Might A Market Emerge? Estimating Latent Demand and Supply for Novel Products That Improve Both Human Health and Agricultural Productivity[*]

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June 10, 2026

Abstract

Submerged aquatic vegetation hosts snails that vector the infectious disease schistosomiasis. Removing that vegetation reduces infection prevalence in northern Senegal, but also generates an excellent feedstock for making compost and livestock feed that boost agricultural productivity. We study the potential for creating a market for not-yet-marketed compost and animal feed produced from removed aquatic vegetation. Generalized second price auctions with a built-in information experiment yield estimates of latent demand with and without information on the products' public health benefits, while household survey data let us estimate households' shadow wages and products' latent supply for these labor-intensive products. We show that a viable market exists for livestock feed and especially for compost. Further, sharing information on the potential health benefits of aquatic vegetation removal significantly boosts demand for compost and animal feed, by about 132% and 82%, respectively. Because latent supply is far more price elastic than latent demand, most of the prospective welfare gains from the market would accrue to purchasers.

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[*] The experiment was registered at the American Economic Association Registry for randomized control trials on May 3, 2023 (AEARCTR-0011195). This research was supported by National Science Foundation grants DEB-2109293 and BCS-2307944. The authors thank Anannyabrata Mandal and Kateri Mouawad for their excellent research assistance, Sidy Bakhoum, Momy Seck, Assane Sylla, and the entire teams at Station d'Innovation Aquacole and Le Centre de Recherche pour le Développement Économique et Social for outstanding field research support in Senegal, and Brian Dillon, Cathy Kling, John Hoddinott, Nicolas Jounard, and seminar participants the 2024 Pacific Conference for Development Economics, the 2024 AERE Summer Conference, and Cornell University for their valuable feedback and comments. The study was approved by the Cornell University IRB under protocol number IRB0010544. The findings, interpretations, and conclusions expressed in this study are entirely those of the authors.

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1 Introduction

As in much of rural sub-Saharan Africa, populations in northern Senegal suffer both low crop and livestock productivity and high prevalence of infectious disease. Creative solutions are needed to help these populations escape poverty-disease traps (Bonds et al., 2010; Ngonghala et al., 2014; Doruska et al., 2024; Barbier, 2025). Local market-based solutions hold particular appeal in settings where scarce government fiscal and foreign aid resources limit the scalability and sustainability of initiatives that rely on external funding. This paper explores the possibility of a market emerging for novel products that both boost agricultural productivity and reduce the infectious disease schistosomiasis.

Schistosomiasis is a parasitic, neglected tropical disease that infects more than 200 million people worldwide (Gryseels et al., 2006; Steinmann et al., 2006; Hotez et al., 2014; Verjee, 2019). Schistosomiasis disproportionately affects children and causes loss of tissue function, stunted growth, and learning deficits among other ailments (King et al., 2005; Kjetland et al., 2006; Mohammed et al., 2007; Verjee, 2019). Treatment of schistosomiasis and other parasitic helminth infections significantly increases human capital, generates gains in earnings and economic productivity when dewormed children reach adulthood (Miguel and Kremer, 2004; Baird et al., 2016; Hamory et al., 2021), and has positive spillovers on siblings of dewormed children (Ozier, 2018). However, treatment does not address the environmental reservoir of the schistosomiasis infection. Dewormed children who reenter infected water sources quickly become reinfected (Rohr et al., 2023).[1] Thus, innovative environmental solutions are needed to complement deworming treatments, targeting other parts of the schistosomiasis infection cycle to reduce worm burdens.

Invasive, submerged aquatic vegetation provides habitat for aquatic snails, the intermediate vector of the schistosoma parasite. When the vegetation grows at or near the access points where people enter water to bathe, clean, fish, or recreate, the likelihood they get infected increases dramatically. Hence, aquatic vegetation removal (AVR) near those water access points offers a strategy for long-term infection control (Rohr et al., 2023). A randomized controlled trial (RCT) in our study area in northern Senegal established that AVR around water access points significantly reduces schistosomiasis reinfection rates (Rohr et al., 2023). The main invasive aquatic plant species that hosts the snail that vectors schistosoma is *Ceratophyllum demersum* (hereafter 'cerato'). It regrows quickly, however, so maintaining clear water access points and reduced infection rates requires regular AVR for an indefinite period. This raises a key question: how to induce sustained AVR?

One attractive option is to make private AVR remunerative for individuals. Crop trials

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[1] Child reinfection rates in our study area are as high as 99% one year after treatment (Rohr et al., 2023).

indicate that compost produced from removed aquatic vegetation significantly increased pepper and onion yields and profitability, even under conservative assumptions about the cost of labor used to clear vegetation and make and apply compost (Rohr et al., 2023). Additional livestock feeding trials found that dried aquatic vegetation yields significantly cheaper isocaloric feed than is available on the market to supplement sheep diets during periods of low forage availability.[2]

These potentially remunerative uses of harvested aquatic vegetation raise the prospect of turning that aquatic vegetation from a public bad into an impure public good, a remunerative private good that also generates infectious disease control co-benefits. Inducing a sustainable transformation, however, requires, sufficient latent local demand and supply exist to support AVR by profit-seeking producers.

The focal questions of this study are thus: Is there sufficient, latent local demand for compost and/or livestock feed derived from removed aquatic vegetation to create a market? And given households' opportunity cost of time spent on AVR, is there sufficient latent profitability for some households to produce and supply these labor-intensive products? Further, does informing prospective purchasers of the public health benefits of removing vegetation boost product demand, increasing the likelihood that a market emerges to induce and sustain voluntary private AVR that helps reduce the local prevalence of schistosomiasis while also boosting agricultural productivity? If so, who is likely to gain most from such a market?

Using the same local partner organization (Station d'Innovation Aquacole, SIA) and procedures as Rohr et al. (2023), we produced similar compost and animal feed from removed aquatic vegetation and then conducted generalized second price auctions (Vickrey, 1961) to elicit villagers' demand for different quantities of each product – i.e., we elicited individual-specific demand curves – for these products.[3] We randomly varied the information given to auction participants to assess how demand varies in response to information about the public health benefits arising from production of the compost and animal feed made from harvested cerato feedstock.[4] We find considerable latent demand at willingness to pay values significantly exceeding the estimated cost of producing compost or livestock feed from

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[2] Most livestock in this system graze extensively. During the dry season, however, forage often grows scarce. While Rohr et al. (2023) demonstrate that animal feed produced from removed aquatic vegetation is not unconditionally profitable, it is far less expensive than other forms of supplemental feed. So, when insufficient forage is available, dried aquatic vegetation offers a much lower-cost supplemental livestock feed.

[3] While it is common to use a Becker-DeGroot-Marshack (BDM) mechanisms to elicit demand, restricted production and transportation capacity limited our ability to fulfill all elicited demand. Therefore, we used second price auctions that likewise offer incentive compatible ways to elicit participants' demand.

[4] All auction participants ultimately received the public health benefits information. We experimentally vary only whether that information was given prior to or after the auction.

harvested cerato. Consumer demand expands significantly in response to information on the products' public health benefits.

We then use household survey data from these same communities to estimate household-specific shadow wages, as labor represents the primary cost of producing compost and livestock feed from harvested cerato. That lets us estimate supply curves for compost and livestock feed made from cerato AVR.

Given high transport costs and the low value-to-weight of these products, latent markets are likely highly localized, just like markets for manure, with upper bound prices set by the cost of imported fertilizer or feed. Likewise, the public health benefits - and the demand effects induced by providing information on the public health benefits of products made from removed cerato – are likely local to the community that stands to benefit from AVR. We therefore combine the estimated demand and supply curves at village scale to show that latent local markets might exist for compost and/or livestock feed made from AVR, at equilibrium prices at or below that of substitute products available on local markets.

Combining the estimated demand and supply functions, we show there exists significant latent welfare gains from creating such a market. A local autarkic cerato-based compost market equilibrium price is 82% below the prevailing price of urea fertilizer, on average. Such a market would produce an estimated consumer surplus of \$17.63 USD per person (388% of the average daily wage for paid work) and producer surplus of \$0.16 USD (3.5% the average daily wage).

We similarly find that there is the potential for a market for animal feed, although the gains are much smaller. The local autarkic cerato-based animal feed price is only 1.3% less than for peanut straw, a common feed purchased in the region, and thus produces a very similar volume of transactions relative to supplemental feed on the market.

The public health benefits information treatment significantly increases total demand for compost and animal feed made from cerato. For compost, auction participants increased their total individual demand by over 1,800 FCFA or \$3 USD, about 89%, when informed of the public health benefits of AVR. At each price level, total revenue from compost sales at that price increased by a median of 132% with public benefits information. The estimated impact of public health benefits information on animal feed demand is smaller. Per capita demand increased by just under 600 FCFA or \$1 USD (45% relative to just private information) when participants were informed of the public health benefits of AVR and total revenue from animal feed sales at each price increased by a median of 82% with public health information. Informing prospective buyers of the public health benefits associated with compost and livestock feed made from cerato generates an estimated extra 65% and 25% of overall welfare per person relative to the welfare gains when consumers only have information about the private productivity benefits of compost and animal feed. A clear opportunity exists for a market to emerge for compost and animal feed that generates both agricultural and public health returns, especially if consumers are made aware of the public health gains, i.e., that compost or livestock feed made from AVR is an impure public good.

We also estimate how the welfare gains from creating such a market are likely distributed between consumers and producers of compost and livestock feed. Buyers capture an estimated 98% (99%) of the gains from compost trade when consumers are (not) informed of the public health benefits of AVR. And, buyers capture 99% of the gains from trade for animal feed. Additionally, we find that both estimated consumer surplus and producer surplus increase with household wealth in the market for compost. Thus, the gains from trade in a potential market for compost and animal feed may benefit better-off households most.

This study contributes to several literatures. The first is the literature on impure public goods (Bergstrom et al., 1986; Kotchen, 2006, 2009; Chan and Kotchen, 2014; Wichman, 2016). We introduce a framework for addressing impure public goods in a setting in which households face multiple market failures. We combine a nonseperable agricultural household model (Singh et al., 1986) appropriate to the context with the characteristics-based approach of impure public goods models to motivate an empirical framework that reveals how different household characteristics may influence individual demand for these impure public goods.

We also contribute to the literature on how consumers value information on the societal spillover benefits arising from goods' production features. A large literature explores how (largely high-income country) consumers respond to fair trade, eco-friendly and similar labels.[5] For example, Loureiro and Lotade (2005) and Gobbi (2000) evaluate how consumers value labeling of fair-trade or eco-labeled coffee. We extend the discussion of how eco-labeling may matter in a low-income country setting, providing new evidence that consumers in low-income settings value information about public benefits associated with the goods they purchase.

We also build upon the literature on private provision of public goods like deworming (Miguel and Kremer, 2004; Kremer and Miguel, 2007; Baird et al., 2016; Ozier, 2018; Hamory et al., 2021), malaria control through insecticide treated nets (ITNs) (Hoffmann et al., 2009; Cohen and Dupas, 2010; Cohen et al., 2015), and water quality improvements (Kremer et al., 2011; Berry et al., 2020). These are all impure public goods, as the individual taking the medication or using the ITN benefits from better health while the community enjoys reduced infection risk. The private incentive of better health is, however, insufficient to fully reduce community infection risk. Hence, the public good is underprovisioned in equilibrium. Similarly, compost and animal feed made from cerato have broad public health benefits.

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[5] See Peattie (2010); Tully and Winer (2014) for a review.

However, compost and animal feed also have large agricultural productivity benefits that may be more salient than the individual health benefits of deworming, ITNs, or improved water quality. Thus, compost and animal feed may have stronger private incentives that may make a local market for compost and animal feed produced from removed aquatic vegetation more viable than is true of previously-studied public health-oriented interventions in low-income settings.

Finally, and most closely related to our setting is a small set of papers that evaluate the potential market for lionfish fillets (Huth et al., 2018; Simnitt et al., 2020; Hwang and Gao, 2025) . Lionfish are an invasive species that massively disrupts coral reef ecosystems in the Caribbean. Developing local markets for lionfish could provide food for consumers (the private benefits) while also reducing the lionfish population (the public benefits), turning a public bad into an impure public good.

The rest of the paper is organized as follows. Section 2 introduces the setting and the AVR innovation. Section 3 discusses how we estimate demand and presents those results while section 4 explains how we estimate supply and reports those results. We combine supply and demand estimates to estimate market equilibria and the distribution of associated welfare gains in section 5. Section 6 discusses and concludes.

2 Study Setting and Innovation

This study takes place in the Senegal River Valley, in the Saint Louis and Louga regions of northern Senegal. Schistosomiasis has been a long running public health problem within the region following the 1988 construction of the Diama dam (Southgate, 1997; Diop et al., 2023) near the mouth of the Senegal River. The subsequent desalination of the water upstream of the dam expanded the habitat suitable for aquatic snails that vector schistosoma, the aquatic parasitic helminths that infect people. Land use change following construction of the dam led to considerable agricultural expansion, especially of irrigated rice (Cisse et al., 2025). Meanwhile, the government's 2004 resumption of fertilizer subsidies that were curtailed in the 1980s led to increased fertilizer use and resultant nutrient leaching into irrigation canals, Lac Guiers and the Senegal River and its tributaries. The changed water chemistry and added nutrient loading have been associated with a rapid expansion of cerato, an invasive aquatic plant and an ideal host for the freshwater snails that vector schistosoma (Halstead et al., 2018; Rohr et al., 2023). Schistosomiasis infection rates have increased sharply over the past thirty-plus years (Diop et al., 2023; Senghor et al., 2022). The combination of the Diama dam, fertilizer subsidies, and expanded cultivation seems to have inadvertently but considerably expanded the risk of schistosomiasis infection within the region.

Schistosomiasis is a widespread neglected tropical disease that affected more than 250 million people in 2024 (World Health Organization, n.d.). The disease causes abdominal pain, diarrhea, blood in the stool or urine, bladder, kidney, liver and spleen damage, anemia, stunting in children, genital damage impacting fertility, perhaps some forms of cancer, and (relatively rarely) death. Two types of schistosomiasis are endemic in the region. *S. mansoni* infects the gastro-intestinal tract and *S. haematobium* infects the urinary tract.[6] Despite ongoing government schistosomiasis control programs that focus on deworming medication, infection rates remain high as schistosomiasis prevalence rates among school children can exceed 87% (Léger et al., 2020; Senghor et al., 2022). Thus, schistosomiasis remains a serious, ongoing public health issue within the study area.

Randomized control trials in Rohr et al. (2023) show that AVR - specifically, of cerato – reduces snail populations and schistosomiasis infection prevalence. Additionally, Rohr et al. (2023) propose that removed vegetation can be turned into either compost that sharply boosts onion and pepper yields in crop trials. Furthermore, cerato-based compost reduces the variance of yields and thus is particularly attractive for risk averse farmers in the region's drought-prone, sandy soils. Or cerato can be dried and used as livestock feed. Trials with sheep show that feeds that replace up to 45% of the calories within the feed with removed aquatic vegetation perform similarly to purchased feed, but at lower cost (Rohr et al., 2023). Livestock productivity is also very low with low lactation rates and limited forage available during dry months requiring livestock owners to purchase supplemental feed (Seck et al., 2016). Rohr et al. (2023) relied on researcher-managed, externally-financed AVR, however. This paper assesses whether latent local demand and supply might suffice to generate local markets for cerato-based compost and animal feed that might endogenously induce and sustain AVR.

3 Estimating Demand

3.1 Overview

Assessing the overall market for compost and animal feed from removed aquatic vegetation requires information about both the demand and supply of these not-yet-marketed goods. We begin by discussing our estimation of latent demand for compost and animal feed made from harvested cerato using a generalized second price auction. We use these generalized second price auctions to estimate demand for compost and animal feed. We then use the experimental variation in the information environment prior to the auction to understand

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[6] *S. haematobium* has also hybridized with *S. bovis*, the cattle form of the disease, generating an added, zoonotic risk.

how information about the public health benefits potentially increases demand for these not-yet-marketed goods. Section 4 covers how we estimate supply.

3.2 Sample Selection and Randomized Information Treatments

Eligibility for the generalized second price auction study was determined in two stages. First, we selected 20 villages in the Saint Louis and Louga regions. We selected 16 villages previously included in the Rohr et al. (2023) study and then selected four additional villages using the following criteria: 1) the village has between 500 and 5,000 residents; 2) the village is within 10 km of a freshwater source with known schistosomiasis transmission; and 3) the village has at least one water access point with submerged vegetation. Within each selected village, we randomly selected 40 households to participate and enrolled the head of household or another adult in these selected households.[7] We enrolled 801 total households.

Following the short enrollment survey, households were randomly assigned to auction treatment arms within their village, as described below. We stratified household randomization based on the amount of land cultivated and by the number of children in the household.[8] We informed participants of their ability to purchase compost and animal feed at the arranged auction time. Within 24 hours of this recruitment process, we simultaneously conducted four auctions in each village where we randomly varied the information about compost and animal feed auction participants received prior to the auctions.

To disentangle the two sources of value for compost and animal feed produced from removed aquatic vegetation, we assigned each participant to one of two information treatment arms: a private productivity gains information treatment arm (the control) and a public health information treatment arm.

Because we were auctioning inputs, all participants received information about the private benefits of using compost and animal feed made from AVR based on estimates from Rohr et al. (2023).[9] All information treatments were reviewed by local partners and presented in a culturally appropriate way using posters and verbal descriptions from the enumerators (Appendix Figures C.2 - C.3). In the public health impacts information treatment arm, participants also received information about the public health benefits of aquatic vegetation

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[7] In one village, there were only 35 households so all 35 household heads or adult representatives were enrolled. To reach our desired sample size, we enrolled 45 households from the next village. We also enrolled 41 households in one village to comply with requests from local authorities.

[8] Specifically, we classified each household within a village as above of below median land cultivated and above or below number of children. We then created four groups: above median land cultivated and children, above median land cultivated and below median children, below median land cultivated and above median children, and below median land cultivated and children. We then randomly assigned households to each treatment arm balancing treatment across these four groups.

[9] The same team, SIA, produced compost and animal feed using the procedure developed in Rohr et al. (2023) to match the characteristics of the compost and animal feed as best as possible.

removal in reducing schistosomiasis exposure, explaining that the compost and feed are co-products along with infectious disease control. After the end of the private productivity gains auctions, participants in the first arm were informed about the public health benefits of AVR so that all participants ultimately received this potentially beneficial information.

Two auctions in each village were assigned to each of the treatment arms. In total, 399 households were randomly assigned to the private productivity gains treatment arm while 402 households were randomly assigned to the public health benefits treatment arm. Of the 801 individuals enrolled in the study, 712 completed the auctions with 355 auction participants in the private productivity gains treatment arm and 357 auction participants in the public health benefits treatment arm.[10] Households were not informed which auction group they were assigned to until they showed up at the auction. Appendix Table D.3 presents summary statistics and balance tests for households that completed the auction and make up the analysis sample.

We find no statistically significant differences in demographic, agricultural, or health characteristics between the control and treatment arms. About half of our survey respondents were female, and slightly more than one-third of household heads could read French. Average household size was quite large, consistent with other data from the region, just under 12 people including five children. Most of the households owned livestock and grew crops. Around 80% of households report using fertilizer. A smaller fraction of households used compost, but compost was somewhat familiar to most households. More than 60% of households reported going to the health center in the last month. As expected, most households reported having at least one member diagnosed with schistosomiasis in the past and most reported that at least one member of the household received deworming drugs. Only about a quarter of households reported that someone with current schistosomiasis infections or red/pink urine, which is common symptom of *S. haematobium* infections.

3.3 Generalized Second Price Auction Procedure

We used a generalized second price auction to elicit total individual demand for compost and animal feed. We moved each of the four auction groups in each village to a private location so that other auction groups could not see or hear the auction. The step-by-step procedure employed in the auction can be found in Appendix A.

Participants received 1500 FCFA (roughly USD 2.50) at the beginning of the auction. This payment served two purposes. First, it was equivalent to roughly a day's wage as an agricultural laborer, therefore compensating participants for their time in the study.

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[10] Appendix Tables D.1 and D.2 show there is no difference in households that did and did not attend the auction across treatment arms. Households that grow crops were less likely to attend the auction.

Second, it helped to relax any liquidity constraints participants faced. While our study design did not allow for long periods of time to gather funds to participate in the auction, our auction items were relatively small and thus we did not expect them to pose a large financial burden for participants. Additionally, vendors often come through these villages selling items unannounced, so households are accustomed to making small to medium value purchases without much advanced notice.

Once participants received their payments we explained the auction procedure, including the types and quantities of the items that they would soon bid on. We explained that the winner of the auction is the person who bids the highest, but that winner pays the second highest bid for the item. We also informed participants that if they win they must purchase the item. This second price auction mechanism is incentive compatible; a utility-maximizing participant should reveal their true maximum willingness to pay (Vickrey, 1961). Before beginning the experiment, we ran a practice auction, for a sickle, an inexpensive, common agricultural tool in the region. Prior to starting the sickle auction, we asked participants if they had any questions, and, to verify that they understood, we to explain who would win the auction and what price they would pay. Generally, participants understood the auction procedure quite well. Prior to the practice auction, 98% of participants said that they understood the rules, 85% of participants correctly identified how to win the auction, and 78% of participants correctly reported the price that the winner had to pay. If participants had questions or incorrectly answered a question, the enumerator explained the rules again and/or answered their questions. We completed practice auctions after these comprehension questions and before the auctions for compost and animal feed. Thus we are confident that participants understood the auction procedure.

To reduce outliers and to help elicit willingness to pay, we gave participants a price list, in 50 FCFA[11] increments, to use to bid for each item. The price list for compost was determined based on current urea prices, allowing for bids well above and below prevailing urea prices in the region. The price list for animal feed was based on current prices of similar animal feeds (peanut straw or corn) in the region.[12]

3.4 Empirical Strategy

The auctions were designed to elicit consumer demand for compost and animal feed made from AVR and to identify what, if any, demand boost the public health information generates. We run the following regression separately for compost and animal feed to test hypotheses

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[11] At the time, the exchange rate was roughly 600 FCFA = 1 USD, thus increments were about 0.08 USD.

[12] It is common to haggle for most items in this setting. It is also common for participants not to want to report a bid prior to knowing a price or starting point. We used the price listing to give participants an idea of reasonable prices and to eliminate the need for enumerators to have to suggest a price to spur bidding.

about factors associated with total individual demand in a linear-in-parameters first order approximation of the shadow price functions derived in Appendix B:

$$
\begin{aligned}
TID_{piv} = \beta_0 + \beta_1 Public\ Benefits_{iv} + \beta_2 Land_{iv} + \\
\beta_3 Crops_{iv} + \beta_4 Livestock_{iv} + \beta_5 Past\ Schistosomiasis_{iv} + \beta_6 Children_{iv} + \delta_v + \theta_s + \varepsilon_{piv}
\end{aligned}
\tag{1}
$$

where TID_{piv} is the individual's total individual demand for product p, compost or animal feed, elicited by a generalized second price auction for participant i in village v. We compute this by multiplying the price each participant bid by the total quantity of the item they requested during the auction. This combines elicited prices and quantities. $Public\ Benefits_{iv}$ is a binary indicator that takes value one if the participant was randomly assigned to receive information on the public health benefits of compost and animal feed from AVR prior to the auction, and zero otherwise; $Land_{iv}$ is the land holdings of the participant's household in hectares; $Crops_{iv}$ is a binary indicator that takes value one if the participant's household grows crops, zero otherwise; $Livestock_{iv}$ takes value one if that the participant's household owns livestock, zero otherwise; $Past\ Schistosomiasis_{iv}$ takes value one if someone in the participant's household has been diagnosed with schistosomiasis, zero otherwise; $Children_{iv}$ is the number of children in the household; δ_v are village fixed effects; and θ_s control for stratification in the randomization process. We cluster standard errors at the village auction level, the level of treatment assignment.[13].

The coefficient β_1 identifies the causal impact of the additional public health information on total individual demand for compost of animal feed. While some villages had prior experience with vegetation removal from their participation in the Rohr et al. (2023) study, randomization is within villages and we include village fixed effects, so this should not confound identification. The treatment effect can be seen as the effect of additional information about the public benefits of aquatic vegetation removal at the point of sale and thus the treatment effect is identified only off of randomization or exposure that happened within this study.

3.5 Total Individual Demand Results

Figure 1 reports the average total individual demand for compost in Panel (a) and the average total individual demand for animal feed in Panel (b). In both cases, average total individual demand is significantly higher in the public health benefits treatment arm. Information about

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[13] With few villages, clustering at the village level may bias standard errors downwards (Cameron and Miller, 2015)

the public health co-benefits of compost or livestock feed production clearly stimulates added demand.

We find robust demand for cerato-based compost and animal feed when participants are informed just about the product characteristics. Total individual demand for compost is about 1200 FCFA ($2 USD) in the private benefits arm. Individual demand for both goods exceeds the prevailing market prices of fertilizer (300 FCFA) and peanut straw (375 FCFA) suggesting that there is sufficient demand for these goods even when individuals are only informed about how these products can boost agricultural productivity.

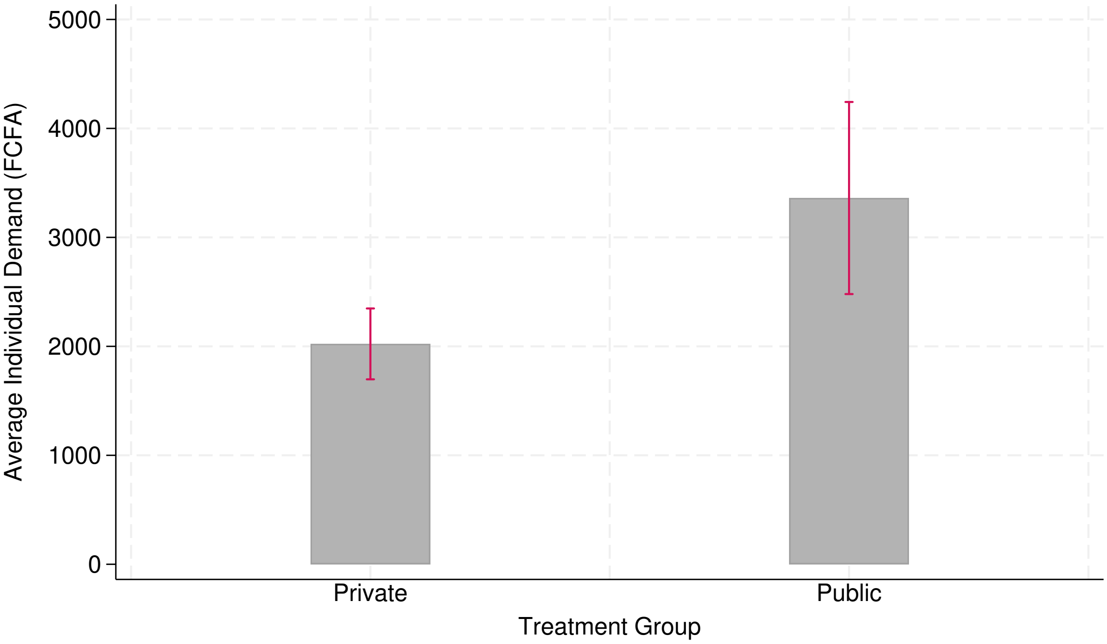
Total individual demand for compost and animal feed significantly increases in the public health benefits information treatment arms (Table 1). For compost, the increase is over 1,800 FCFA ($3 USD) per household or 89% of total individual demand in the private benefits group. The increase in total individual demand induced by providing information on public health co-benefits is smaller for animal feed, about 600 FCFA ($1 USD or 45% of public benefits group mean). The value of community benefits from AVR are high enough to potentially sustain AVR by members of the community.

Households with livestock are willing to pay more for animal feed. Total individual demand for animal feed is higher for those who raise poultry, in particular, although the point estimates for other species are positive but not statistically significant (Appendix Table D.4). This small experiment likely lacks statistical power to detect a significant inter-species effect. We find no meaningful relationships between livestock ownership and total individual demand for compost.

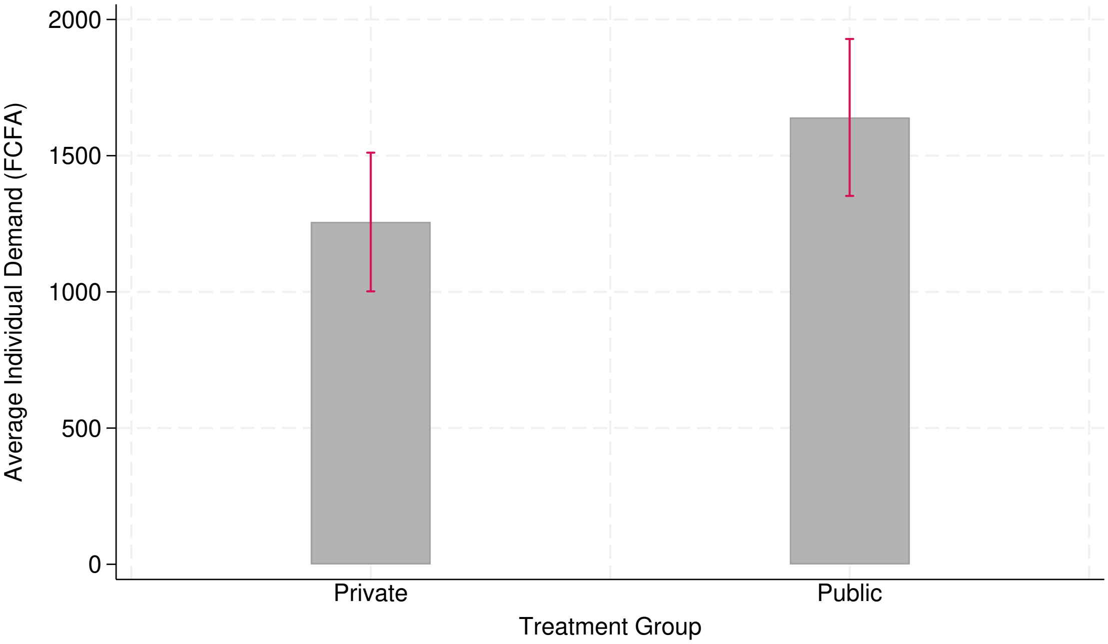
We do not find any statistically significant relationship between growing crops and willingness to pay for compost or animal feed, although that may simply reflect limited variation, as nearly 90% of respondents grew crops. Of the main crops in these villages, rice and cassava, and peppers and onions – the two crops used in the original compost trials (Rohr et al., 2023) – households that grow cassava demand more compost (Appendix Table D.5). This may reflect that farmers grow cassava on poorer quality soils and thus cassava plots may need additional soil remediation or nutrients from compost relative to the other crops. As expected, there is no relationship between total individual demand for animal feed and crop production of any crop type. There are no statistically significant interaction effects between the public health information treatment and households that raise crops or own livestock and total individual demand for compost or animal feed (Appendix Tables D.6 and D.7).

We find that past household experience with schistosomiasis is positively associated with higher overall total individual demand for compost (Table 2). This association is both statistically significant and economically meaningful in magnitude as it increases total individual demand for compost by over $1.50 USD. In Appendix Table D.8 and Appendix Table D.9, we

Figure 1. Average Total Individual Demand by Treatment Arm



(a) Compost



(b) Animal Feed

Notes: Private represents auctions in the private productivity gains treatment arm. Public represents auctions in the public health benefits treatment arm. Bar height is the mean total individual demand and the error bar is the 95% confidence interval for the estimate of the mean.

Table 1. Total Individual Demand Regression Results

	(1) Compost	(2) Compost	(3) Animal Feed	(4) Animal Feed
Public Health Benefits	1812.848**	1944.123***	570.993**	586.120**
	(689.050)	(719.782)	(269.415)	(271.817)
Land Owned (Hectares)		-62.671		-6.738
		(53.929)		(21.952)
Raise Livestock		92.155		471.848**
		(621.074)		(217.841)
Grow Crops		693.525		286.160
		(681.197)		(243.823)
Past Schistosomiasis		1391.925***		119.389
		(513.905)		(400.726)
Children		16.449		-35.769
		(56.164)		(33.601)
Private Mean	2022.5	2022.5	1256.5	1256.5
Village FE	X	X	X	X
Stratification FE	X	X	X	X
Enumerator FE	X	X	X	X
Observations	712	700	712	700
Adjusted R^2	0.0287	0.0286	0.0545	0.0519

Notes: Total individual demand is measured in FCFA. Public Health Benefits is an indicator variable that takes the value of one if the participant received the public health benefits information prior to the auctions. Raise Livestock and Grow Crops are indicator variables that takes the value of one if the participant's household raises livestock or grows crops, respectively. Past Schistosomiasis is an indicator variable that takes the value of one if at least on member of the participant's household was diagnosed with schistosomiasis. Children is the number of children within the household. Private Mean reports the mean total individual demand for private benefits auction participants in FCFA. Standard errors are clustered at village auction level. ***, **, and * indicate significance at the 1, 5, and 10 percent level.

use different measures of schistosomiasis infection. Since we test multiple measures of schistosomiasis infection, we report sharpened q-values in brackets following Anderson (2008). Households with a current schistosomiasis infection have a higher total individual demand for animal feed. We also report results for interaction effects with these different measures of schistosomiasis infection in Appendix Tables D.10 and D.11. We find no statistically significant interaction effects of any report of schistosomiasis infection or symptoms and the public health information on total individual demand for compost or animal feed after correcting for multiple hypothesis testing.

Given that the public information treatment emphasizes the link between AVR and decreased schistosomiasis infection risk, we would expect there to be a positive interaction between the public benefit information and past experience with schistosomiasis in the household. We in fact find increases in individual demand for households with past exposure, but no additional increase with the public health information thus the increases are most prominent when households have experience with schistosomiasis and received the private benefit information only. The point estimates of these interactions are positive as expected (Table 2) but imprecisely estimated. However, over 80% of households report past experience with schistosomiasis within the household and thus households who currently do not have experience with schistosomiasis are likely quite different than most other households in the sample. Given that rice farming comes with an occupational risk for schistosomiasis infection, perhaps households without past schistosomiasis infections within the households are not as engaged in agriculture (have smaller plots or herds) or are otherwise less exposed or concerned with schistosomiasis. Ideally, we could measure how much each auction participant felt schistosomiasis was a problem for them, their household, or their community, but we have limited details on auction participants and their households.

Because children are more vulnerable to schistosomiasis infection, we hypothesized that households with more children may respond more strongly to information about reducing potential schistosomiasis infections than households with fewer children. Similarly, households with previous experience with schistosomiasis may be more informed about the risk and symptoms associated with schistosomiasis infection and thus may respond more strongly to information about how to avoid future infections. To test these hypotheses, we look at the interaction between the public health benefits information treatment and both experience with schistosomiasis within households and number of children in a household. Neither interaction effect is statistically or economically significant, however (Tables 2 and 3).

Land ownership, which is a proxy for wealth, has no statistically or economically significant relationship with total individual demand for compost or animal feed. However, as land ownership increases, the public health benefits treatment is associated with a lower

Table 2. Determinants of Total Individual Demand: Interaction with Schistosomiasis Experience

	(1) Compost	(2) Animal Feed
Public Health Benefits	1162.883	-275.567
	(777.048)	(612.070)
Public Health × Past Schistosomiasis	942.993	1040.096
	(772.445)	(660.069)
Past Schistosomiasis	906.571**	-415.945
	(418.904)	(673.564)
Private Mean	2022.5	1256.5
Village FE	X	X
Stratification FE	X	X
Enumerator FE	X	X
Observations	700	700
Adjusted R^2	0.0280	0.0565

Notes: Total individual demand is measured in FCFA. Public Health Benefits is an indicator variable that takes the value of one if the participant received the public health benefits information prior to the auctions. Past Schistosomiasis is an indicator variable that takes the value of one if at least on member of the participant's household was diagnosed with schistosomiasis. The regressions also include controls for the amount of land a household owns, whether the household raises livestock or grows crops and the number of children in the household. Private Mean reports the mean total individual demand for private benefits auction participants in FCFA. Standard errors are clustered at village auction level. ***, **, and * indicate significance at the 1, 5, and 10 percent level.

Table 3. Determinants of Total Individual Demand: Interaction with Children

	(1) Compost	(2) Animal Feed
Public Health Benefits	2517.720***	870.541**
	(726.016)	(355.722)
Public Health × Children	-114.346	-58.292
	(107.666)	(44.288)
Children	65.645	-9.402
	(64.466)	(43.943)
Private Mean	2022.5	1256.5
Village FE	X	X
Stratification FE	X	X
Enumerator FE	X	X
Observations	700	700
Adjusted R^2	0.0287	0.0520

Notes: Total individual demand is measured in FCFA. Public Health Benefits is an indicator variable that takes the value of one if the participant received the public health benefits information prior to the auctions. Children is the number of children within the household. The regressions also include controls for the amount of land a household owns, whether the household raises livestock or grows crops, and their experience with past schistosomiasis infections in the household. Private Mean reports the mean total individual demand for private benefits auction participants in FCFA. Standard errors are clustered at village auction level. ***, **, and * indicate significance at the 1, 5, and 10 percent level.

Table 4. Determinants of Total Individual Demand: Past Vegetation Removal

	(1) Compost	(2) Animal Feed
Public Health Benefits	1916.155**	574.501*
	(826.085)	(295.334)
Past Removal	182.636	238.561
	(566.763)	(279.740)
Private Mean	2022.5	1256.5
Village FE		
Stratification FE	X	X
Enumerator FE	X	X
Observations	700	700
Adjusted R^2	0.0111	0.00675

Notes: Total individual demand is measured in FCFA. Public Health Benefits is an indicator variable that takes the value of one if the participant received the public health benefits information prior to the auctions. Past Removal is an indicator variable that takes the value of one if the village had previous aquatic vegetation removal. The regressions also include controls for the amount of land a household owns, whether the household raises livestock or grows crops, the number of children in the household, and the household's past experience with schistosomiasis infection. Private Mean reports the mean total individual demand for private benefits auction participants in FCFA. Standard errors are clustered at village auction level. ***, **, and * indicate significance at the 1, 5, and 10 percent level.

individual demand for compost (Appendix Table D.6).

Finally, we explore how past experience with aquatic vegetation removal influences total individual demand for compost and animal feed. Because treatment in Rohr et al. (2023) was at the village level, we cannot use village fixed effects in this analysis as the village fixed effect would be collinear with treatment in Rohr et al. (2023). We thus drop the village fixed effects and include an indicator variable for vegetation removal in the Rohr et al. (2023) study. We find that past removal is positively associated with total individual demand for both compost and animal feed, but this relationship is not statistically significant (Table 4). The interaction effects suggest a positive interaction between past removal and the public health benefits information for total individual demand for compost (Appendix Table D.12), but this effect is only weakly statistically significant.

3.6 Estimated Demand for Cerato-Based Compost and Livestock Feed

We use the elicited joint bid price and quantity data to construct demand curves for both compost and animal feed by treatment group (Figure 2). We construct estimates of the error by bootstrapping 1,000 times.

The demand curve, aggregated across all auction participants, has the expected shape. with relatively price inelastic demand for the first 1000 kgs, above 1500 FCFA/kg. The public health information treatment significantly shifts the demand curve to the right. That shift is driven by a higher number of bids for more than one bag of compost or animal feed. While we could not enforce incentive compatibility for bids greater than one due to limited production capacity, these higher number bids suggest that there could be additional consumer surplus and thus added welfare from information about reduced schistosomiasis risk. The statistically significant differences emerge only beyond the control group's price inelastic range. There's no significant demand expansion at high unit prices, only when prices are FCFA1200 per kg or less. These figures suggest that the relevant elasticities differ between the two treatment groups and thus point to possible increases in welfare patterns resulting from fully capturing the public and private benefits of AVR. With the outward shift in demand with public health information, we would expect an increase in quantity traded which would increase consumer surplus within the market.

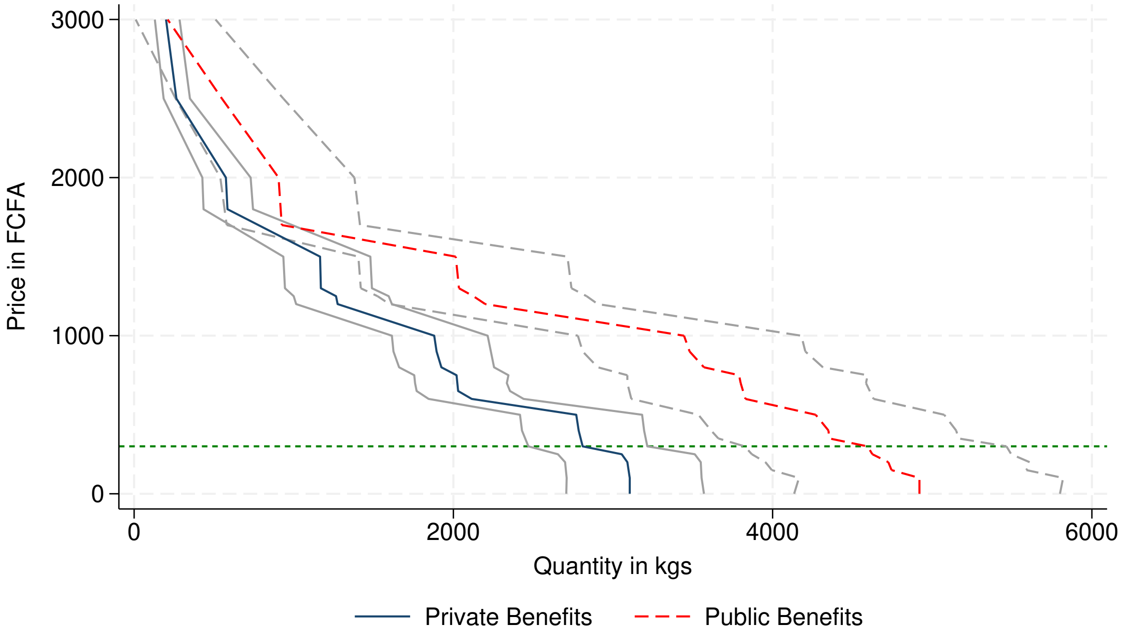
4 Estimating Supply

4.1 Overview

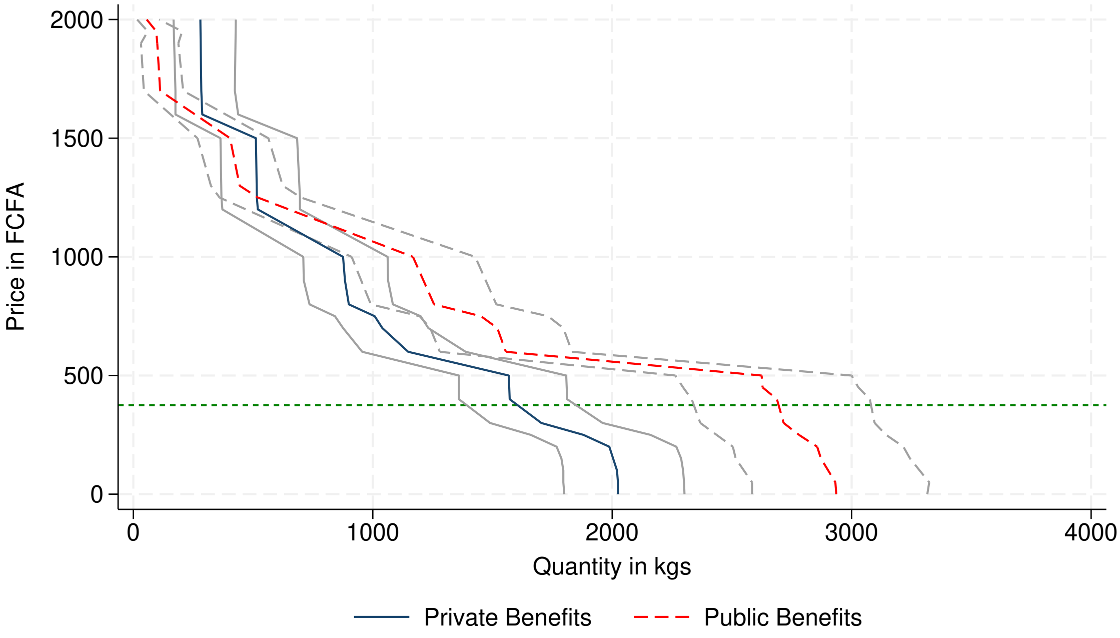
We estimate the supply curve for households producing either compost or animal feed from AVR using slack labor. The main input for households is labor spent during AVR and bags to store and package either product. Animal feed also requires purchased feeds, like peanut straw, to be mixed with removed aquatic vegetation. Compost production, on the other hand, includes other fixed costs to purchase a cart and rakes (or comparable tool) to aid in moving aquatic vegetation and turning aquatic vegetation during the composting process.

Because households in this setting likely face multiple market failures, we assume that they solve a nonseparable agricultural household model (Singh et al., 1986; Benjamin, 1992; LaFave and Thomas, 2016). Thus, their household-specific shadow wage is the relevant value of labor to their decision-making, not market wage rates. We estimate shadow wages following Barrett et al. (2008)'s method for estimating shadow wages in the presence of multiple market failures. We then use those estimated shadow wages as the cost of labor inputs into the production of compost and animal feed based on AVR. Finally, we calculate

Figure 2. Demand Curves by Treatment Arm



(a) Compost



(b) Animal Feed

Notes: Private benefits represents auctions in the private productivity gains treatment arm. Public benefits represents auctions in the public health benefits treatment arm. The gray lines represent the 5th and 95th percentiles from 1,000 bootstrap replications. The green dashed line represents the median fertilizer price or animal feed price in the study region from Barrett et al. (2024).

estimated region market supply by valuing labor and other inputs to production following Rohr et al. (2023) to estimate average labor requirements for producing both compost and animal feed.

4.2 Data

To estimate potential supply curves for compost and animal feed, we use additional household survey data on time use, agricultural production and inputs, household income and labor, and general household characteristics. These household survey data come from 20 randomly selected households in each of 104 villages (11 of which had auctions in 2023) within the same Senegal River Valley region (2,080 households total) in both 2024 and 2025. Additional details on this data collection can be found in Barrett et al. (2024).

Summary statistics for data used to estimate latent cerato-based compost and livestock feed supply can be found in Appendix Table E.1. In this sample, household size is a bit smaller than in the auctions sample, with an average of about 8 members and just over 3.5 children in each household. A majority (58%) of households cultivated land, an average of 1.9 hectares. Rice is the main staple crop for households; 74% of households that cultivate land grow rice. Just under 30% of households have at least one member that works for cash wages, while only 12% households hire outside labor to work on their farm. Households that do not cultivate land or work for a wage are primarily engaged in raising livestock. The average household owns just over 2 tropical livestock units (TLU).[14]

4.3 Estimating Household-Specific Shadow Wages

Following Barrett et al. (2008) we estimate shadow wages in a multi-step process. We first estimate a household agricultural production function. Then, we use the estimated production function to calculate the marginal product of labor at the household-specific input values. We then compute the deviation between market wages and the estimated marginal product of labor for households who both work for cash wages in the labor market and in agriculture on their own farm. We then associate that gap between the market wage and the estimated marginal product of labor with household characteristics to predict this gap for households that only work on their own farm. With a prediction of the gap between the market wage and the marginal product of labor for each household, we then can compute a shadow wage for all households, including the vast majority that do not sell labor in the market. Consistent with existing literature, we expect most households to value labor on their own farm below the market wage rate (Caunedo and Kala, 2021; Agness et al., 2025).

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[14] Cattle, horses, and draft animals are one TLU, goats and sheep are 0.1 TLU, donkeys are 0.5 TLU, pigs are 0.2 TLU and poultry are 0.01 TLU.

To estimate a representative household's agricultural production function, we estimate a generalized Leontief functional form:

$$y_{ivt} = \sum_i \sum_j \beta_{ij} X_i^{0.5} X_j^{0.5} + \alpha_1 Manure + \alpha_2 Compost + \alpha_3 HHWaste + \gamma_v + \delta_t + \varepsilon_{ivt} \quad (2)$$

where y_{ivt} is the total value of agricultural production for household i in village v at time t, X_i and X_j are vectors of inputs to production that include the hectares in production, household labor hours spent on agriculture, fertilizer use, the number of hired laborers, and the number of mechanical agricultural equipment the household owns. Manure, Compost, and HHWaste are binary indicator variables that take value one if the household uses manure, compost, or household waste on one of its plots, respectively, and zero otherwise. γ_v are village fixed effects and δ_t are survey wave fixed effects, with a mean zero, iid error term. We use a random effects estimator. We impose that when $i = j$, $\beta_{ij} = \beta_{ji}$. We cluster the standard errors at the village level.

Mean estimated factor elasticities - across all household-specific elasticity estimates for each input – for continuous inputs of the production function can be found in Table 5. We also estimate a generalized quadratic production function, explore using household fixed effects and/or adding livestock holdings as an input to production in Appendix E. We select the generalized Leontief production function with random effects without including livestock holdings as an input because this model produces the most realistic factor elasticities (Appendix Table E.2). We also calculate shadow wages and estimate supply with a generalized quadratic production function with household fixed effects as this best fits the data as robustness check. Alternatively, we conservatively estimate shadow wages as 80% of the mean or median market wage (Agness et al., 2025) for further robustness.

Table 5. Generalized Leontief Estimated Elasticities

	Land	HH Labor	Fertilizer	Hired Labor	Equipment
Estimated Elasticity	0.390	0.152	0.273	0.212	0.163

Notes. This table reports estimated factor elasticities for the estimated generalized Leontief production function for the continuous inputs in the production function. We report means of estimated household-specific estimated elasticities for each factor.

Using the preceding regression results, we then calculate the estimated marginal product of household labor in agricultural production for each household. Summary statistics showing the estimated marginal product of labor can be found in Table 6. The average estimated marginal product of labor is 850 FCFA, or 31% of the average daily market wage.

For households without wage labor, we predict their market wage based on the number of household members ages 15 and over, and the gender, literacy, numeracy, and education levels of household members over 15 and the household. The shadow wage is below the predicted market wage of the household for 59% of households.

Table 6. Estimated Marginal Product of Labor

	Count	Mean	St. Dev.	Min	Max
Marginal Product of Labor	2088	850.497	1522.060	0	22007.98
Daily Wage for Paid Work	1165	2725.448	1938.665	0	6666.667

Notes. This table reports summary statistics of the estimated marginal product of labor for households who cultivate crops and have non-zero household labor hours and the daily wage for households reporting paid work. The specification reports the specification used to calculate the marginal product of labor.

For households that have members working on the farm and for a wage, we then calculate allocative inefficiency, which is defined as the inverse hyperbolic sine of the ratio of the wage for paid work to the estimated marginal product of labor.[15] We then plot allocative inefficiency across the land-to-labor ratio along with the fractional polynomial line of best fit (Figure E.1). As one would expect, allocative inefficiency falls as the land to labor ratio increases; the relationship approximates the shape of a negative exponential function.

To be able to predict allocative inefficiency for households that only work on their farm, we estimate factors that influence allocative inefficiency (Table E.3). We include basic demographic characteristics of the household: household head age, gender, age, and age squared, household size, household size squared, number of children and number of children squared, whether or not the household grows rice, the number of different crops it grows and its square, the number of hectares in production and its square, and the livestock owned in TLU and its square in the regression. We then use these estimates to estimate allocative inefficiency for households that only have agricultural labor. Using the estimated allocative inefficiency, we can estimate the shadow wage for households only working on their farm as

$$sw = e^{AI} * MRP_L \tag{3}$$

where AI is the estimated allocative inefficiency and MRP_L is the estimated marginal revenue product of labor. Summary statistics for shadow wage estimation for households that only engage in agricultural labor can be found in Table 7. The median estimated shadow

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[15] Allocative inefficiency should be positive; however, 14% of our estimates are negative and thus we use the inverse hyperbolic sine and not the natural logarithm transformation.

wage is below the daily wage for paid work outside of the home, consistent with Agness et al. (2025). There is a long right tail to the shadow wage distribution that pulls up the mean of the estimated shadow wage.

Table 7. Estimated Shadow Wages

	Count	Mean	St. Dev.	Min	Median	Max
Shadow Wage	1430	3161.543	4681.958	0	1896.881	55889.84
Daily Wage for Paid Work (FCFA)	1165	2725.448	1938.665	0	2500	6666.667

Notes. This table reports summary statistics of the estimated shadow wage for households who only cultivate crops and the daily wage for households who work outside the farm.

4.4 Estimated Supply Results

Now that we have estimated the value of slack labor for households in the region, we calculate the marginal cost of producing compost and animal feed to estimate the supply curve for both items. We use estimates of labor inputs to produce compost or animal feed from Rohr et al. (2023). One ton of compost requires 9.35 days of labor to produce. One kilogram of animal feed requires 357.8 grams of aquatic vegetation and 642.2 grams of peanut straw. 50 kg bags to hold compost or animal feed cost 200 FCFA/bag and peanut straw to supplement aquatic vegetation in animal feed costs 375 FCFA/kg. We then calculate the amount of slack labor hours each household has for household members above 15 years old. We then assume they devote all this slack labor to compost or animal feed production and determine how compost or animal feed households could produce using rates of compost removal in Rohr et al. (2023) to determine how much cerato the slack labor produces.[16] We value household labor as either the estimated shadow wage for households that only work on the farm or their outside wage if a household member works for a wage.

We use these estimates of household compost or animal feed production to trace out estimated region-scale market supply curves for compost or animal feed in Figure 3. Estimated supply is quite flat in the relevant areas, suggesting that there is sufficient slack labor to produce low cost compost in these areas and that most of the gains from trade would therefore accrue to consumers of compost or animal feed. Animal feed is more expensive to produce than compost given that it requires peanut straw to supplement aquatic vegetation.[17]

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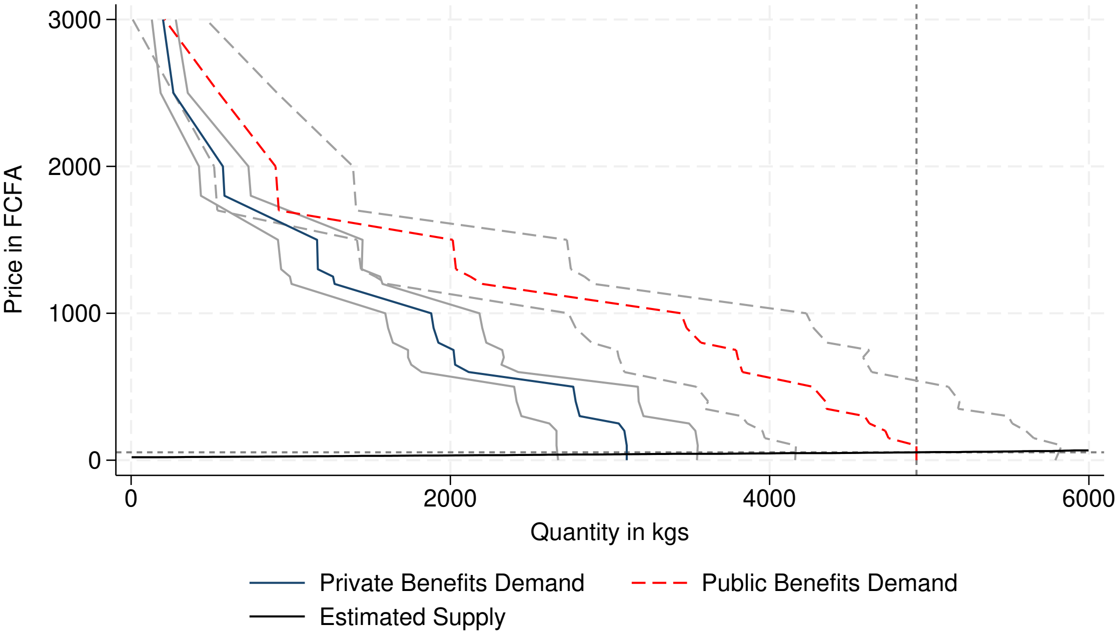
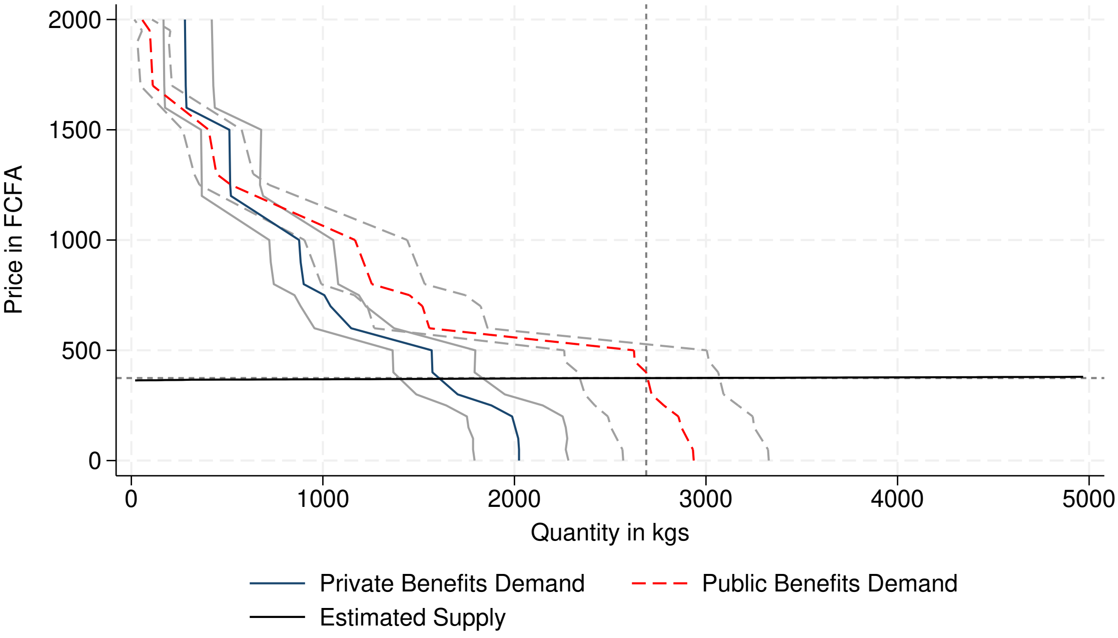
[16] We assume that labor, not cerato availability limits production. All the slack labor in the household would remove about 50% of the average village level removed in Rohr et al. (2023).

[17] Rohr et al. (2023) experimented with several different mixtures of purchased feedstock and dried cerato in producing livestock feed. One could in principle reduce the purchased content and increase the cerato share while holding energy content constant, which could reduce production costs. But since we only used the 70/30 formulation in the generalized second price auctions, we stick just to the cost of that formulation.

Figure 3. Potential Markets for Compost and Animal Feed



(a) Compost



(b) Animal Feed

Notes: Private benefits represents auctions in the private productivity gains treatment arm. Public benefits represents auctions in the public health benefits treatment arm. The gray lines represent the 5th and 95th percentiles from 1,000 bootstrap replications. The black line is the estimate of the supply curve from slack labor.

5 Welfare Gains

To calculate the welfare gains from trade in a potential market for compost or animal feed, we first need to estimate the average village-level market equilibrium price and transactions volume. With only private benefits information, we estimate that all consumers who have positive willingness to pay for compost will make trades as the equilibrium price of compost is quite low at about 40 FCFA per kg and 3,105 kgs of compost are traded. With the addition of public health information, the volume of transactions rises to 4,920 kgs and the price rises to 53 FCFA per kg. Relative to the prevailing price of urea in the region, 300 FCFA per kg, these equilibrium prices represent an 86% and 82% decrease in price. For animal feed, the equilibrium price with just private benefit information is 370 FCFA and 1,576 kgs of animal feed are traded. The public benefit information increases the volume traded to 2,688 kgs and the price to 373 FCFA. Peanut straw (a purchased animal feed) currently sells for 375 FCFA in the region and thus the price of cerato-based animal feed is similar to other substitute goods. Importantly, our supply estimates capture production costs but not the opportunity cost of delayed payment, inventory risk, or working-capital constraints, which are likely more important for compost than for animal feed.

With estimated market equilibrium prices and transactions volumes in hand, we can calculate the area between the estimated demand curve and the estimated supply curve, i.e., the sum of consumer and producer surplus, or total village welfare gains from creating a market in these novel products. We do these calculations for demand estimated from auctions with just the private benefits information and then again for demand estimated from auctions with both private benefits and public health information.

Information about the public health benefits of aquatic vegetation removal increase overall welfare. We estimate that welfare gains from trade in the compost market are $17.79 USD per person with just the private benefits information (Table F.1). These welfare gains grow to $29.38 USD per person when participants are also informed about the public health benefits of AVR. Thus, knowledge of both the private and public health benefits of AVR increases overall welfare by 65%. These gains from trade largely accrue to consumers, given the highly price elastic nature of supply. Buyers capture virtually all - a point estimate of 98% (99%) - of the gains from compost trade when consumers are (not) informed of the public health benefits of AVR. Consumers gain $17.63 USD per person in consumer surplus while producers only gain $0.16 USD per person when auction participants only had information about the private benefits of compost. When auction participants had information about both the private and public benefits, consumers gain $28.98 USD per person in consumer surplus while producers only gain $0.40 USD per person.

Similar patterns emerge in the animal feed market, although the overall gains from trade are smaller because animal feed is more expensive to produce. The welfare gains from trade are \$5.58 USD per person without public health benefits information and \$6.99 USD per person with the public health benefits information. This yields more modest welfare increases than in the prospective compost market, just 25%. Consumers again capture almost all (99%) of the gains from trade under both information environments. Consumers gain \$5.54 (\$6.92) per person in consumer surplus while producers only gain \$0.04 (\$0.07) per person when auction participants without (with) information on the public health benefits of cerato-based livestock feed. While the welfare estimates change slightly, the overall pattern of welfare gains from trade that increase with public health information and are almost all captured by consumers are robust to using different estimates of shadow wages to estimate supply (Table F.1).

One important difference between the two products is the timing of production and revenue. Dried livestock feed can be produced and sold within roughly two weeks, whereas compost may require six to nine months before it is usable. This delay may materially affect market emergence even if static production costs are low. Compost producers would need to incur labor and input costs months before receiving revenue, bear storage and quality risks, and have sufficient working capital to wait for returns. These dynamic constraints are likely more severe in low-income rural settings with incomplete credit markets. Thus, although the simulated welfare gains are larger for compost than for livestock feed, the feed market may be easier to initiate entrepreneurially because the production cycle is shorter and returns are realized more quickly.

Because these gains from trade benefit almost exclusively consumers, a natural hypothesis is that richer households - e.g., those with more livestock to feed or more crop land to incorporate compost – stand to gain the most. We construct an wealth index for households that participated in the auctions using their land holdings and whether or not they raise livestock. We then run a non-parametric regression of to understand how the estimated consumer surplus of these households in the market for compost vary with this wealth index. These non-parametric results (Appendix Figure F.1) suggest that richer households do have higher consumer surplus[18].

On the producer side, we similarly use a non-parametric regression to see how estimated producer surplus varies with household wealth. In this case, we have additional data and use a standardized asset index. We find that households with higher wealth also have higher producer surplus (Appendix Figure F.2). Given the limited producer surplus in the market

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[18] The estimated coefficient is positive but noisily estimated given that we have limited information to construct a wealth index.

for animal feed, we do not have sufficient variation to estimate similar non-parametric regressions. Thus, while AVR has the potential to make many households better off by reducing schistosomiasis infection risk, the gains from trade in a potential market for compost and animal feed may benefit better-off households most.

6 Discussion and Conclusion

Reducing schistosomiasis infections has large economic benefits (Miguel and Kremer, 2004; Baird et al., 2016; Ozier, 2018; Hamory et al., 2021); however, in the Senegal River Valley periodic mass deworming campaigns are insufficient to control infections (Diop et al., 2023). AVR is an additional infection control strategy that has the potential to also boost agricultural productivity because removed aquatic vegetation can be made into agricultural inputs (Doruska et al., 2024; Rohr et al., 2023). In this paper, we evaluate the potential for a local market for compost and animal feed made from AVR generated by harvesting the environmental reservoir of schistosomiasis, the invasive aquatic plant cerato.

First, we estimate latent demand for compost and animal feed using generalized second price auctions. We experimentally varied the information environment of these auctions to explore if information on the public benefits of AVR, that AVR reduces schistosomiasis infection risk, increases demand for products produced from AVR. We find that information on the public health benefits increases total individual demand for compost by over 1,800 FCFA ($3 USD) per household or about 89% relative to when there is only private information. Individual demand for animal feed also increases by about 600 FCFA ($1 USD, 45% relative to just private information) for households with public benefits information. Even without the public health information, households demand both compost and animal feed suggesting that there are potential consumers for these not-yet-marketed products.

Second, we estimate potential supply for compost and animal feed from slack labor of agricultural households within the region. We estimate that the median shadow wage is about 75% of the median market wage within the region. Then we use estimated labor requirements and the prices of other inputs to craft a supply curve for both products. This region has high levels of slack labor and thus both compost and animal feed are relatively cheap to produce and very flat supply curves.

Finally, we estimate the welfare gains from trade with the estimated demand and supply curves. For both goods, there is potential for a local market with significant gains in consumer surplus with just private productivity gains information alone. Overall welfare gains from trade are $17.79 per person in the market for compost and $5.58 per person in the market for animal feed with only private productivity information. Overall welfare per person increases by 65% in the market for compost and 21% in the market for animal feed when consumers are informed of both the private productivity gains and public health benefits of AVR. These benefits almost exclusively go to consumers as consumer surplus is 99% or 98% of the overall welfare gains in all evaluated markets and these benefits are likely going to accrue for better-off households. Thus, while is significant potential for AVR in this context, the benefits from compost and animal feed production may benefit the better-off households the most.

In the case of compost, the estimated equilibrium price is quite low when compared to the price of available substitutes. Local median (subsidized) fertilizer prices are 300 FCFA per kilogram which far greater than the estimated equilibrium price of compost and slightly above the 200 FCFA per kilogram mean willingness to pay for compost we found in our experimental auctions. Because the equilibrium compost price would be less than the fertilizer price, increased compost use would expanded soil nutrient amendment in a region with extremely sandy soils. Improving soil water retention could through compost could further boost crop productivity. Furthermore, because of the relatively high price of fertilizer, compost produces could use a pricing strategy that considers the price of close substitutes to capture more of the gains from trade while still inducing the additional added benefits of composting. The equilibrium price of animal feed in our analysis is similar to other available feeds on the market and thus animal feed producers may have fewer options to capture more of the gains from trade.

Overall, these results suggest there is the potential to create markets for compost and animal feed from removed aquatic vegetation. However, inducing the private provision of public goods or new technology adoption can be difficult (Kremer and Miguel, 2007; Hoffmann et al., 2009; Cohen and Dupas, 2010; Kremer et al., 2011; Cohen et al., 2015; Berry et al., 2020; Berkouwer and Dean, 2022; Aker and Jack, 2025). Further, the challenge in creating local markets for cerato-based agricultural inputs lies mainly in inducing suppliers who, as best as we can estimate, stand to enjoy only incremental gains. There may be a case for public provision of AVR services or public or philanthropic subsidization of private AVR to help crowd in private supply.

These auctions were held in a limited number of villages with a limited supply of compost and animal feed. Thus, future work should consider how local households could endogenously take up and sustain AVR to grow the overall production and market of these items so that individuals and communities can benefit from the potential welfare gains. And, given that we find that richer households may benefit the most, future work should consider how any potential AVR contributes to inequality within communities.

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A Instructions for the Generalized Second Price Auction

The generalized second price auction will be implemented using the following process:

1. At the agreed upon time, participants will be split into the assigned auction groups and taken into four areas in the village so that activities in the other auctions are not observable by other participants.
2. Once each group is off in their own area, the enumerator will explain the rules of the auction
   (a) The auction is won by the household who offers the highest price per unit. The winning household pays the second highest price per unit offer for the good and buys the quantity listed in their offer.
   (b) If the winning household cannot pay or their is additional product available after the first household buys all of the product they bid on, continue with the household who offered the second highest price per unit. This household pays the third highest price per unit for the good and purchases the quantity listed in their offer. If this household cannot pay or there is product remaining, continue down the list in this manner. This process continues until the supply is exhausted or demand is exhausted, whichever comes first. It is important to explain to households that their offers are important and if they win, you will visit to sell the product. We will develop procedure to minimize the instances of nonpayment by winning households.
3. The enumerator will explain the bid procedure (steps 6-8).
4. The enumerator will then complete the practice auction so participants can learn the auction procedure.
5. The enumerator will invite each household to write their "proposition" - the maximum price per unit at which you would buy the agricultural equipment (ex. sickle) and the number they want at that price - on the proposition paper that contains your name and your proposed price.
6. All households in the auction group will be invited to submit their proposals and put them in a jar.
7. Once all bids are submitted, the enumerator will open the jar and publicly read the propositions.

8. The household that wrote the highest proposition wins the auction and will buy the agricultural equipment at the second highest price per unit proposed in the jar. They will buy the quantity they put on their proposition. If there is remaining agricultural equipment, continue with the second highest price per unit bidder paying the third highest price per unit and follow this process until all fertilizer has been purchased.

9. Then, the enumerator will complete the auction using the following procedure.
    (a) First, the enumerator informs all participants of the benefits found in Rohr et al. (2023) relating to private productivity gains (benefits to pepper and onion production, cheaper than traditional forms of animal feed). If the participant has been assigned to the public health impacts treatment arm, we will also inform them of reduced schistosomiasis infection risk from AVR. Then, the enumerator will allow households to inspect the products carefully prior to making their bids.
    (b) The enumerator will then explain the bid procedure (steps 10c-10e).
    (c) The enumerator will ask each household to write their "proposition" - the maximum price per unit at which you will would buy to compost or animal feed and the amount you will buy at that price - on the proposition paper that contains your name and your proposed price.
    (d) All households in the auction group will be invited to submit their proposals and put them in a jar
    (e) Once all bids are submitted, the enumerator will open the jar and publicly read the propositions.
    (f) The household that wrote the highest proposition wins the auction and will buy the compost or animal feed at the second highest price per unit proposed in the jar. They will buy the quantity they put on their proposition. If there is remaining compost or animal, continue with the second highest price per unit bidder paying the third highest price per unit and follow this process until all compost or animal feed has been purchased or their are no bids remaining, whichever comes first.

B Theoretical Model

Building on Doruska et al. (2023) we develop a variant of the nonseparable agricultural household model to conceptualize household decision making and non-marketed valuation of the impure public good of aquatic vegetation removal within this context. In this nonseparable agricultural household model, consumption and production decisions become inextricably linked by multiple market failures (Singh et al. (1986)).

The economic model begins with the household, which maximizes utility, defined over consumption of food, consumption of an aggregate household good[19], leisure, and the health status of members of the household. We assume that utility is well-defined, increasing in all its arguments and concave. We model health status using a health production function that depends on the amount of vegetation in the water source - a proxy for schistosomiasis density - the household's nutrient intake via food consumption, the number of children in the household,[20] and the household's knowledge about schistosomiasis. In this context, knowledge about schistosomiasis includes information like a household's past experience with schistosomiasis, whether or not a household is informed about aquatic vegetation removal and its benefits, and any past experience with aquatic vegetation removal. We assume that health status increases with food consumption, representing the value of increased nutrient intake in a region with widespread food insecurity and low rates of obesity or overweight. Health status decreases as vegetation increases since more vegetation leads to a larger population of snails - the helminth's vector - and therefore to more infection Rohr et al. (2023). Consistent with Rohr et al. (2023), a household can clear the water source of aquatic vegetation with only small fraction of its overall labor availability. Households with more children have lower health status since children are more susceptible to schistosomiasis. Knowledge about the link between vegetation and health increases health status through avoidance behaviors. There is no market for health in the model.

The household engages in agricultural production of both crops and livestock. The main decisions facing the household are how to allocate time and money. They can choose to allocate time between agricultural activities (cultivation and livestock husbandry), harvesting aquatic vegetation, selling labor on the labor market or leisure. Households can also buy labor on the labor market to use in agriculture crop production or aquatic vegetation harvest. Because aquatic vegetation is a common pool resource, there is no market for aquatic vegetation, either in the water or as harvested vegetation. Thus, the multiple market failures in health status and aquatic vegetation create nonseparability between the household's

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[19] The aggregate household good represents all non-food goods and services a household can consume that are available on the market.

[20] Children are most adversely affected by schistosomiasis.

production and consumption decisions. We also assume that there is no land market because relatively few land rentals occur in this region. Harvested vegetation becomes compost or animal feed, which increases agricultural productivity Rohr et al. (2023). Households produce crops using land, labor, fertilizer, and compost from harvested aquatic vegetation. Producing harvested aquatic vegetation only requires labor.[21] Livestock production only depends on the amount of food provided to the animal, which can either be produced from harvested vegetation or bought in the market.

Let i denote the different goods a household consumes, produces, or uses as an input. Let q_i denote the quantity of goods produced or used as inputs in the production process by the household. The household produces $(q_i \geq 0)$ of crops $(i = f)$ using land $(i = d)$, labor $(i = lf)$, fertilizer $(i = u)$, and compost (δq_v). The household makes compost from harvested vegetation $(i = v)$, and harvesting vegetation requires labor $(i = lv)$. Households can also hire labor to produce food L_f^h or to harvest vegetation L_v^h. Let $L_f = q_{l,f} + L_f^h$ be the total amount of labor used in the production of food and $L_v = q_{l,v} + L_v^h$ be the total amount of labor used to harvest vegetation. The household's production technology for crops is then given by $F(L_f, q_d, q_u, q_v)$ and the production technology for vegetation is $G(L_v)$. The household produces $(q_i \geq 0)$ of livestock $i = a$ using feed q_{af} and endowment of livestock e_a with the production technology $J(q_{af}, e_a)$. Vegetation becomes livestock feed with technology $K(L_v)$.

Let $\boldsymbol{c}$ denote the vector of all goods consumption, comprised of food $(i = f)$, non-food household goods $(i = g)$, and leisure $(i = l)$. Let $H(V, c_f, n, I)$ denote the household's health status, where $V(L_v)$ is the amount of vegetation in the water source, n is the number of children in the household, I is the information set of the household, and c_f is food consumption. Household utility is denoted $U(\boldsymbol{c}, H)$.

Each household has endowments of labor e_l, land e_d, and livestock e_a. Each household member has one unit of labor; however, infection reduces the labor availability of an individual to τ where $0 \leq \tau \leq 1$. Infection reduces nutrient absorption from food and overall results in less labor productivity, effectively reducing the labor availability of infected individuals. The labor available to the household a_l is the sum of the labor availability of its individual members. A household generates income by growing crops and livestock and selling its labor in the local labor market, L^m. The household buys and sells labor at wage w. There are perfectly competitive markets for food, the aggregate household good, labor, fertilizer, livestock, and animal feed (the tradables set $T = \{f, h, l, u, a, af\}$), but there are not markets

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[21] While it requires a pit to convert vegetation into compost, consistent with conditions in our study region, we assume that there exists sufficient unused and free land within the village such that land is not a constraint to the production of compost and thus land does not enter into the production of vegetation or compost. Animal feed simply requires drying the vegetation, which can be done on available marginal land.

for vegetation, land, and health (the non-tradables set $NT = \{v, d, H\}$). Each household must fully self-provide non-tradable goods. Finally, let p_i denote the market price for good i.

Thus, in each period, the household solves the problem:

$$\max_{(\boldsymbol{c},\boldsymbol{q})} U(\boldsymbol{c}, H) \tag{4}$$

subject to the budget constraint for tradable goods,

$$p_f c_f + p_g c_g \leq p_f(F(L_f, q_d, q_u, q_v)) - w(L_f^h + L_v^h) - p_u q_u + p_a J(K(L_v), e_a)) - p_{af} q_{af,b} + wL^m \tag{5}$$

the constraint for vegetation use,

$$q_v - c_v \geq 0 \tag{6}$$

the constraint on the household's labor endowment,

$$e_a \tau \equiv a_l \geq q_{lf} + q_{lv} + L^m + c_l \tag{7}$$

and the health production function.

$$H = H(V, c_f, n, I) \tag{8}$$

The household will optimally use all its land in food production and all of its harvested aquatic vegetation turns into compost, an agricultural input, or animal feed according to

$$q_v = G(q_{lv}, L_v^h) \tag{9}$$

and

$$q_{af,v} = K(q_{lv}, L_v^h) \tag{10}$$

where the total animal feed is the sum of the amount produced from vegetation and the amount bought on the market, $q_{af} = q_{af,v} + q_{af,b}$,

The labor constraint can be substituted into the budget constraint to create a full income constraint:

$$p_f c_f + p_g c_g + w(c_l + q_{lf} + q_{lv}) \leq$$
$$p_f(F(q_{lf}, L_f^h, q_d, q_u, q_v(q_{lv}, L_v^h)) - w(L_f^h + L_v^h) + p_a J(q_{af,v}, q_{lv}, L_v^h, q_{af,b}, e_a) - p_{af} q_{af,b} - p_u q_u + wL^m \tag{11}$$

Assuming an interior solution, and a Lagrange multiplier λ on the household's full income constraint, the first order conditions for the maximization problem are

$$\frac{\partial U}{\partial c_f} + \frac{\partial U}{\partial H}\frac{\partial H}{\partial c_f} = \lambda p_f \tag{12}$$

$$\frac{\partial U}{\partial c_g} = \lambda p_g \tag{13}$$

$$\frac{\partial U}{\partial c_l} = \lambda w \tag{14}$$

$$\lambda p_f \frac{\partial F}{\partial q_{l,f}} = \lambda w \tag{15}$$

$$\frac{\partial U}{\partial H}\frac{\partial H}{\partial V}\frac{\partial V}{\partial q_{lv}} + \lambda(p_f \frac{\partial F}{\partial q_v}\frac{\partial q_v}{\partial q_{lv}} + p_a \frac{\partial J}{\partial q_{af,v}}\frac{\partial q_{af,v}}{\partial q_{lv}}) = \lambda w \tag{16}$$

$$p_f \frac{\partial F}{\partial L_f^h} = w \tag{17}$$

$$\frac{\partial U}{\partial H}\frac{\partial H}{\partial V}\frac{\partial V}{\partial L_v^h} + \lambda(p_f \frac{\partial F}{\partial q_v}\frac{\partial q_v}{\partial L_v^h} + p_a \frac{\partial J}{\partial q_{af,v}}\frac{\partial q_{af,v}}{\partial L_v^h}) = \lambda w \tag{18}$$

$$p_f \frac{\partial F}{\partial q_u} = p_u \tag{19}$$

$$p_a \frac{\partial J}{\partial q_{af,b}} = p_{af,b} \tag{20}$$

Equations (12), (13), and (14) can be rearranged to show that the ratio of the marginal benefit of consuming food (which includes direct increases in utility and indirect utility increases through improved in health) to the marginal benefit of consuming the aggregate household good or leisure equals the price ratio. Equation (15) demonstrates that labor is used in crop production until the value of the marginal product equals the shadow wage and equation (17) states the same condition for the use of hired labor in food production, so the marginal product of labor equals the wage.

Equations (16) and (18) indicate that the value of labor in vegetation removal has multiple benefits. First, there is the benefit that comes from more food and livestock production via the creation of compost and animal feed, which generally means that labor is used until the value of the marginal product of labor in aquatic vegetation removal equals the shadow wage for household labor or the market wage for hired labor. In this model, however, labor used in aquatic vegetation removal impacts utility indirectly via the health production function. Therefore, the optimal use of labor in aquatic vegetation removal depends on the household health status in addition to its shadow wage. Finally, equations (19) and (20) say fertilizer is used and animal feed is bought until the value of the marginal product equals the marginal cost.

The key first order conditions governing the amount of vegetation harvest and thus the amount of compost and animal feed from aquatic vegetation removal produced are equations (16) and (18). From these first order conditions we can define the reduced form relationship between household and community characteristics and their price of compost p_v and animal feed $p_{af,v}$:

$$\left.\begin{array}{r} p_v \\ p_{af,v} \end{array}\right\} = f(V, n, I, w, p_f, p_a, p_{af,b}, e_a, e_d, e_l, \lambda) \tag{21}$$

So, the households individual demand for compost or animal feed depends on their household-specific information I, the number of children they have n, and their land and livestock endowments e_d and e_q. Household individual demand also depends on community-level characteristics: vegetation in the water source V and market prices w, p_f, p_a, and $p_{af,b}$. With village fixed effects to control for these community-level characteristics, household individual demand for compost and animal feed depends on the household-specific information, number of children, and livestock and land endowments that can be estimated using the following equation:

$$\begin{aligned} TID_{iv} = \beta_0 + \beta_1 Public\ Benefits_{iv} + \beta_2 Land_{iv} + \\ \beta_3 Crops_{iv} + \beta_4 Livestock_{iv} + \beta_5 Past\ Schistosomiasis_{iv} + \beta_6 Children_{iv} + \delta_v + \varepsilon_{iv} \end{aligned} \tag{22}$$

The household-specific information set is determined by whether or not the household receives information on the public benefits of aquatic vegetation removal and the household's past experience with schistosomiasis. The number of children, household land holdings and livestock holdings follow directly from the model. We include whether or not the household cultivates crops to model since compost only applies to crop and thus total individual demand for compost should depend on the household's cultivation decisions.

C Information Treatment Posters

Figure C.1. Poster for the Private Productivity Information of Compost

Figure C.2. Poster for the Private Productivity Information of Animal Feed

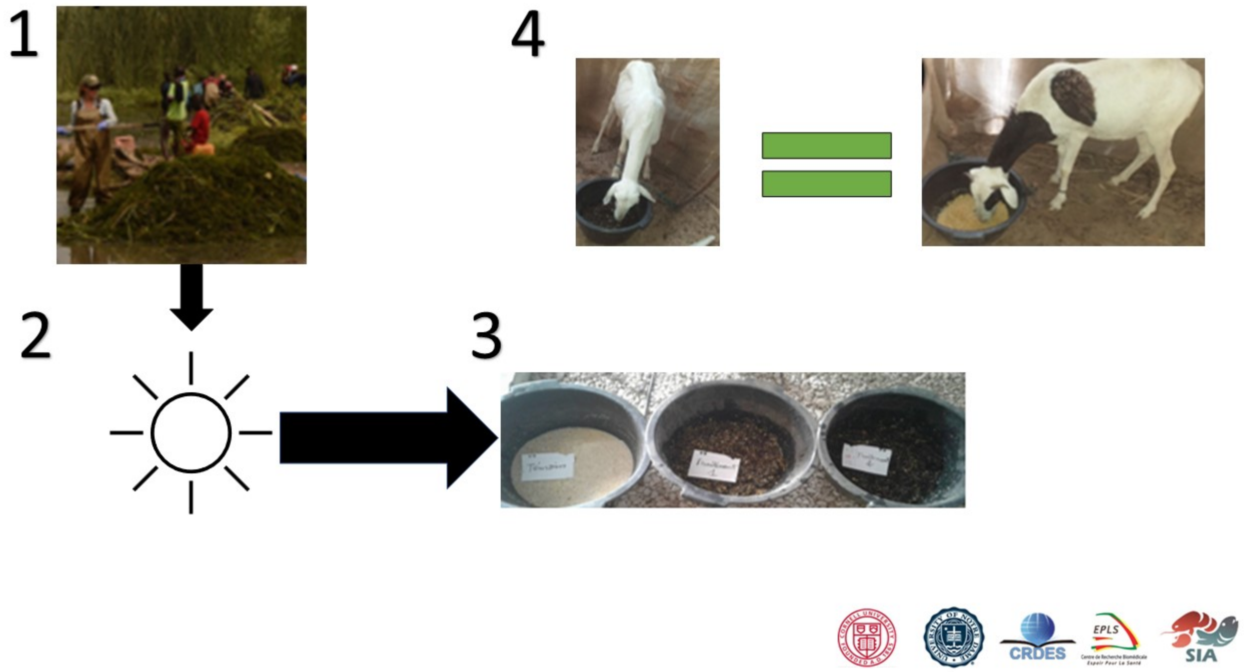
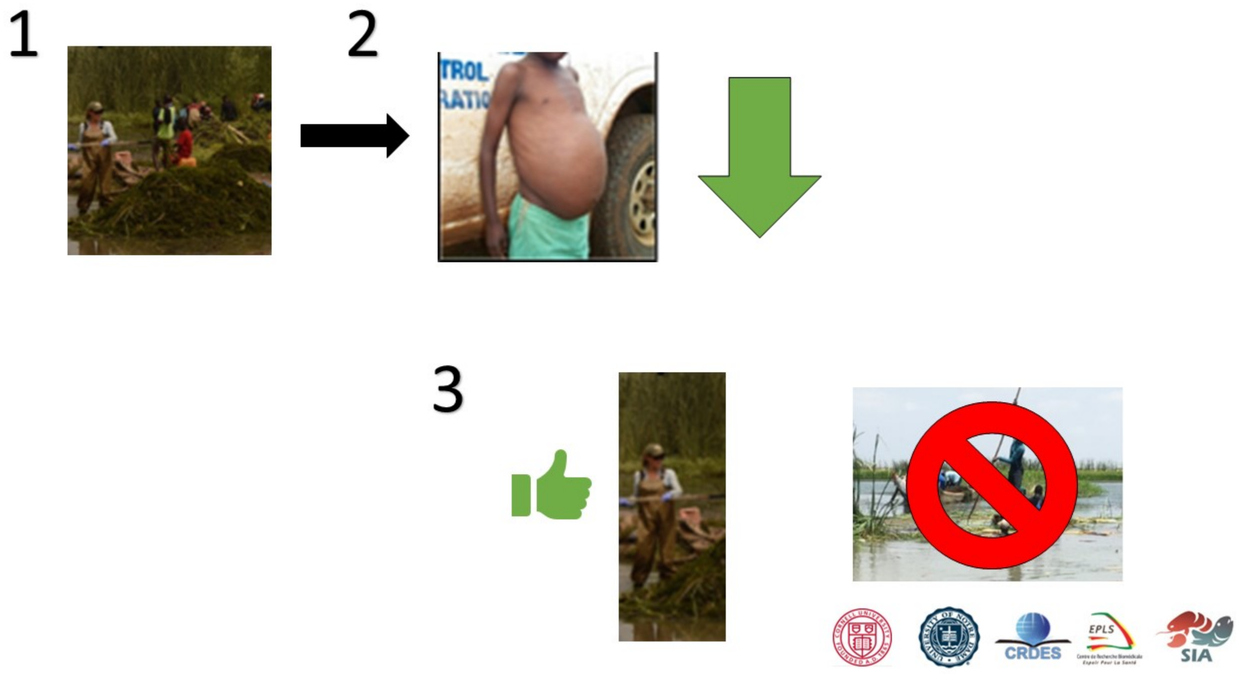


Figure C.3. Poster for the Public Health Benefits Information



D Additional Demand Estimation Tables

Table D.1. Differential Non-Attendance Across Treatment Arms

	(1) Did Not Attend Auction
Public Health Benefits	0.002
	(0.022)
Observations	801
Adjusted R^2	-0.00124

Notes. This table reports results of a regression that tests for differential non-attendance of auctions across treatment arms. Did Not Attend Auction is an indicator variable that takes the value of one if an individual did not attend the auction for any reason. Standard errors clustered at the village auction level are in parentheses.* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table D.2. Factors that Influence Non-Attendance

	(1) Did Not Attend Auction
Age	-0.001
	(0.001)
Female	0.019
	(0.023)
Read French	0.039
	(0.024)
Household Size	-0.001
	(0.003)
Children	0.003
	(0.006)
Raise Livestock	-0.064
	(0.052)
Grow Crops	-0.131**
	(0.055)
Land Owned (Hectares)	-0.003
	(0.003)
Fertilizer	0.053
	(0.033)
Compost	0.005
	(0.028)
Health Center	-0.001
	(0.023)
Past Schistosomiasis	-0.007
	(0.032)
Past Deworming	-0.018
	(0.031)
Current Schistosomiasis	0.004
	(0.041)
Red Urine	-0.030
	(0.041)
Observations	742
Adjusted R^2	0.0131

Notes. This table reports results of a regression that tests for characteristics of differential non-attendance of auctions. Did Not Attend Auction is an indicator variable that takes the value of one if an individual did not attend the auction for any reason. Standard errors clustered at the village auction level are in parentheses.* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table D.3. Balance Table

	(1)		(2)		(1)-(2)	
	Private Benefits		Public Benefits		Pairwise t-test	
Variable	N/Clusters	Mean/(SE)	N/Clusters	Mean/(SE)	Mean difference	
Age	355	48.394	357	48.207	712	0.187
	40	(0.947)	40	(1.041)	80	
Female	355	0.527	357	0.493	712	0.034
	40	(0.032)	40	(0.029)	80	
Read French	355	0.386	357	0.409	712	-0.023
	40	(0.037)	40	(0.036)	80	
Household Size	355	11.797	357	11.765	712	0.032
	40	(0.355)	40	(0.393)	80	
Children	355	5.042	357	5.020	712	0.023
	40	(0.195)	40	(0.208)	80	
Raise Livestock	355	0.890	357	0.922	712	-0.031
	40	(0.019)	40	(0.018)	80	
Grow Crops	355	0.885	357	0.868	712	0.016
	40	(0.026)	40	(0.028)	80	
Land Owned (Hectares)	349	2.847	352	3.065	701	-0.218
	40	(0.253)	40	(0.309)	80	
Fertilizer	354	0.780	355	0.780	709	-0.001
	40	(0.038)	40	(0.040)	80	
Compost	353	0.300	354	0.305	707	-0.005
	40	(0.027)	40	(0.023)	80	
Health Center	354	0.653	355	0.606	709	0.047
	40	(0.027)	40	(0.030)	80	
Past Schistosomiasis	355	0.820	356	0.806	711	0.014
	40	(0.030)	40	(0.026)	80	
Past Deworming	353	0.887	356	0.874	709	0.013
	40	(0.019)	40	(0.018)	80	
Current Schistosomiasis	343	0.274	346	0.257	689	0.017
	40	(0.035)	40	(0.033)	80	
Red Urine	345	0.249	350	0.249	695	0.001
	40	(0.034)	40	(0.026)	80	
F-test of joint significance (F-stat)						0.696

Notes: The value displayed for the F-test is the F-statistic. Standard errors are clustered at village auction level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table D.4. Determinants of Total Individual Demand: Livestock Types

	(1) Compost	(2) Animal Feed
Public Health Benefits	2036.192***	622.823**
	(726.342)	(257.216)
Cattle	556.384	175.316
	(856.588)	(291.791)
Sheep	752.248	264.865
	(647.125)	(291.658)
Goat	458.405	295.867
	(642.982)	(276.866)
Poultry	502.366	383.363*
	(483.221)	(206.777)
Other Livestock	3.271	-64.364
	(650.875)	(219.217)
Private Mean	2022.5	1256.5
Village FE	X	X
Stratification FE	X	X
Enumerator FE	X	X
Observations	634	634
Adjusted R^2	0.0233	0.0470

Notes: Total individual demand is measured in FCFA. Public Health Benefits is an indicator variable that takes the value of one if the participant received the public health benefits information prior to the auctions. Cattle, Sheep, Goat, Poultry and Other Livestock are indicator variables that takes the value of one if the participant's household raises cattle, sheep, goats, poultry or other types of livestock, respectively. The regressions also include controls for the amount of land a household owns, whether the household grows crops, the number of children in the household, and their experience with past schistosomiasis infections in the household. Private Mean reports the mean total individual demand for private benefits auction participants in FCFA. Standard errors are clustered at village auction level. ***, **, and * indicate significance at the 1, 5, and 10 percent level.

Table D.5. Determinants of Total Individual Demand: Crop Types

	(1) Compost	(2) Compost	(3) Animal Feed	(4) Animal Feed
Public Health Benefits	2008.711^{***}	2009.719^{***}	676.592^{**}	680.200^{**}
	(717.347)	(712.971)	(290.011)	(290.035)
Rice	119.675	131.482	-171.362	-211.892
	(1153.764)	(1160.062)	(371.098)	(360.071)
Onion	-566.475		-329.494	
	(621.658)		(268.606)	
Pepper	-551.101		-30.038	
	(583.298)		(355.143)	
Cassava	2397.473^{*}	2405.469^{*}	288.779	273.861
	(1244.097)	(1260.241)	(310.237)	(311.774)
Pepper or Onion		-696.117		-315.144
		(582.948)		(273.493)
Private Mean	2022.5	2022.5	1256.5	1256.5
Village FE	X	X	X	X
Stratification FE	X	X	X	X
Enumerator FE	X	X	X	X
Observations	616	616	616	616
Adjusted R^2	0.0401	0.0418	0.0458	0.0474

Notes: Total individual demand is measured in FCFA. Public Health Benefits is an indicator variable that takes the value of one if the participant received the public health benefits information prior to the auctions. Rice, Onion, Pepper and Cassava are indicator variables that takes the value of one if the participant's household grows rice, onion, peppers or cassava, respectively. Pepper or Onion is an indicator variable that takes the value of one if the household grows peppers or onions. The regressions also include controls for the amount of land a household owns, whether the household raises livestock, the number of children in the household, and their experience with past schistosomiasis infections in the household. Private Mean reports the mean total individual demand for private benefits auction participants in FCFA. Standard errors are clustered at village auction level. ***, **, and * indicate significance at the 1, 5, and 10 percent level.

Table D.6. Determinants of Total Compost Individual Demand: Other Interactions

	(1)	(2)	(3)
Public Health Benefits	2521.290***	1185.524	1200.007
	(819.767)	(1011.671)	(1143.747)
Land Owned (Hectares)	55.542	-62.598	-62.976
	(60.105)	(54.008)	(53.995)
Public Health × Land Owned (Hectares)	-202.286**		
	(88.765)		
Grow Crops	704.513	239.295	692.954
	(683.187)	(519.513)	(682.655)
Raise Livestock	64.745	108.122	-264.440
	(615.523)	(617.110)	(654.838)
Public Health × Grow Crops		862.350	
		(976.823)	
Public Health × Raise Livestock			840.206
			(1032.221)
Private Mean	2022.5	2022.5	2022.5
Village FE	X	X	X
Stratification FE	X	X	X
Enumerator FE	X	X	X
Observations	700	700	700
Adjusted R^2	0.0310	0.0277	0.0275

Notes: Total individual demand is measured in FCFA. Public Health Benefits is an indicator variable that takes the value of one if the participant received the public health benefits information prior to the auctions. Raise Livestock and Grow Crops are indicator variables that takes the value of one if the participant's household raises livestock or grows crops, respectively. All regressions also include controls for the number of children in the household and their experience with past schistosomiasis infections in the household. Private Mean reports the mean total individual demand for private benefits auction participants in FCFA. Standard errors are clustered at village auction level. ***, **, and * indicate significance at the 1, 5, and 10 percent level.

Table D.7. Determinants of Total Animal Feed Individual Demand: Other Interactions

	(1)	(2)	(3)
Public Health Benefits	534.353	319.101	461.704
	(324.086)	(282.662)	(429.471)
Land Owned (Hectares)	-17.341	-6.713	-6.789
	(26.436)	(21.964)	(22.017)
Public Health × Land Owned (Hectares)	18.144		
	(39.246)		
Grow Crops	285.174	126.275	286.064
	(243.310)	(291.866)	(243.523)
Raise Livestock	474.306**	477.468**	412.225*
	(215.908)	(217.706)	(224.804)
Public Health × Grow Crops		303.538	
		(278.821)	
Public Health × Raise Livestock			140.482
			(393.420)
Private Mean	1256.5	1256.5	1256.5
Village FE	X	X	X
Stratification FE	X	X	X
Enumerator FE	X	X	X
Observations	700	700	700
Adjusted R^2	0.0507	0.0508	0.0506

Notes: Total individual demand is measured in FCFA. Public Health Benefits is an indicator variable that takes the value of one if the participant received the public health benefits information prior to the auctions. Raise Livestock and Grow Crops are indicator variables that takes the value of one if the participant's household raises livestock or grows crops, respectively. All regressions also include controls for the number of children in the household and their experience with past schistosomiasis infections in the household. Private Mean reports the mean total individual demand for private benefits auction participants in FCFA. Standard errors are clustered at village auction level. ***, **, and * indicate significance at the 1, 5, and 10 percent level.

Table D.8. Determinants of Total Compost Individual Demand: Other Schistosomiasis Measures

	(1)	(2)	(3)	(4)
Public Health Benefits	1944.123***	1850.182**	1843.048**	1929.880***
	(719.782)	(709.382)	(718.739)	(702.408)
Past Schistosomiasis	1391.925***			
	(513.905)			
	[0.035]			
Past Deworming		511.277		
		(572.169)		
		[0.599]		
Current Schistosomiasis			295.101	
			(484.198)	
			[0.690]	
Red Urine				-485.085
				(464.553)
				[0.599]
Private Mean	2022.5	2022.5	2022.5	2022.5
Village FE	X	X	X	X
Stratification FE	X	X	X	X
Enumerator FE	X	X	X	X
Observations	700	698	680	685
Adjusted R^2	0.0286	0.0231	0.0226	0.0256

Notes: Total individual demand is measured in FCFA. Public Health Benefits is an indicator variable that takes the value of one if the participant received the public health benefits information prior to the auctions. Past Schistosomiasis is an indicator variable that takes the value of one if at least on member of the participant's household was diagnosed with schistosomiasis. Past Deworming is an indicator variable that takes the value of one if at least one member of the participant's household has ever received deworming medication. Current Schistosomiasis is an indicator variable that takes the value of one if at least one member of the participant's household currently has schistosomiasis while Red Urine is an indicator variable that takes the value of one if at least one member of the participant's household currently has red urine. The regressions also include controls for the amount of land a household owns, whether the household raises livestock or grows crops, and the number of children in the household. Private Mean reports the mean total individual demand for private benefits auction participants in FCFA. Standard errors are clustered at village auction level. Sharpened q values following Anderson (2008) are reported in brackets. ***, **, and * indicate significance at the 1, 5, and 10 percent level of the clustered standard errors.

Table D.9. Determinants of Total Animal Feed Individual Demand: Other Schistosomiasis Measures

	(1)	(2)	(3)	(4)
Public Health Benefits	586.120**	584.448**	539.624**	575.087**
	(271.817)	(263.773)	(270.558)	(267.082)
Past Schistosomiasis	119.389			
	(400.726)			
	[1.000]			
Past Deworming		-348.931		
		(526.116)		
		[1.000]		
Current Schistosomiasis			793.641***	
			(284.871)	
			[0.028]	
Red Urine				67.059
				(198.334)
				[1.000]
Private Mean	1256.5	1256.5	1256.5	1256.5
Village FE	X	X	X	X
Stratification FE	X	X	X	X
Enumerator FE	X	X	X	X
Observations	700	698	680	685
Adjusted R^2	0.0519	0.0537	0.0651	0.0527

Notes: Total individual demand is measured in FCFA. Public Health Benefits is an indicator variable that takes the value of one if the participant received the public health benefits information prior to the auctions. Past Schistosomiasis is an indicator variable that takes the value of one if at least on member of the participant's household was diagnosed with schistosomiasis. Past Deworming is an indicator variable that takes the value of one if at least one member of the participant's household has ever received deworming medication. Current Schistosomiasis is an indicator variable that takes the value of one if at least one member of the participant's household currently has schistosomiasis while Red Urine is an indicator variable that takes the value of one if at least one member of the participant's household currently has red urine. The regressions also include controls for the amount of land a household owns, whether the household raises livestock or grows crops, and the number of children in the household. Private Mean reports the mean total individual demand for private benefits auction participants in FCFA. Standard errors are clustered at village auction level. Sharpened q values following Anderson (2008) are reported in brackets. ***, **, and * indicate significance at the 1, 5, and 10 percent level of the clustered standard errors.

Table D.10. Determinants of Total Compost Individual Demand: Other Schistosomiasis Measures with Interactions

	(1)	(2)	(3)	(4)
Public Health Benefits	1162.883	1157.041	1972.046**	2381.031***
	(777.048)	(1016.497)	(830.678)	(793.097)
Public Health × Past Schistosomiasis	942.993			
	(772.445)			
	[0.408]			
Past Schistosomiasis	906.571**			
	(418.904)			
	[0.155]			
Public Health × Past Deworming		781.108		
		(1020.879)		
		[0.629]		
Past Deworming		103.105		
		(724.766)		
		[0.629]		
Public Health × Current Schistosomiasis			-505.262	
			(976.767)	
			[0.629]	
Current Schistosomiasis			543.220	
			(402.049)	
			[0.408]	
Public Health × Red Urine				-1815.670**
				(780.650)
				[0.408]
Red Urine				446.100
				(377.855)
				[0.155]
Private Mean	2022.5	2022.5	2022.5	2022.5
Village FE	X	X	X	X
Stratification FE	X	X	X	X
Enumerator FE	X	X	X	X
Observations	700	698	680	685
Adjusted R^2	0.0280	0.0220	0.0213	0.0280

Notes: Total individual demand is measured in FCFA. Public Health Benefits is an indicator variable that takes the value of one if the participant received the public health benefits information prior to the auctions. Past Schistosomiasis is an indicator variable that takes the value of one if at least on member of the participant's household was diagnosed with schistosomiasis. Past Deworming is an indicator variable that takes the value of one if at least one member of the participant's household has ever received deworming medication. Current Schistosomiasis is an indicator variable that takes the value of one if at least one member of the participant's household currently has schistosomiasis while Red Urine is an indicator variable that takes the value of one if at least one member of the participant's household currently has red urine. The regressions also include controls for the amount of land a household owns, whether the household raises livestock or grows crops, and the number of children in the household. Private Mean reports the mean total individual demand for private benefits auction participants in FCFA. Standard errors are clustered at village auction level. Sharpened q values following Anderson (2008) are reported in brackets. ***, **, and * indicate significance at the 1, 5, and 10 percent level of the clustered standard errors.

Table D.11. Determinants of Total Animal Feed Individual Demand: Other Schistosomiasis Measures with Interactions

	(1)	(2)	(3)	(4)
Public Health Benefits	-275.567	-760.128	522.150*	595.853**
	(612.070)	(896.752)	(304.646)	(283.794)
Public Health × Past Schistosomiasis	1040.096			
	(660.069)			
	[0.466]			
Past Schistosomiasis	-415.945			
	(673.564)			
	[0.902]			
Public Health × Past Deworming		1515.216		
		(951.805)		
		[0.466]		
Past Deworming		-1140.715		
		(957.507)		
		[0.466]		
Public Health × Current Schistosomiasis			68.441	
			(516.663)	
			[0.902]	
Current Schistosomiasis			760.032*	
			(423.083)	
			[0.466]	
Public Health × Red Urine				-83.577
				(373.002)
				[0.902]
Red Urine				109.922
				(225.644)
				[0.902]
Private Mean	1256.5	1256.5	1256.5	1256.5
Village FE	X	X	X	X
Stratification FE	X	X	X	X
Enumerator FE	X	X	X	X
Observations	700	698	680	685
Adjusted R^2	0.0565	0.0612	0.0637	0.0513

Notes: Total individual demand is measured in FCFA. Public Health Benefits is an indicator variable that takes the value of one if the participant received the public health benefits information prior to the auctions. Past Schistosomiasis is an indicator variable that takes the value of one if at least on member of the participant's household was diagnosed with schistosomiasis. Past Deworming is an indicator variable that takes the value of one if at least one member of the participant's household has ever received deworming medication. Current Schistosomiasis is an indicator variable that takes the value of one if at least one member of the participant's household currently has schistosomiasis while Red Urine is an indicator variable that takes the value of one if at least one member of the participant's household currently has red urine. The regressions also include controls for the amount of land a household owns, whether the household raises livestock or grows crops, and the number of children in the household. Private Mean reports the mean total individual demand for private benefits auction participants in FCFA. Standard errors are clustered at village auction level. Sharpened q values following Anderson (2008) are reported in brackets. ***, **, and * indicate significance at the 1, 5, and 10 percent level of the clustered standard errors.

Table D.12. Determinants of Total Individual Demand: Past Vegetation Removal Interaction

	(1) Compost	(2) Animal Feed
Public Health Benefits	1192.015	415.677
	(1093.758)	(390.521)
Past Removal	-726.597	39.140
	(460.792)	(405.482)
Public Health × Past Removal	1810.002*	396.985
	(1066.463)	(535.244)
Private Mean	2022.5	1256.5
Village FE		
Stratification FE	X	X
Enumerator FE	X	X
Observations	700	700
Adjusted R^2	0.014	0.007

Notes: Total individual demand is measured in FCFA. Public Health Benefits is an indicator variable that takes the value of one if the participant received the public health benefits information prior to the auctions. Past Removal is an indicator variable that takes the value of one the village had past aquatic vegetation removal. The regressions also include controls for the amount of land a household owns, whether the household raises livestock or grows crops, the number of children in the household, and the household's past experience with schistosomiasis infection. Private Mean reports the mean total individual demand for private benefits auction participants in FCFA. Standard errors are clustered at village auction level. ***, **, and * indicate significance at the 1, 5, and 10 percent level.

E Estimating Shadow Wages

We estimate a household production function using a generalized Leontief production function where the outcome of interest is the total value of production. We use village level price data to value production of rice, maize, millet, sorghum, cowpea, tomatoes, onions, and peanuts. For cassava, sweet potatoes, yams, carrots, cucumbers, peppers, beans, peas, and lentils, we use the median price per kg reported by households. Inputs into production are the land, measured as the total hectares in production for crops reported in the total value of production, household labor, measured as the total household hours spent on agriculture aggregating individual hours spent on agriculture over the last 7-days for each household member, the planting season, the peak growing season, and the harvest season, the number of hired laborers, fertilizer use including urea, NPK, phosphates, and other chemical fertilizer, the number of pieces of mechanical equipment the household has, livestock ownership measured in tropical livestock units (TLU) to proxy for the amount of manure used on the farm, and indicator variables of if the household uses manure, household waste, or compost on any of their plots. Summary statistics can be found in Table E.1.

We estimated two different functional forms of the production function for households that cultivate crops. Prior to estimation, we demean the data. We first estimate a generalized Leontief production function:

$$y_{ivt} = \sum_i \sum_j \beta_{ij} X_i^{0.5} X_j^{0.5} + \alpha_1 Manure + \alpha_2 Compost + \alpha_3 HHWaste + \gamma_v + \delta_t + \varepsilon_{ivt} \tag{23}$$

where y_{ivt} is the total value of agricultural production for household i in village v at time t, X_i and X_j are vectors of inputs to production that include the hectares in production, household labor hours spent on agriculture, fertilizer use, the number of hired laborers, the livestock holdings of the household, and the number of mechanical agricultural equipment the household owns, Manure, Compost, and HHWaste are indicator variables if the household uses manure, compost, or household waste on one of its plots, γ_v are village fixed effects, and δ_t are survey wave fixed effects. We use a household random effects or household fixed effects estimator. We impose that when $i = j$, $\beta_{ij} = \beta_{ji}$. We cluster the standard errors at the village level. Given that livestock holdings are not very well correlated with manure use (correlation 0.03), we estimate these production functions with and without including livestock holdings as a separate factor of production.

Table E.1. Summary Statistics for Supply Curve Estimation

	Count	Mean	St. Dev.	Min	Max
Cultivate Land (1 = Yes)	4144	0.585	0.493	0	1
Number of Plots	4144	0.801	0.913	0	11
Total Value of Crop Production (FCFA)	4157	1.01e+06	1.79e+06	0	1.04e+07
Hectares in Production	4157	1.893	6.235	0	50
Total Household Hours Spent on Agriculture	4157	145.006	182.335	0	892
Total Fertilizer Used (kgs)	4157	285.320	588.967	0	4000
Number of Plots Collectively Managed (1 = Yes)	2413	0.363	0.744	0	7
Number of Plots that Used Manure	2413	0.361	0.664	0	6
Number of Plots that Used Compost	2413	0.066	0.277	0	3
Number of Plots that Used Household Waste	2413	0.068	0.286	0	3
Has Hired Ag Labor (1 = Yes)	4157	0.124	0.336	0	2
Number of Hired Laborers	4147	0.494	1.956	0	25
Total Number of Pieces of Mechanical Ag Equipment	4157	0.555	1.213	0	25
Livestock Owned (TLU)	4157	2.200	4.739	0	32.3
Household Member Paid Work (1 = Yes)	4151	0.295	0.456	0	1
Daily Wage for Paid Work (FCFA)	1165	2725.448	1938.665	0	6666.667
Household Does Agriculture and Paid Work (1 = Yes)	4157	0.178	0.383	0	1
Household Head Age	4157	54.684	13.056	14	99
Household Head Female (1 = Yes)	4157	0.210	0.408	0	1
Household Head No Education (1 = Yes)	4157	0.782	0.413	0	1
Household Size	4157	8.118	3.682	1	55
Number of Children	4157	3.579	2.362	0	28
Household Grows Rice	2413	0.739	0.813	0	10
Number of Crops Grown	2413	1.379	0.800	1	11
Standardized Asset Index	4157	-0.000	1.000	-2.153203	4.882803

Notes. This table reports summary statistics for household level data used to estimate a potential supply curves for compost and animal feed.

We then also estimate a generalized quadratic production function:

$$y_{ivt} = \sum_i \beta_i X_i + \sum_i \sum_j \beta_{ij} X_i X_j + \alpha_1 Manure + \alpha_2 Compost + \alpha_3 HHWaste + \gamma_v + \delta_t + \varepsilon_{ivt} \tag{24}$$

where the variables are defined as before. We then calculate factor elasticities for continuous inputs (Table E.2). We selected the generalized Leontief production function without TLU and random effects as it produced the most sensible substitution patterns.

Table E.2. Estimated Elasticities

	Land	HH Labor	Fertilizer	TLU	Hired Labor	Equipment	RMSE
Quadratic, RE	-3.282	-3.906	-1.905	-0.705	-0.022	-2.282	1675328.3
Leontief, RE	-0.889	-0.122	-0.494	-0.767	0.091	0.181	1678127.7
Quadratic, FE	-1.489	-13.077	-1.699	-3.326	-0.166	0.207	1026956.7
Leontief, FE	0.602	0.364	-0.126	-0.114	2.125	-0.921	1049801.5
Quadratic, RE, No TLU	-3.499	0.708	0.228		-0.034	0.050	1682702.3
Leontief, RE, No TLU	0.390	0.152	0.273		0.212	0.163	1694186.9
Quadratic, FE, No TLU	0.135	0.490	0.504		0.008	-0.242	1034633.0
Leontief, FE, No TLU	0.476	-0.259	-0.026		0.120	0.103	1065260.5

Notes. This table reports estimated factor elasticities for estimated production functions using the estimator and functional form noted, showing the mean of household-specific estimated elasticities. Each column represents a different continuous input in the production functions. The final column RMSE reports the root mean squared error for the specification.

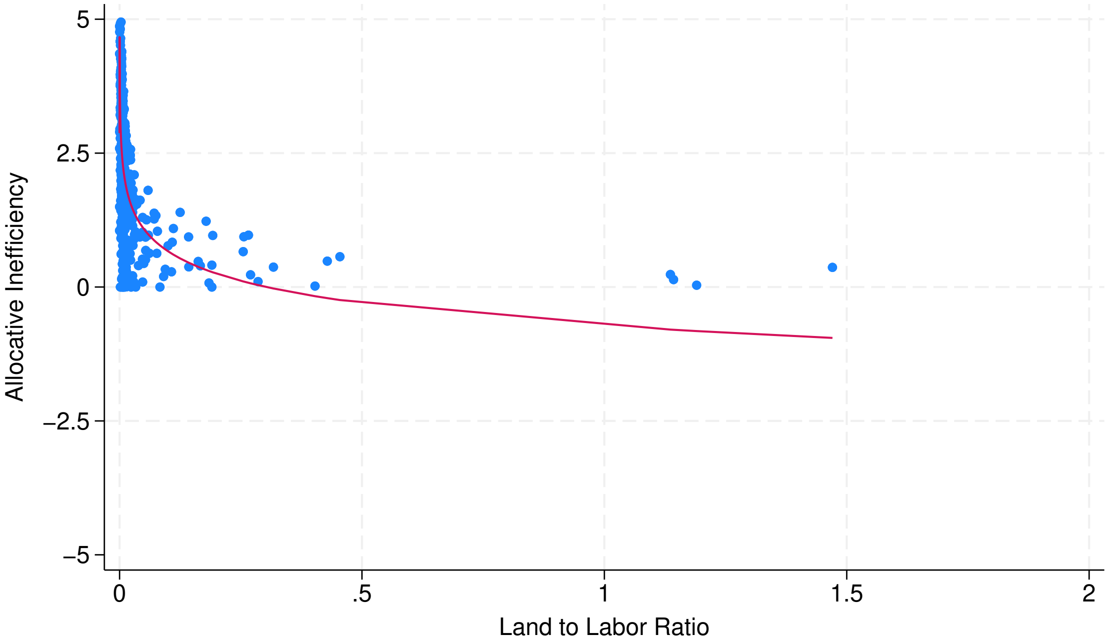


Figure E.1. Plot of the allocative inefficiency changes with the land to labor ratio using the generalized Leontief random effects model production function estimates.

Table E.3. Factors that Influence Allocative Inefficiency

	(1)
Household Head No Education	-0.155
	(0.148)
Household Head Female	0.255
	(0.205)
Household Head Age	0.010
	(0.030)
Household Head Age^2	-0.000
	(0.000)
Household Size	0.031
	(0.048)
Household Size^2	-0.001
	(0.002)
Number of Children	-0.078
	(0.076)
Number of Children^2	0.008
	(0.007)
Household Grows Rice	0.053
	(0.110)
Number of Crops Grown	0.025
	(0.144)
Number of Crops Grown^2	-0.016
	(0.019)
Hectares in Production	-0.190***
	(0.024)
Hectares in Production^2	0.003***
	(0.000)
Livestock Owned (TLU)	-0.050*
	(0.029)
Livestock Owned (TLU)^2	0.001
	(0.001)
Observations	472
R^2	0.147

Notes. This table presents the results of a regression to understand which factors influence allocative inefficiency. Standard errors clustered at the village level in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

F Producer and Consumer Surplus Figures and Tables

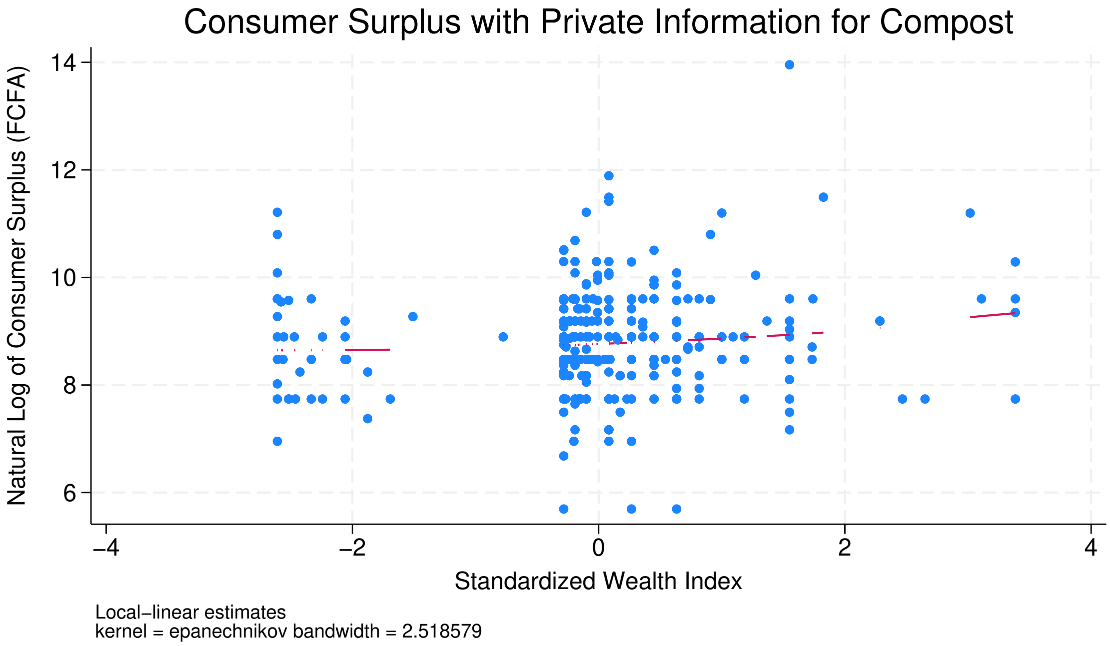


Figure F.1. Plot of the results of a non-parametric regression of estimated household consumer surplus in the market for compost on a household wealth index. This analysis considers households who participated in the auctions experiment.

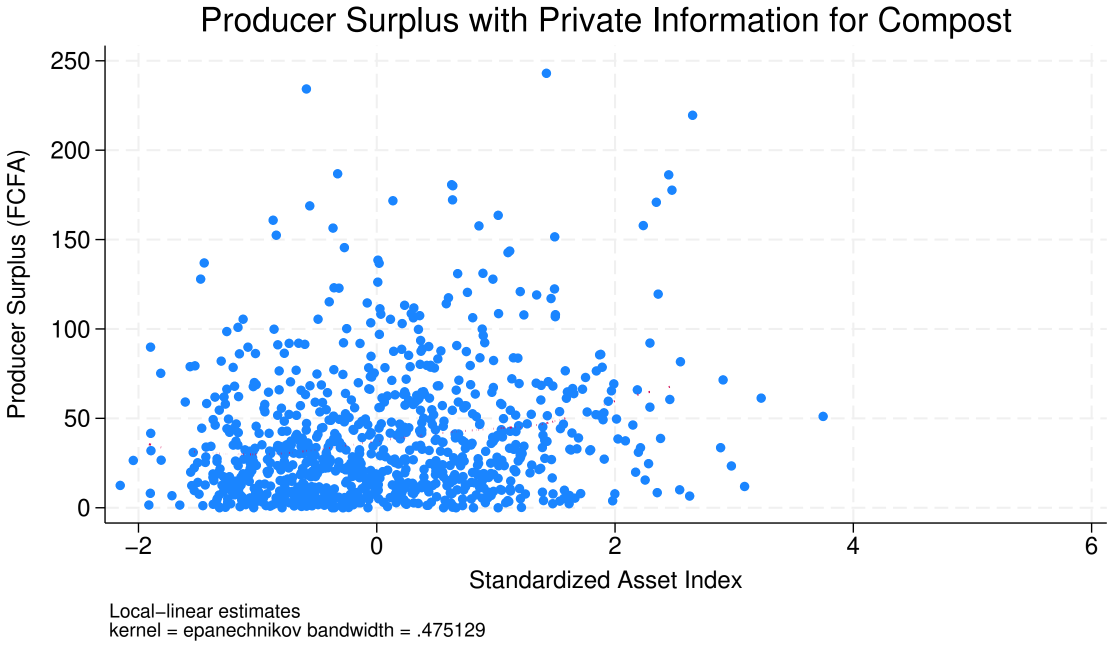


Figure F.2. Plot of the results of a non-parametric regression of estimated household producer surplus in the market for compost on a household asset index. This analysis considers households in Barrett et al. (2024).

Table F.1. Estimated Welfare Gains From Trade

	Without Public Benefits			With Public Benefits			
Shadow Wage	Consumer Surplus	Producer Surplus	Total Welfare	Consumer Surplus	Producer Surplus	Total Welfare	% Increase
Panel A. Compost							
Leontief Production Function	17.63	0.16	17.79	28.98	0.40	29.38	65
Quadratic Production Function	17.70	0.16	17.86	29.08	0.38	29.46	65
80% of Predicted Market Wage	17.65	0.09	17.74	29.26	0.12	29.38	66
80% of Median Market Wage	17.66	0.07	17.73	29.24	0.07	29.31	65
80% of Mean Market Wage	13.69	0.09	13.78	29.28	0.09	29.37	113
Panel B. Animal Feed							
Leontief Production Function	5.54	0.04	5.58	6.92	0.07	6.99	25
Quadratic Production Function	5.45	0.07	5.52	8.06	0.07	8.13	47
80% of Predicted Market Wage	5.68		5.68	6.82		6.82	20
80% of Median Market Wage	5.68		5.68	6.82		6.82	20
80% of Mean Market Wage	5.68		5.68	6.82		6.82	20

Notes. This table reports estimated welfare gains from trade from different shadow wage estimation scenarios to estimate supply of compost and animal feed. Each row represents a different estimated shadow wage procedure. Leontief production function and Quadratic production function use a Leontief or Quadratic production function to estimate household agricultural productivity and then household-specific shadow wages. The predicted market wage is a household-specific prediction of the market wage based on household education, numeracy, and literacy levels, number of members, and the gender of household members. The producer surplus is blank when the supply curve is flat for the entire area at or below the demand curve and thus there is no producer surplus. All welfare measures are in USD rounded to the nearest 0.01.