(27.625)	(23.827)
N		106			76	76	76	76
Control Mean		0.717			0.474	3.263	106.026	102.026

Note: Robust standard errors in parentheses.

TABLE 3: Impacts on Firms: Services and Payment

	Number of services	Offered threshing	Number of customers	Payment options: Cash	Credit	Threshing Price
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Followup survey 1, ITT						
Supply Side Treatment	-0.123	-0.032	18.373	0.020	-0.158*	
	(0.094)	(0.053)	(26.160)	(0.061)	(0.083)	
N	100	100	100	100	100	
Control Mean	1.080	0.920	109.670	0.900	0.660	
Panel B: Followup survey 1, TOT						
Attended Training	-0.281	-0.072	41.953	0.047	-0.361*	
	(0.219)	(0.122)	(58.949)	(0.140)	(0.191)	
N	100	100	100	100	100	
Control Mean	1.080	0.920	109.670	0.900	0.660	
Panel C: Followup survey 2, ITT						
Supply Side Treatment	0.134**	0.000	20.874	0.000	-0.057	31.016*
	(0.065)	(.)	(26.045)	(0.040)	(0.088)	(17.081)
N	76	76	76	76	76	73
Control Mean	1.053	1.000	124.197	0.974	0.842	347.877
Panel D: Followup survey 2, TOT						
Attended Training	0.348*	0.000	54.184	-0.000	-0.149	74.822*
	(0.182)	(.)	(67.855)	(0.103)	(0.229)	(43.570)
N	76	76	76	76	76	73
Control Mean	1.053	1.000	124.197	0.974	0.842	347.877

Note: Robust standard errors in parentheses.

TABLE 4: Summary Statistics on Voucher Distribution and Take Up

	Voucher Value		
Characteristic	**1000 Birr**	**1500 Birr**	**All**
All			
Number of Households Assigned Voucher	234	250	484
% Vouchers Distributed	89.32	92.40	90.91
% Vouchers Redeemed	40.19	38.53	39.32
Total Spending Using Voucher (in Birr, mean)	2,420	3,000	2,718
Out of Pocket Spending Using Voucher (in Birr, mean)	1,421	1,514	1,469
Female Headed Households			
Number of Households Assigned Voucher	99	98	197
% Vouchers Distributed	88.89	89.80	89.34
% Vouchers Redeemed	35.23	38.64	36.93
Total Spending Using Voucher (in Birr, mean)	1,859	2,591	2,242
Out of Pocket Spending Using Voucher (in Birr, mean)	859	1,096	983
Male Headed Households			
Number of Households Assigned Voucher	135	152	287
% Vouchers Distributed	89.63	94.08	91.99
% Vouchers Redeemed	43.80	38.46	40.91
Total Spending Using Voucher (in Birr, mean)	2,748	3,253	3,005
Out of Pocket Spending Using Voucher (in Birr, mean)	1,749	1,773	1,761

TABLE 5: Adoption of Mechanization: Household Analysis

	Any Mechanization Service used (1)	Own Mechanization Service (days) (2)	Hired Mechanization Service (days) (3)	Total Mechanization Service (days) (4)	Number different services (5)	Number different services (excl. threshing) (6)
Panel A: All Households						
HH voucher	0.150***	-0.041	0.266***	0.234**	0.145***	-0.011
	(0.026)	(0.068)	(0.073)	(0.104)	(0.030)	(0.014)
N	948	948	948	948	963	948
Control Mean	0.476	0.133	0.823	0.957	0.492	0.057
Panel B: All Households by gender of HHH						
HH voucher	0.133***	-0.077	0.236**	0.173	0.131***	-0.012
	(0.034)	(0.113)	(0.103)	(0.159)	(0.040)	(0.020)
HH voucher X Female HHH	0.041	0.090	0.077	0.154	0.033	0.005
	(0.053)	(0.114)	(0.142)	(0.188)	(0.059)	(0.027)
Female headed HHH	-0.308*	-0.034	-0.678**	-0.716**	-0.301*	0.033
	(0.185)	(0.059)	(0.309)	(0.314)	(0.182)	(0.028)
N	948	948	948	948	963	948
Control Mean	0.476	0.133	0.823	0.957	0.492	0.057
p-val: voucher + FXvoucher =0	0.000	0.295	0.001	0.001	0.000	0.662

Note: Robust standard errors in parentheses.

TABLE 6: Adoption of Mechanization: Household Analysis by Size of Voucher

	Any Mechanization Service used (1)	Own Mechanization Service (days) (2)	Hired Mechanization Service (days) (3)	Total Mechanization Service (days) (4)	Number different services (5)	Number different services (excl. threshing) (6)
Panel A: All Households						
High Value Voucher	0.154***	-0.086	0.362***	0.289**	0.146***	-0.009
	(0.033)	(0.073)	(0.096)	(0.127)	(0.037)	(0.017)
Low Value Voucher	0.144***	0.007	0.163**	0.175	0.143***	-0.012
	(0.031)	(0.091)	(0.083)	(0.129)	(0.035)	(0.018)
N	948	948	948	948	963	948
Control Mean	0.476	0.133	0.823	0.957	0.492	0.057
Panel B: All Households by gender of HHH						
High Value Voucher	0.119***	-0.140	0.335**	0.217	0.113**	-0.015
	(0.042)	(0.120)	(0.133)	(0.190)	(0.050)	(0.024)
Low Value Voucher	0.149***	-0.006	0.123	0.123	0.152***	-0.009
	(0.040)	(0.154)	(0.115)	(0.201)	(0.047)	(0.027)
High voucher X Female HHH	0.092	0.138	0.070	0.185	0.085	0.017
	(0.066)	(0.120)	(0.187)	(0.232)	(0.073)	(0.031)
Low voucher X Female HHH	-0.010	0.034	0.098	0.129	-0.021	-0.008
	(0.063)	(0.156)	(0.162)	(0.234)	(0.072)	(0.035)
Female headed HHH	-0.309*	-0.040	-0.671**	-0.713**	-0.301	0.033
	(0.187)	(0.060)	(0.310)	(0.314)	(0.184)	(0.028)
N	948	948	948	948	963	948
Control Mean	0.476	0.133	0.823	0.957	0.492	0.057
p-val: high + FXhigh = 0	0.000	0.744	0.002	0.002	0.000	0.929
p-val: low + FXlow = 0	0.005	0.225	0.054	0.036	0.015	0.456
p-val: high=low	0.514	0.390	0.136	0.676	0.488	0.840
p-val: high +FXhigh =low + FXlow	0.206	0.193	0.218	0.328	0.277	0.464

Note: Robust standard errors in parentheses.

TABLE 7: Expenditure on Mechanization: Household Analysis - IHS

	Expenditure on Mechanization in Birr (IHS)								
	All			Never Used Mechanization at Baseline			Has Used Mechanization at Baseline		
	All	All Out of Pocket	Threshing	All	All Out of Pocket	Threshing	All	All Out of Pocket	Threshing
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: All Households (ITT)									
HH voucher	1.192***	0.658***	1.285***	1.756***	1.248***	1.685***	0.750**	0.307	0.981***
	(0.238)	(0.241)	(0.236)	(0.332)	(0.317)	(0.329)	(0.340)	(0.355)	(0.342)
N	963	963	963	453	453	453	510	510	510
Control Mean	2307.361	2247.278	2065.304	844.374	817.347	766.626	3492.701	3405.836	3117.518
Panel B: All Households (ToT)									
Used Any Mechanized Service	8.577***	4.674***	9.256***	8.472***	5.910***	8.107***	9.106***	3.829	11.846***
	(0.412)	(0.994)	(0.706)	(0.160)	(0.664)	(0.467)	(1.222)	(2.635)	(2.429)
N	948	948	948	446	446	446	502	502	502
Control Mean	2350.002	2288.809	2103.472	863.829	836.180	784.290	3544.444	3456.293	3163.704
Panel C: All Households (ITT)									
High Value Voucher	1.230***	0.671**	1.306***	1.963***	1.357***	1.902***	0.621	0.214	0.808*
	(0.294)	(0.297)	(0.293)	(0.420)	(0.400)	(0.416)	(0.422)	(0.436)	(0.429)
Low Value Voucher	1.152***	0.644**	1.263***	1.534***	1.131***	1.452***	0.893**	0.409	1.173***
	(0.281)	(0.293)	(0.277)	(0.394)	(0.385)	(0.388)	(0.397)	(0.434)	(0.392)
N	963	963	963	453	453	453	510	510	510
Control Mean	2307.361	2247.278	2065.304	844.374	817.347	766.626	3492.701	3405.836	3117.518
Panel D: All Households (ITT)									
HH voucher	1.073***	0.553*	1.207***	1.841***	1.359***	1.795***	0.516	0.088	0.765*
	(0.319)	(0.324)	(0.318)	(0.501)	(0.485)	(0.503)	(0.414)	(0.426)	(0.419)
HH voucher X Female HHH	0.296	0.261	0.195	-0.167	-0.220	-0.218	0.773	0.720	0.714
	(0.475)	(0.480)	(0.471)	(0.667)	(0.636)	(0.660)	(0.722)	(0.764)	(0.723)
Female headed HHH	-3.500**	-3.701**	-3.432**	-2.543	-2.665	-2.525	0.621	-0.238	0.678
	(1.697)	(1.658)	(1.702)	(2.713)	(2.878)	(2.732)	(1.797)	(1.777)	(1.819)
N	963	963	963	453	453	453	510	510	510
Control Mean	2307.361	2247.278	2065.304	844.374	817.347	766.626	3492.701	3405.836	3117.518
p-val: voucher + FXvoucher =0	0.000	0.022	0.000	0.000	0.006	0.000	0.030	0.205	0.013

Note: Robust standard errors in parentheses.

TABLE 8: Labor Impacts: Household Analysis

	Share of adults doing any crop activity (1)	Average hrs per day on crop activities (2)	Average days per week on crop activities (3)	Average total hours per week on crop activities (4)
Panel A: All Households (ITT), Male report of adult male labor				
HH voucher	0.002	0.177	0.079	1.351
	(0.012)	(0.148)	(0.090)	(0.934)
N	685	685	685	685
Control Mean	0.964	6.659	4.755	33.706
Panel B: All Households (ITT), Female report of adult male labor				
HH voucher	-0.000	0.038	-0.013	0.170
	(0.013)	(0.139)	(0.094)	(0.884)
N	685	685	685	685
Control Mean	0.954	6.578	4.553	32.051
Panel C: All Households (ITT), Male report of adult female labor				
HH voucher	-0.003	0.150	0.098	1.164
	(0.021)	(0.125)	(0.124)	(0.717)
N	684	684	684	684
Control Mean	0.892	3.647	3.627	15.239
Panel D: All Households (ITT), Female report of adult female labor				
HH voucher	0.033*	0.172	0.048	0.189
	(0.018)	(0.133)	(0.109)	(0.718)
N	684	684	684	684
Control Mean	0.912	4.297	3.743	18.358
Panel E: All Households (ITT), Male report of child labor				
HH voucher	0.016	0.445*	0.333	2.970**
	(0.034)	(0.242)	(0.205)	(1.415)
N	343	343	343	343
Control Mean	0.823	3.406	3.045	13.541
Panel F: All Households (ITT), Female report of child labor				
HH voucher	-0.049	-0.406*	-0.345*	-2.135
	(0.037)	(0.245)	(0.189)	(1.294)
N	343	343	343	343
Control Mean	0.886	4.137	3.584	17.512

Note: Robust standard errors in parentheses.

TABLE 9: Labor Impacts: Household Analysis

	Share of adults doing any crop activity (1)	Average hrs per day on crop activities (2)	Average days per week on crop activities (3)	Average total hours per week on crop activities (4)
Panel A: All Households (ITT), Male report of adult male labor				
HH voucher	-0.003	0.184	-0.018	0.793
	(0.013)	(0.166)	(0.100)	(1.049)
HH voucher X Female HHH	0.024	-0.033	0.465**	2.690
	(0.029)	(0.364)	(0.220)	(2.302)
Female headed HHH	0.091	0.365	0.595	0.669
	(0.079)	(0.982)	(0.595)	(6.207)
N	685	685	685	685
Control Mean	0.964	6.659	4.755	33.706
p-val: voucher + FXvoucher =0	0.419	0.641	0.023	0.090
Panel B: All Households (ITT), Female report of adult male labor				
HH voucher	-0.002	-0.034	-0.055	-0.265
	(0.015)	(0.157)	(0.106)	(0.993)
HH voucher X Female HHH	0.008	0.350	0.198	2.095
	(0.033)	(0.344)	(0.232)	(2.179)
Female headed HHH	0.205**	1.028	1.041*	3.841
	(0.089)	(0.927)	(0.626)	(5.876)
N	685	685	685	685
Control Mean	0.954	6.578	4.553	32.051
p-val: voucher + FXvoucher =0	0.820	0.304	0.487	0.346
Panel C: All Households (ITT), Male report of adult female labor				
HH voucher	-0.022	0.113	-0.006	1.095
	(0.023)	(0.142)	(0.140)	(0.812)
HH voucher X Female HHH	0.089*	0.172	0.474	0.313
	(0.050)	(0.303)	(0.298)	(1.734)
Female headed HHH	-0.033	1.478*	1.107	10.845**
	(0.138)	(0.835)	(0.822)	(4.782)
N	684	684	684	684
Control Mean	0.892	3.647	3.627	15.239
p-val: voucher + FXvoucher =0	0.131	0.289	0.076	0.358
Panel D: All Households (ITT), Female report of adult female labor				
HH voucher	0.027	0.145	-0.002	0.017
	(0.021)	(0.151)	(0.124)	(0.814)
HH voucher X Female HHH	0.023	0.119	0.224	0.782
	(0.044)	(0.322)	(0.264)	(1.738)
Female headed HHH	0.147	1.601*	-0.192	3.792
	(0.121)	(0.889)	(0.728)	(4.791)
N	684	684	684	684
Control Mean	0.912	4.297	3.743	18.358
p-val: voucher + FXvoucher =0	0.190	0.354	0.341	0.603

Note: Robust standard errors in parentheses.

TABLE 10: Child Labor Impacts: Household Analysis

	Share of adults doing any crop activity (1)	Average hrs per day on crop activities (2)	Average days per week on crop activities (3)	Average total hours per week on crop activities (4)
Panel A: All Households (ITT), Male report of child labor				
HH voucher	0.054	0.679***	0.550**	4.359***
	(0.036)	(0.260)	(0.220)	(1.521)
HH voucher X Female HHH	-0.253***	-1.571**	-1.457**	-9.330**
	(0.094)	(0.674)	(0.570)	(3.943)
Female headed HHH	0.260	2.220	1.744	11.503
	(0.206)	(1.472)	(1.245)	(8.605)
N	343	343	343	343
Control Mean	0.823	3.406	3.045	13.541
p-val: voucher + FXvoucher =0	0.022	0.153	0.086	0.173
Panel B: All Households (ITT), Female report of child labor				
HH voucher	-0.032	-0.181	-0.221	-0.940
	(0.041)	(0.264)	(0.204)	(1.392)
HH voucher X Female HHH	-0.113	-1.508**	-0.832	-8.026**
	(0.105)	(0.684)	(0.529)	(3.608)
Female headed HHH	0.032	1.139	0.324	6.019
	(0.230)	(1.493)	(1.155)	(7.874)
N	343	343	343	343
Control Mean	0.886	4.137	3.584	17.512
p-val: voucher + FXvoucher =0	0.135	0.008	0.032	0.008

Note: Robust standard errors in parentheses.

6 Maps and Figures

FIGURE 1: Timeline

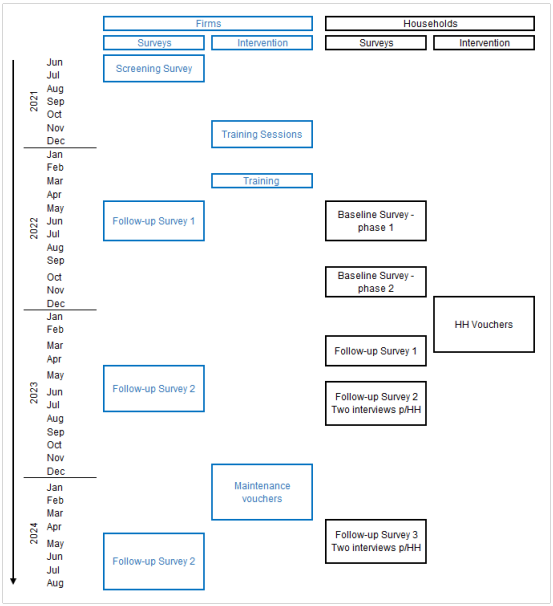


FIGURE 2: Usage of Vouchers Over Time By Farmers (Weekly)

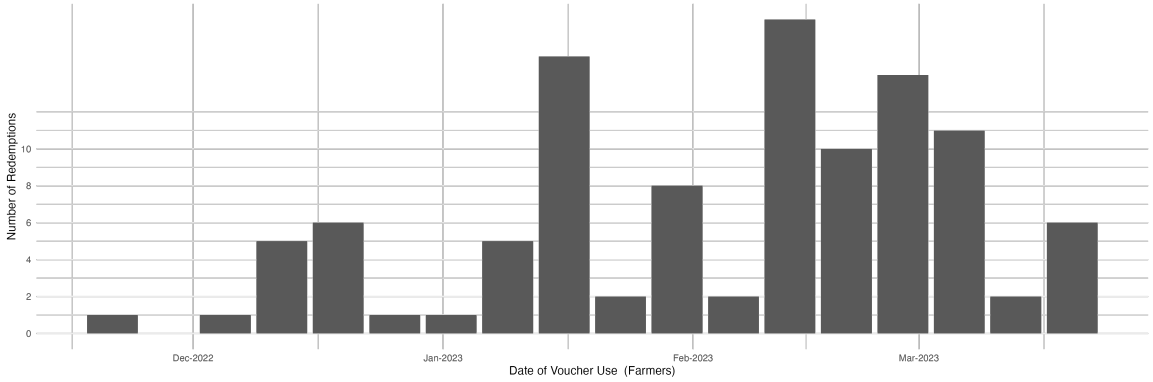


FIGURE 3: Usage of Vouchers Over Time By Service Providers (Weekly)

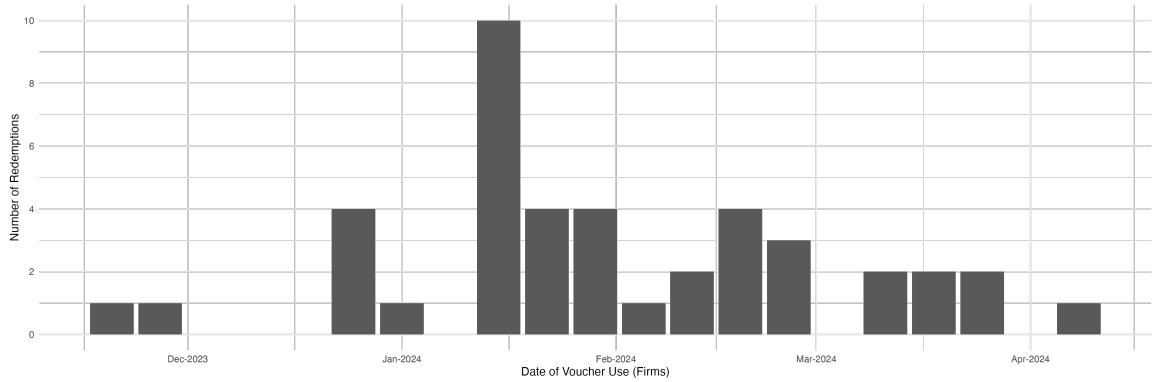


FIGURE 4: Location of Study Villages and Two-wheel Tractor Service Providers

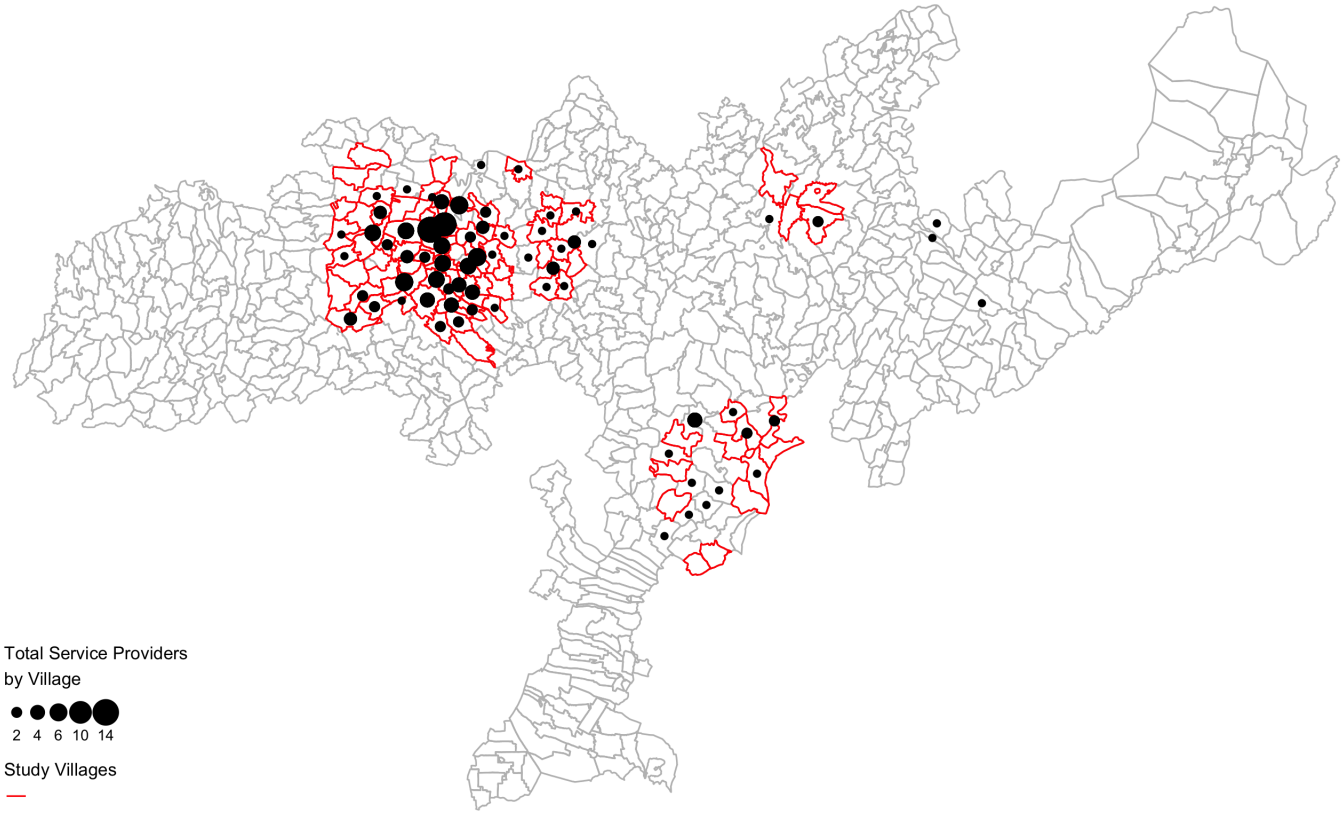


FIGURE 5: Number of Service Providers by Origin/Destination and Supply Side Treatment

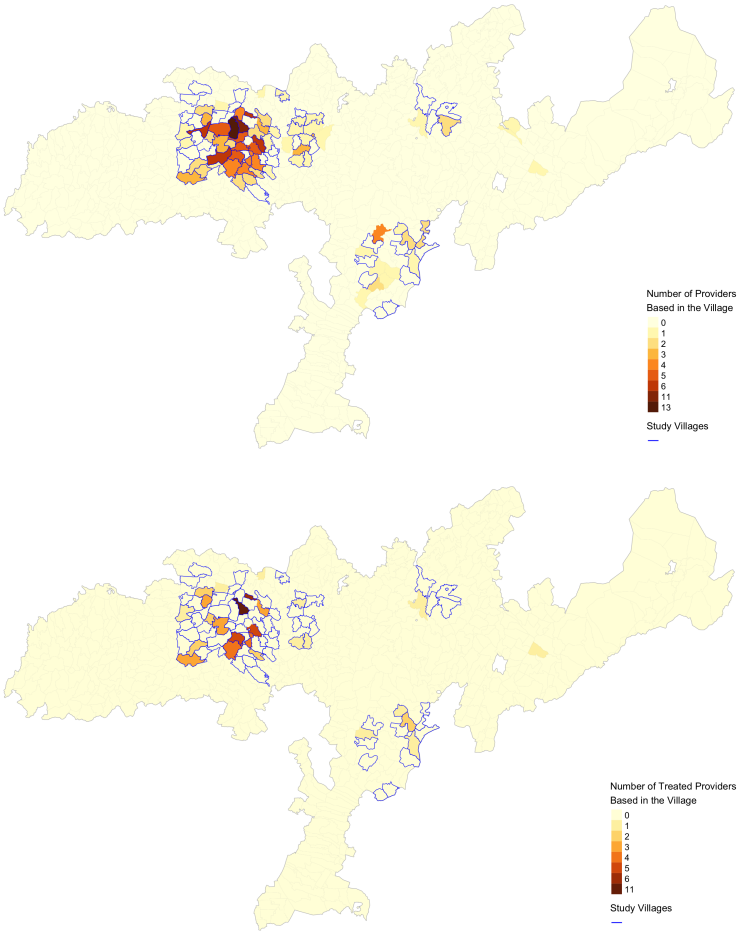


FIGURE 6: Example voucher

VAAWUCHARIIN KUN (17860588) HANGA GURAANDHALA 30, 2015 tti QOFA FAYYADAMUUF HOJIIRRA OOLA
ቫውቸሩ የሚሰራው እስከ የካቲት 30 ቀን 2015 ዓ.ም ድረስ ብቻ ነው።

MAQAA FI LAKKOFSA BILBILAA TAJAAJILA KENNITOOTA ULAAAGAA GUUATANII
የአገልግሎት አቅራቢዎች ስም እና ስልክ ቁጥር

Order	ServiceProviderName	PhoneNumbers
1	[redacted]	
2		
3		

Obbo/Aadde _____ kan jedhamu tajaajila meekaanayzeshinii kan kennu, ana Obbo/Aadde _____f tajaajila _____ waliigala baasii Qarshii _____ ta'een naaf kennuu issaa mallattoo kiyyaan nan mirkaneessa.

_____ የተባለው አገልግሎት አቅራቢ ለእኔ _____የሚከተለውን አገልግሎት_____ በጠቅላላ ወጪ _____ ብር አገልግሎት ሰጥተዋል።

Mallattoo/ፊርማዎች:
Qonnaan bulaa / ገበሬ: _____
Tajaajila Kenna / አገልግሎት አቅራቢ.: _____
Guyyaa Itti Fayyadamaa / ጥቅም ላይ የዋለበት ቀን_____

Waa'ee vaawucharii kanaa gaaffii yoo qabaattan, qunnamaa [redacted] yookaan [redacted] ስለዚህ ቫውቸር ጥያቄ ካሎት አቶ አብዱ መሀመድን [redacted] ወይም ወይዘሮ አዲስ ፀጋዬን [redacted] በስልክ ያግኙ።