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Impact Assessment of Aquaculture in Small Reservoirs Pilots in Northern Ghana

A Baseline Technical Report

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EXECUTIVE SUMMARY

The CGIAR Resilient Aquatic Foods Systems Initiative (RAqFS) aims to enhance the resilience of aquatic food systems by addressing systemic challenges. As part of this initiative, the International Water Management Institute (IWMI) partnered with the CSIR Water Research Institute and the Fisheries Commission of Ghana in 2023 to co-design and implement an aquaculture pilot in four small reservoirs across four communities in the North-East Region of Ghana. The pilot project engaged groups of 10-15 individuals in each community, ensuring the inclusion of youth and women, and provided them with technical training and essential inputs to undertake tilapia cage culture. The groups cultivated fish in August-September 2023 and completed the first cycle in September-October 2024.

A rigorous Impact Assessment is being conducted to evaluate the pilot's impact on the livelihoods of direct beneficiaries and their communities. Baseline data were collected at the start of the pilot, between September and October 2023, from both beneficiary communities (treatment group) and communities near small reservoirs not participating in the project (control group). Follow-up data collection took place in 2024, at the end of the implementation phase. While these data allow estimates of some of the short-term impacts of the project (Zane et al., 2024), an additional round of data collection should take place once after a sufficiently long period to capture the project's medium- to long-term impacts. The evaluation team plans to use these data to implement a difference-in-difference identification strategy, which involves comparing the difference in outcomes between the treatment and control groups before and after the project.

This report details the sampling and data collection strategies and outlines the methodology for the planned impact assessment. The survey data used as a baseline for the impact assessment was collected with the additional purpose of characterizing the multiple uses of water in the small reservoirs in northern Ghana. To achieve this, the survey extended beyond the treatment and control groups to include a broader range of reservoirs. In total, approximately 1,400 households

surrounding 80 small reservoirs in the North-East and Upper-East Regions of Ghana were surveyed.

The analysis of the baseline data shows that, although fish is the source of proteins consumed with the highest frequency, fishing and aquaculture are rarely practiced by the households in the sample. Most survey participants engage exclusively in crop farming and livestock rearing. Respondents generally believe aquaculture could be a viable livelihood option for them, but the high investment and training requirements represent significant obstacles to adoption.

To assess the viability and limitations of the difference-in-difference identification strategy planned for the Impact Assessment, this report compares baseline household characteristics between the treatment communities and the selected control group. Since the selection of beneficiaries and beneficiary communities was not randomized, these groups are not expected to be identical. However, the difference-in-difference approach relies on the critical assumption that, in the absence of the project, both groups would have experienced similar trends in outcomes over time, which is less likely to hold when the groups are very different at baseline.

The comparison of treated and control communities reveal the presence of relevant differences between the two groups: treated communities were found to have more diversified livelihood sources, higher wealth, and less food insecurity compared to control communities. Households in treated communities were less likely to be crop farmers and more likely to engage in petty trading. Wealth differences were linked to higher ownership of electronics (smartphones, laptops, TVs, and fridges) and motorbikes in treated communities before the implementation of the project.

These differences indicate that using this sample for the Impact Assessment could produce biased or misleading results if, for example, treated communities can grow faster since they start from a privileged position. To strengthen the credibility and robustness of the findings, it is crucial to complement the difference-in-difference analysis with methods that adjust for

observable differences between groups, such as propensity score matching. However, even with these adjustments, unobserved factors may still bias the results, underscoring the need for cautious interpretation and transparency about the study's limitations.

1. INTRODUCTION

Aquatic foods provide a vital source of nutrients, income, employment, in low- and middle-income countries and particularly so in Ghana, where fish contributes to 60% of the animal protein intake (FAO, 2016; Hasselberg et al 2020).

With the marine fisheries facing depletion, aquaculture in Ghana is becoming increasingly important (FAO, 2016). However, the adoption of aquaculture is not without challenges. It requires substantial upfront investment and technical knowledge, which can be a barrier, especially for communities unfamiliar with it. To address this, the Government of Ghana (GoG) has launched the Aquaculture for Foods and Jobs (AFJ) program, encouraging youth groups to venture into aquaculture and providing them with necessary support in terms of initial investment and technical training.

In northern Ghana, the poorest part of the country, the increasing availability of small earth dams constructed by the One Village One Dam (1V1D) project presents a unique opportunity for aquaculture expansion. The CGIAR Resilient Aquatic Foods Systems Initiative (RAqFS), a joint venture between World Fish and the International Water Management Institute (IWMI), aims to increase the resilience of aquatic food systems by addressing systematic challenges. As part of this initiative, in 2023, IWMI partnered with the CSIR Water Research Institute and the Fisheries Commission of Ghana to co-design and implement an aquaculture pilot in 4 small reservoirs in four communities in the North-East region of Ghana.

The pilot involved selecting groups of 10-15 people (males and females) in each of the 4 communities and providing them with technical training and inputs to undertake the first cycle of aquaculture production. The group members were selected with the help of community leaders based on criteria that prioritized youth participation, gender inclusion, and the beneficiaries' interest in and capacity to volunteer their time for the project.. The groups started

cultivating fish around August-September 2023 and completed their first harvest in September-October 2024.

In addition to regularly monitoring the progress of the pilot to draw lessons for its potential upscale, an Impact Assessment will also be conducted to rigorously study the effect of the project on the livelihoods of the direct beneficiaries and their community. This technical report describes the impact assessment methodology and presents the results from the baseline data collection, which took place between September and October 2023 and consisted of a household survey of about 1400 households living around 80 small reservoirs in the North-East and Upper-East regions of Ghana. In addition to serving as a baseline for the impact assessment, this dataset can also be used to characterise the multiple uses of the small reservoirs in the regions as participants were selected to represent the different user groups: households using water for irrigation, fishing/aquaculture, livestock production, and domestic uses.

This report is organised as follows: Section 2 describes the context and provides information on the ongoing aquaculture pilot; Section 3 presents the impact evaluation design and data collection; Section 4 presents the data and the comparison between treatment and control, Section 5 summarises the main findings.

2. AQUACULTURE PILOTS IN THE NORTH-EAST REGION OF GHANA

2.1. Design of the aquaculture pilot

The northern part of Ghana is by far the poorest part of the country, with over half of its population living below the poverty line in 2016. Its economy is mainly based on rainfed agriculture, with limited irrigation development and high vulnerability to climate change.

Figure 1 shows the regional poverty rates in 2016. At that time, Ghana was divided into 10 regions. The North-East Region, where the aquaculture pilot is taking place, was created in 2018,

as the Northern Region split into Northern, North-East and Savannah. Overall, 61% of the population in this area was estimated to be below the poverty line in 2016. In the Upper East, the other region object of this study, the poverty rate in 2016 was 55% (World Bank, 2020).

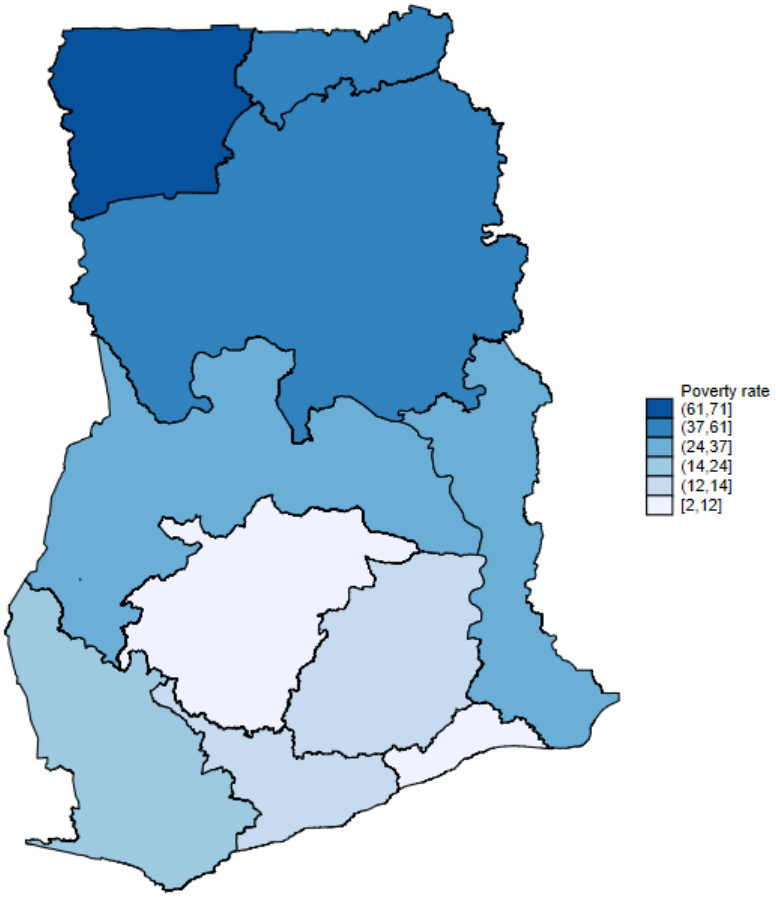

Figure 1: Poverty map of Ghana in 2016.
Source: World Bank (2020) Based on data from GLSS 7, Collected in 2016.

In 2017, the Government of Ghana launched the 'One Village, One Dam' (1V1D) Program to construct 570 dams in the northern region. The purpose of these dams was to provide year-round

water to support dry season irrigation, livestock keeping, and domestic uses. Although the use of the dam for fish production was not part of the program's original design, some of these dams, especially the largest ones that can hold enough water all year round, could be suitable for introducing cage culture.

To explore these opportunities, IWMI, the CSIR-WRI, and the Fisheries Commission of Ghana are conducting a pilot program to implement fish cage culture in four reservoirs. The design of the pilot is similar to that of the Government's flagship program, Aquaculture for Food and Jobs (AFJ), where youth groups are trained in aquaculture practices and are provided with the equipment, input, and technical assistance necessary to run one aquaculture cycle. The group is encouraged to formally register as a business and reinvest the revenues from the first cycle.

Specifically, each group was provided with 2 cages (5m x 5m x 3m) installed in the reservoirs, one canoe, and four life jackets. Each cage was stocked with 4,000 tilapia fingerlings between August and September 2023. Feed sufficient for one production cycle was also provided. Harvest is expected to take place after 6 months, between February and March 2024. As of December 2023, the groups also received technical training in aquaculture and regular monitoring and technical assistance. The project plans to provide additional training on group formation and business skills before the end of the cycle. Additional technical training on post-harvest handling is also planned.

2.2. Selection of Sites and Beneficiaries for Aquaculture Pilots

The pilot project is being conducted in four reservoirs located in 2 districts; East Mamprusi and Chereponi districts in the North-East Region. Specifically, the pilots are being undertaken in Langbinsi, Nalerigu, Nansoni, and Tombu dams. These sites were chosen from a preliminary list of 17 reservoirs provided by the Fisheries Commission, which identified potential locations for aquaculture based on expert local knowledge. To validate this list, remote sensing techniques were employed to confirm that the dams maintained water throughout the 2021-22 dry season (November – April) and each had a minimum surface area of 2 hectares in the driest month. This process restricted the list of potential reservoirs from 17 to 8. Finally, comprehensive field visits were undertaken to gather detailed information on the reservoirs' physical characteristics, such

as size, depth, shape, and position within the watershed. Additionally, the visits aimed to understand the reservoirs' usage, the community of users, water quality, and the socioeconomic and institutional dynamics of the surrounding communities. These field visits also provided an opportunity for direct consultations with traditional authorities and community and district-level stakeholders to ensure their interest and secure their support for the project.

Nansoni dam at the end of the dry season, March 2023. Photo: Giulia Zane.

Once the dams were selected, the beneficiary groups needed to be identified among the members of the communities using them. Importantly, since the water bodies belong to the community, it was important to ensure everyone was happy with the direct beneficiaries selected. The project team provided a list of criteria to the community leaders (see box 1) to ensure that the program would mostly benefit youth and that the beneficiaries were willing and able to volunteer their time during the fish production process.

Box 1 – List of criteria for selecting members of the groups

Members of the group should: (i) be aged between 18 and 35, (ii) be willing to volunteer their time for the project without receiving any compensation for at least six months, (iii) have another income-generating activity (fishing/farming/trading, etc.), (iv) be a permanent resident of the community for at least five years, (v) not be already engaged in commercial fish farming; (vi) not have tertiary education, (vii) be residing in proximity to the water body, and (viii) be willing to participate in a three-day initial technical training followed by other training and meetings in due course.[1]

In each community, a meeting was held in the presence of traditional leaders, assemblymen, and the proposed beneficiaries to finalise the selection of the group members. The meetings were attended by large groups of potential beneficiaries, some of whom did not necessarily satisfy the criteria provided. Therefore, these gatherings were used as an opportunity to collect data about the people present, which could be used to determine eligibility. On this occasion, the necessity to have group members capable of communicating in English was also brought up, to ensure their ability to benefit from the technical aquaculture training, which would be provided in English.[2]

The final groups of beneficiaries were selected using a combination of data gathered during the meeting and decisions made by the community leaders – mostly assemblymen, who played a key role in this process.

[1] The training was hosted in hotel, participants received accommodation, food, and facilitation for transport.

[2] The project implementers later understood the necessity to provide inclusive training in the local language so that all beneficiaries could participate. Therefore, further training and coaching activities implemented by the project were conducted in local languages in the beneficiaries' villages, inviting all group members.

Community meeting in Langbinsi to discuss group formation in March 2023. Photo: Giulia Zane

3. DATA AND METHODS

3.1. Impact evaluation design

Since participation in the pilot (both at the reservoir level and at the group member level) was not randomly assigned, to assess the impact of the project, we will rely on Difference – in – Difference identification strategy in which the outcomes for the project beneficiaries are compared to those of a (carefully selected) comparison group, also referred to as "control group", before and after the benefits of the project are realised.

This methodology allows us to estimate the effect of the program by calculating the differences between *changes* in outcomes for the treatment group and with those of the control group. The idea is that, even if treatment and control groups are not identical before the program, both in observable and unobservable characteristics, we can compare the change in their outcomes if,

in the absence of the program, they would grow (or decrease) at the same rate (parallel trends assumption).

To implement this strategy, socio-economic data on treatment and control groups must be collected before and after the project's benefits are realised. Specifically, this evaluation will rely on household survey data collected in the North-East and Upper-East Regions of Ghana in September - October 2023 and data on the same set of households, to be collected after the implementation of the project, in the second half of 2024.

The empirical model to be estimated can be described by the following equation, estimated on the set of treated farmers and farmers selected as a control group:

$$Y_{ict} = \beta_0 + \beta_1 Treated_{ic} + \beta_2 Post_t + \beta_3 Treated_{ic} * Post_t + \epsilon_{ict} \quad (1)$$

Where Y_{ict} it is the outcome of interest (for example, household income) for household *i* residing in community *c*, measured in year *t* (either 2023 or 2024); $Treated_{ic}$ is a dummy variable equal to 1 if the household participated in the aquaculture pilot or equal to zero if the household was selected as part of the control group; $Post_t$ is a dummy variable equal to 1 if the outcome was measured in 2024, as part of the endline survey, and equal to zero if the outcome was measured in 2023, as part of the baseline survey; ϵ_{ict} is an error term specific to household *i* residing in community *c*, and year *t.*

In this model, the coefficient of interest, β_3, captures the effect of the program as it measures the additional change in the outcome of interest experienced by the treated group compared to the control group.

Because the project is expected to affect the group members directly, but also the rest of the community indirectly, we will also look at spillover effects on the other members of the community by estimating the following equation on the set of households in treated and control communities that did not participate in the program and were not chosen to be part of the control group.

$$Y_{ict} = \gamma_0 + \gamma_1 Treated_c + \gamma_2 Post_t + \gamma_3 Treated_c * Post_t + \epsilon_{ict} \quad (2)$$

Where Y_{it} it is the outcome of interest for household *i* residing in community *c*, measured in year t; $Treated_c$ is a dummy variable equal to 1 if the community participated in the aquaculture pilot or equal to zero otherwise; $Post_t$ is a dummy variable equal to 1 if the outcome was measured in 2024, as part of the endline survey, and equal to zero if the outcome was measured in 2023, as part of the baseline survey; ϵ_{ict} is an error term specific to household *i* residing in community *c*, and year *t.*

3.2. Outcomes of interest

The objective of the program was to create employment opportunities for the beneficiaries, which should increase their income and other aspects of their well-being, including nutrition, food security, etc. These job opportunities should also decrease migration out of the community, in particular dry season migration. Finally, the inclusion of youth and women should increase empowerment for these categories of people.

For the community, the program is expected to increase the availability of nutritious food and, as a consequence, increase nutrition and food security.

Finally, we will also look at whether the program affected the use of the water of the reservoir for other purposes, including agriculture. Outcomes will also be disaggregated by age groups and gender.

3.3. Survey design

A household survey was conducted in September-October 2023 with the objective to serve as a baseline for this Impact Evaluation but also to allow us to characterise the multiple uses of the reservoirs in northern Ghana. For this reason, the survey targets not only the project communities and some communities identified as 'control' but also a larger set of communities in the North-East and Upper-East Regions. The sampling design is described in section 3.3 below.

The questionnaires are reported in appendix. Tables 1 and 2 report the content of the household and community questionnaires, respectively.

Table 1: Content of household questionnaire

Section Number	Content Summary	Detailed Content Summary
A	Household Information	Location, household demographic information, main economic activities, health, time use, use of dam/reservoir
B	Dwelling Characteristics	Visible characteristics of the dwelling, other characteristics of the dwelling, household assets
C	Livelihoods	Crop farming, livestock, fishing and aquaculture
D	Businesses	Household businesses and their characteristics
E	Shocks and Coping Strategies	Experiences with shocks and coping strategies in the past 10 years
F	Household Food Security	Questions about household food security and food diversity in the last 12 months
H	Water Security for Health and Livelihoods	Water security issues for both health and livelihoods, including coping strategies
G	Survey End	GPS coordinates, comments, and interview end-time

Table 2: Content of community questionnaire

Section Number	Content Summary	Detailed Content Summary
A	Community Identifier	Location, respondent characteristics
B	Community Characteristics	General characteristics, seasonality, services, groups/associations
C	Use of the Dam/Reservoir	Reservoir details, household use, water uses, obstacles/governance, participation in aquaculture
D	Migration	Household and individual migration details
E	Shocks	Community experiences with shocks and coping strategies
F	Survey End	GPS coordinates, comments, and interview end time

3.4. Sampling protocol

The household survey included about 1400 living around 80 reservoirs in the North-East and Upper East Regions of Ghana. Sampling took place in two stages: first, reservoirs in the two regions were selected, and then households living near the selected reservoirs were sampled.

3.4.1. Reservoir selection

In the North-East region, 8 reservoirs were included in the survey, which had been considered suitable for aquaculture based on the Fisheries Commission's knowledge and satellite data (Figure 2). Four of them were eventually included in the project (Langbinsi, Nalerigu, Nansoni, and Tombu), while the other four were excluded either because they were found not be eligible for the program or because the community rejected the program.

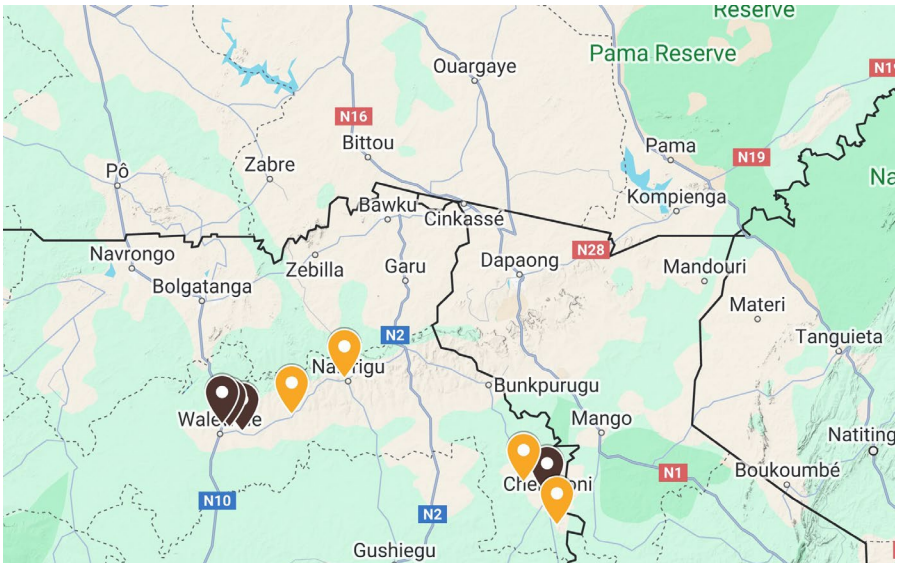

Figure 2: Selected reservoirs in the North-East Region of Ghana
Note: Orange icons represent the treated communities, the brown icons represent the non-treated communities.

In the Upper East region, 72 reservoirs are included in the survey, which were selected from a database created using remote techniques (Ghansah et al. 2022). This dataset provides information on all the small reservoirs in the region, whether they provide water during the dry season months and their surface area. For this survey, a subset of reservoirs providing water all

year round and with a minimum surface area of 2 hectares in April 2022 were selected as they were considered potentially suitable for aquaculture.

The reservoir selection in the Upper East region happened in three stages. First, 4 reservoirs were selected for the pre-testing exercise. Three of them had participated in an aquaculture pilot in 2017-2018 under the Resilient and Sustainable Livelihoods Transformation (RESULT) project, and 1 was picked from the list as a test. Second, 16 reservoirs were selected as a comparison group for the 4 reservoirs in the North-East Region by manually matching on observable characteristics: size, and distance from the regional capital. Third, 52 reservoirs were randomly sampled, stratifying on size (large: over 5 hectares; or small: below 5 hectares) and distance to the regional capital (close: less than 66 minutes away; or far: more than 66 away, as estimated using Google maps).

The original plan involved narrowing down the list of "control" reservoirs from 16 to 10 by consulting with the Fisheries Commission extension officers. The idea is that, based on their local knowledge, they could tell us which sites were more likely to be suitable for aquaculture, mimicking the fieldwork that was conducted in the North-East region at the time of site identification. However, during this consultation, we only managed to narrow down the list from 16 to 15 as the Fisheries Commission staff were not familiar with all the reservoirs in the region. Therefore, the final selection of control reservoirs happened during the data collection phase, when control and treatment reservoirs were manually matched based on data collected during the community survey using information such as age of the reservoir, size of the community, and connection to grid electricity. Overall, 3 control reservoirs were matched to Nalerigu, 2 to Langbinsi, and 5 to both Tombu and Nansoni.

Finally, during data collection, it was necessary to make a few adjustments for the following reasons: (i) two reservoirs were excluded because of conflict in the; (ii) two sampled reservoirs were parts of the same water body; (iii) one reservoir was excluded because the community did not agree to participate in the survey. The excluded reservoirs were replaced by others with similar characteristics.

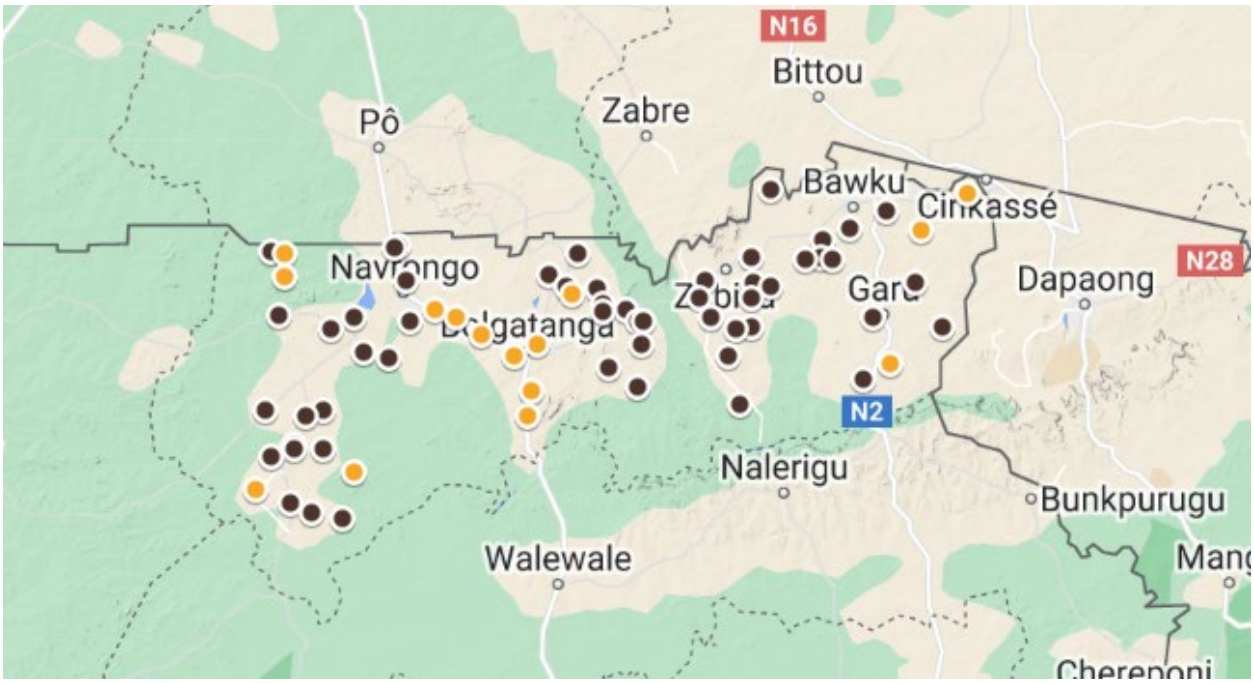

Figure 3: Selected reservoirs in the Upper-East Region of Ghana.
Note: Orange icons represent the communities selected as control group; the brown icons represent the remaining communities.

3.4.2. Sampling households

Each selected reservoir was matched to the nearest village. Once the villages were identified, a complete census/listing of the households in the village was conducted, completing a short questionnaire with information such as contacts of the household head, household size, and uses of the reservoir. In case the reservoir was matched with large communities, the listing exercise was restricted to a set of approximately 80 households located in the vicinity of the reservoir.

Based on this information, the set of households in each village was stratified into three groups: (i) households that use water for fishing/aquaculture; (ii) households that do not use water for fishing/aquaculture but use it for irrigation; (iii) households that do not use the water for fishing/aquaculture or irrigation. To the extent possible, five households and one replacement

were sampled for each of these strata.[3] In case not enough households were available in any of the categories, the sample size in the other categories was increased.

In the reservoirs in which the pilot will take place, i.e., the *Treatment reservoirs*, about 10 additional households were added to the sample to include the project beneficiaries. In the reservoirs selected as the comparison group, i.e., the *Control reservoirs*, approximately 15 additional households were included in the sample, selected with criteria that simulate the beneficiary selection for the pilot. To do so, a community leader (ideally the assemblyman) was approached and asked to provide a list of individuals who would be willing and capable of participating in a hypothetical aquaculture pilot and satisfying a set of requirements (see box 1).

The total sample size will be approximately 1400 households in 80 villages.

3.5. Qualitative data collection

In addition to the quantitative data collection described above, qualitative data collection in the form of 20 Focused Group Discussions (FGDs) and 20 Key Informants Interviews (KIIs), was also conducted.

During the survey pre-testing phase, FGDs and KIIs were designed to gather information on the context, including the most important uses of the reservoirs, to inform and update the design of the quantitative instruments. At this time, FGDs and KIIs were also conducted in three communities in which an aquaculture project had taken place, introducing cage fish culture in the small reservoirs to understand the benefits obtained from the project and the challenges encountered.

[3] The original plan was to define strata in the following way (i) household that use water for irrigation, (ii) households that use water for domestic purposes but not irrigation, (iii) households that do not use water from the reservoir. However, once the listing data was collected, we realized that the share of households not using water from the reservoir was very low or non-existent in many of the selected villages. Therefore, the categories were adjusted.

During the main data collection phase, FGDs and KIIs were conducted to gather additional information on the reservoir's uses and the context in which the project is taking place. This can help corroborate the fact that treatment and control communities are indeed comparable.

KIIs were also conducted with Fisheries extension workers and fish farmers operating in the two regions to gather additional insights on challenges and opportunities related to aquaculture in northern Ghana.

Focused Group Discussion with program beneficiaries in Langbinsi: Photo George Asare

4. DESCRIPTION OF THE DATA

4.1. Demographics and Socio-economic Characteristics

4.1.1. Household composition

The average household size in the sample is 5.4, and households have, on average, 2 children below 15, 1.6 adult males, and 1.8 adult females (over 15). Among the adults, 0.7 are male youth (age 18-35), and 0.8 are female youth. Household size is not balanced across treatment and control groups, with households in treated communities being larger and having more children and more young women than households in the control group (Table 3).

Table 3. Composition of the household

Variable	(1) Overall	(2) Treaded reservoirs	(3) Control reservoirs	(4) Diff	(5) Treated households	(6) Control Households	(7) Diff
Household size (total)	5.368	5.907	5.126	0.780***	6.213	5.269	0.943**
	(2.517)	(3.233)	(2.133)	(0.271)	(3.470)	(1.695)	(0.378)
Less than 15	1.994	2.270	1.647	0.623***	2.617	1.778	0.839***
	(1.632)	(2.304)	(1.350)	(0.182)	(2.212)	(1.386)	(0.274)
Males >15	1.557	1.725	1.644	0.081	1.660	1.653	0.007
	(1.091)	(1.042)	(0.980)	(0.109)	(1.128)	(0.994)	(0.175)
Females >15	1.818	1.913	1.835	0.077	1.936	1.838	0.098
	(1.158)	(1.181)	(1.166)	(0.127)	(1.420)	(0.953)	(0.184)
Male youth (18-35)	0.699	0.755	0.722	0.033	0.660	0.701	-0.041
	(0.873)	(0.846)	(0.817)	(0.090)	(0.841)	(0.749)	(0.132)
Female youth (18-35)	0.755	1.123	0.726	0.397***	1.149	0.766	0.382***
	(0.790)	(0.794)	(0.793)	(0.086)	(1.042)	(0.752)	(0.141)
Observations	1,444	110	307	417	47	152	199

Notes: Columns 1, 2, 3, 5, and 6 report means and standard deviations (in parenthesis). Columns 4 and 7 report differences in means and the respective standard errors (in parenthesis). $* p < .10$, $** p < .05$, $*** p < .01$.

4.1.2. Age, gender, education, marital status, and seasonal migration of the respondent and household head

Survey respondents are, on average, 46 years old, and about 40% of them are female (see Table 4). In 84% of the cases, the respondent is also the household head. Education levels are very low,

as 56% of the respondents did not have any formal schooling. Only 16% of the respondents completed secondary education. About 75% of the respondents are married, and 6% of them engage in seasonal migration.

In the treatment group, respondents are more likely to be younger and more likely to be male. They are also more likely to have higher levels of education than their counterparts in the control group. Treated respondents are more likely to be married, and none of them are seasonal migrants.

Compared to the respondents, the household heads are less likely to be female: only 29% of households are female-headed, and this share is particularly low for the households in the treated communities, where only 12% of the household heads are female.

Table 4. Demography of the respondent and the household head

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variable	Overall	Treaded reservoirs	Control reservoirs	Diff	Treated households	Control Households	Diff
Resp: Age	46.422	41.145	47.247	-6.102***	39.532	43.246	-3.714*
	(16.161)	(14.773)	(16.142)	(1.716)	(13.418)	(12.735)	(2.207)
Resp: Female	0.397	0.279	0.418	-0.139***	0.362	0.509	-0.147*
	(0.490)	(0.450)	(0.494)	(0.052)	(0.486)	(0.502)	(0.085)
Resp: No schooling	0.559	0.521	0.572	-0.052	0.426	0.539	-0.113
	(0.497)	(0.502)	(0.496)	(0.054)	(0.500)	(0.500)	(0.086)
Resp: Primary incomplete	0.064	0.007	0.076	-0.070***	0.021	0.114	-0.092*
	(0.245)	(0.082)	(0.266)	(0.025)	(0.146)	(0.319)	(0.050)
Resp: Primary complete	0.092	0.056	0.109	-0.053*	0.000	0.114	-0.114**
	(0.289)	(0.230)	(0.312)	(0.032)	(0.000)	(0.319)	(0.048)
Resp: Junior Sec complete	0.130	0.126	0.112	0.014	0.128	0.096	0.032
	(0.336)	(0.333)	(0.315)	(0.035)	(0.337)	(0.295)	(0.052)
Resp: Secondary +	0.155	0.292	0.131	0.160***	0.426	0.138	0.288***
	(0.362)	(0.457)	(0.338)	(0.041)	(0.500)	(0.346)	(0.066)
Resp: Married	0.746	0.883	0.664	0.219***	0.936	0.725	0.212***
	(0.436)	(0.323)	(0.473)	(0.047)	(0.247)	(0.448)	(0.071)
Resp: Seasonal Migrant	0.060	0.000	0.061	-0.061***	0.000	0.024	-0.024
	(0.238)	(0.000)	(0.240)	(0.022)	(0.000)	(0.153)	(0.023)
Respondent is HH Head	0.843	0.809	0.863	-0.054	0.766	0.808	-0.042
	(0.364)	(0.395)	(0.344)	(0.039)	(0.428)	(0.395)	(0.069)
HH Head: Age	48.181	44.974	48.513	-3.539**	43.106	45.156	-2.049
	(15.923)	(13.977)	(15.942)	(1.678)	(13.535)	(12.278)	(2.151)
HH Head: Female	0.285	0.117	0.323	-0.206***	0.191	0.383	-0.192**
	(0.451)	(0.323)	(0.468)	(0.047)	(0.398)	(0.488)	(0.080)
HH Head: No schooling	0.578	0.538	0.572	-0.034	0.426	0.569	-0.143*
	(0.494)	(0.501)	(0.496)	(0.054)	(0.500)	(0.497)	(0.085)
HH Head: Primary incomplete	0.058	0.007	0.070	-0.064***	0.021	0.102	-0.081*
	(0.234)	(0.082)	(0.256)	(0.024)	(0.146)	(0.303)	(0.047)
HH Head: Primary complete	0.092	0.063	0.110	-0.047	0.000	0.114	-0.114**
	(0.290)	(0.245)	(0.313)	(0.032)	(0.000)	(0.319)	(0.048)
HH Head: Junior Sec complete	0.109	0.085	0.099	-0.014	0.128	0.078	0.050
	(0.311)	(0.280)	(0.299)	(0.032)	(0.337)	(0.269)	(0.049)
HH Head: Secondary +	0.162	0.307	0.141	0.166***	0.426	0.138	0.288***
	(0.368)	(0.463)	(0.348)	(0.042)	(0.500)	(0.346)	(0.066)
HH Head: Married	0.746	0.883	0.664	0.219***	0.936	0.725	0.212***
	(0.436)	(0.323)	(0.473)	(0.047)	(0.247)	(0.448)	(0.071)
HH Head: Seasonal Migrant	0.060	0.000	0.061	-0.061***	0.000	0.024	-0.024
	(0.238)	(0.000)	(0.240)	(0.022)	(0.000)	(0.153)	(0.023)
Observations	1,444	110	307	417	47	152	199

Notes: Columns 1, 2, 3, 5, and 6 report means and standard deviations (in parenthesis). Columns 4 and 7 report differences in means and the respective standard errors (in parenthesis). $* p < .10$, $** p < .05$, $*** p < .01$.

4.1.3. Household Characteristics

Christianity is the most common religion among study respondents (Table 5). Indeed, about half of the households surveyed report being Christian, while the other half practices Islam and traditional religion in equal proportions. In the treated communities, however, Islam is practised by 71% of the households in the sample and almost three-quarters of the project beneficiaries.

Most of the households are originally from their residence area, with only 9.4% of the sample reporting to have migrated from another place. Moreover, about 14% of the households have at least one member who holds a leadership role in the community. The share is as high as 19% in treated households but the difference with the control households is not statistically significant.

Table 5. Characteristics of the household

Variable	(1) Overall	(2) Treaded reservoirs	(3) Control reservoirs	(4) Diff	(5) Treated households	(6) Control Households	(7) Diff
Religion: Christianity	0.502	0.274	0.625	-0.350***	0.234	0.587	-0.353***
	(0.500)	(0.448)	(0.485)	(0.052)	(0.428)	(0.494)	(0.082)
Religion: Islam	0.222	0.711	0.113	0.598***	0.745	0.192	0.553***
	(0.416)	(0.455)	(0.318)	(0.039)	(0.441)	(0.395)	(0.069)
Religion: Traditional	0.265	0.015	0.262	-0.247***	0.021	0.222	-0.200***
	(0.441)	(0.120)	(0.440)	(0.041)	(0.146)	(0.417)	(0.064)
Migrant Household	0.055	0.094	0.026	0.068***	0.043	0.006	0.037*
	(0.228)	(0.293)	(0.158)	(0.022)	(0.204)	(0.077)	(0.020)
At least one leader	0.142	0.156	0.157	-0.001	0.191	0.150	0.042
	(0.349)	(0.364)	(0.364)	(0.040)	(0.398)	(0.358)	(0.063)
Observations	1,444	110	307	417	47	152	199

Notes: Columns 1, 2, 3, 5, and 6 report means and standard deviations (in parenthesis). Columns 4 and 7 report differences in means and the respective standard errors (in parenthesis). $* p < .10$, $** p < .05$, $*** p < .01$.

4.1.4. Group membership

Overall, 66% of the households in the sample have at least one member who is part of a group or organisation (Table 6). Common group types are savings groups, where 46% of the households have at least one member, women's groups (34%) and youth groups (16%).

Interestingly, group membership is less common in the treated communities, where only 24% of the households have members who belong to groups or organisations. Lower participation occurs across the board, but particularly so for women's groups, attended by less than 5% of the households in treated communities compared to 35% in control communities, and savings groups, attended by 10% of the households in treated communities compared to 54% of the households in control communities.

Table 6. Group membership

Variable	(1) Overall	(2) Treaded reservoirs	(3) Control reservoirs	(4) Diff	(5) Treated households	(6) Control Households	(7) Diff
Any group/organisation	0.655	0.240	0.686	-0.446***	0.340	0.731	-0.390***
	(0.476)	(0.429)	(0.465)	(0.050)	(0.479)	(0.445)	(0.078)
Farmers' group/cooperative	0.141	0.031	0.134	-0.103***	0.064	0.162	-0.098
	(0.348)	(0.175)	(0.342)	(0.033)	(0.247)	(0.369)	(0.059)
Youth Group	0.163	0.117	0.200	-0.083**	0.170	0.275	-0.105
	(0.370)	(0.323)	(0.401)	(0.041)	(0.380)	(0.448)	(0.074)
Savings group	0.455	0.101	0.543	-0.441***	0.149	0.545	-0.396***
	(0.498)	(0.303)	(0.499)	(0.049)	(0.360)	(0.500)	(0.081)
Women's group	0.343	0.046	0.345	-0.299***	0.043	0.467	-0.425***
	(0.475)	(0.210)	(0.476)	(0.046)	(0.204)	(0.501)	(0.078)
WUA/Irrigation group	0.031	0.003	0.035	-0.032*	0.021	0.042	-0.021
	(0.173)	(0.054)	(0.184)	(0.017)	(0.146)	(0.201)	(0.033)
Observations	1,444	110	307	417	47	152	199

Note: the variable *Any group/organisation* is a dummy equal to one if at least one person in the household is part of a group or organisation except aquaculture groups. Columns 1, 2, 3, 5, and 6 report means and standard deviations (in parenthesis). Columns 4 and 7 report differences in means and the respective standard errors (in parenthesis). $* p < .10$, $** p < .05$, $*** p < .01$.

4.2. Livelihoods and Wealth

4.2.1. Sources of Livelihood

Crop farming is by far the most important source of livelihood for the households surveyed, followed by livestock keeping (Table 7). All other activities are much less important (Figure 4). Indeed, for 86% of the households surveyed, crop farming is the major source of livelihood and 94% practice it. The second most important source of livelihood is livestock keeping, practised by 71% of the sample, while the third, petty trading, is practised by 13% of the sample. About 9% of

the sample reported salaries and wages as a source of livelihood, and 5% reported artisanal activities and fishing/aquaculture.

Except for petty trading, which is more common among treated communities, the prevalence of the different livelihood sources is similar across treatment and control communities.

Table 7. Livelihoods

Variable	(1) Overall	(2) Treaded reservoirs	(3) Control reservoirs	(4) Diff	(5) Treated households	(6) Control Households	(7) Diff
Major livelihood: Crops	0.864	0.816	0.848	-0.032	0.872	0.934	-0.062
	(0.343)	(0.389)	(0.360)	(0.040)	(0.337)	(0.249)	(0.046)
All sources of livelihood							
Crops	0.941	0.879	0.940	-0.061**	0.936	0.976	-0.040
	(0.235)	(0.327)	(0.238)	(0.029)	(0.247)	(0.153)	(0.030)
Livestock	0.714	0.640	0.634	0.006	0.660	0.665	-0.005
	(0.452)	(0.482)	(0.483)	(0.053)	(0.479)	(0.474)	(0.081)
Fishing/Aquaculture	0.047	0.040	0.038	0.002	0.298	0.066	0.232***
	(0.211)	(0.197)	(0.191)	(0.021)	(0.462)	(0.249)	(0.053)
Petty Trading	0.130	0.216	0.132	0.084**	0.149	0.329	-0.180**
	(0.336)	(0.413)	(0.339)	(0.039)	(0.360)	(0.472)	(0.077)
Salaries/wages	0.085	0.152	0.123	0.029	0.128	0.084	0.044
	(0.279)	(0.360)	(0.329)	(0.037)	(0.337)	(0.278)	(0.050)
Artisanal	0.049	0.058	0.085	-0.026	0.085	0.096	-0.011
	(0.215)	(0.236)	(0.279)	(0.029)	(0.282)	(0.295)	(0.050)
Other	0.084	0.064	0.036	0.028	0.064	0.078	-0.014
	(0.278)	(0.246)	(0.187)	(0.022)	(0.247)	(0.269)	(0.045)
Observations	1,444	110	307	417	47	152	199

Notes: Columns 1, 2, 3, 5, and 6 report means and standard deviations (in parenthesis). Columns 4 and 7 report differences in means and the respective standard errors (in parenthesis). $* p < .10$, $** p < .05$, $*** p < .01$.

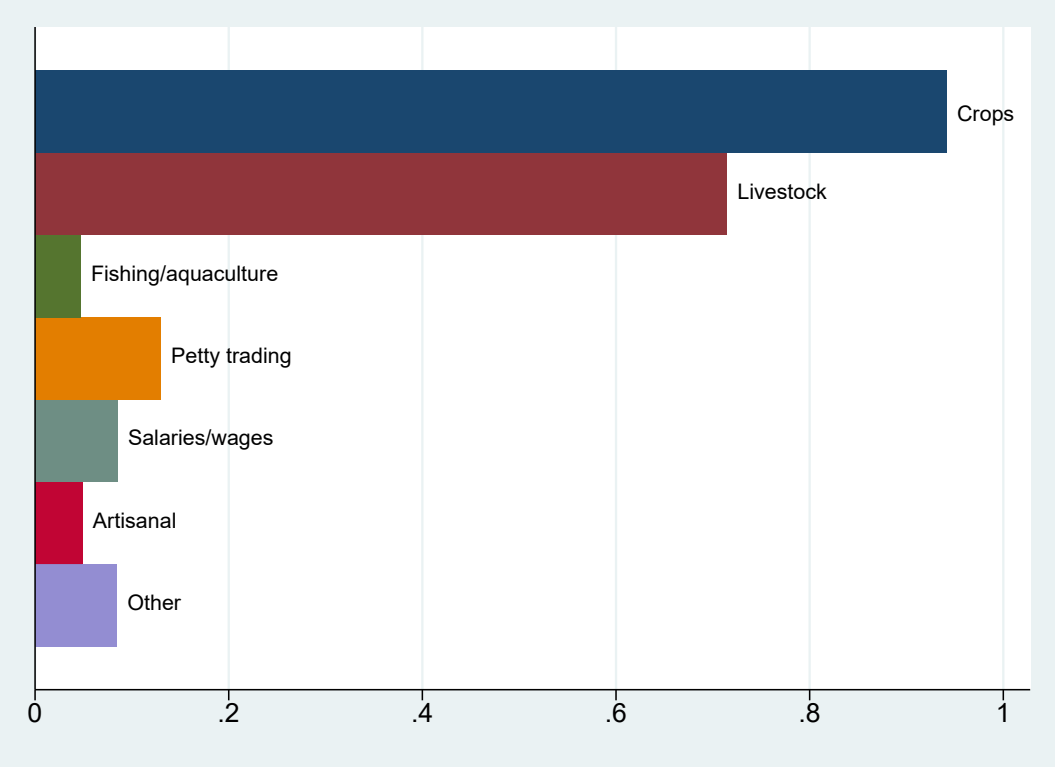

Figure 4: Sources of livelihood

Note: The graph shows the share of households surveyed engaged in each livelihood source

4.2.2. Occupations

Table 8 reports the share of household members aged 15 or older engaged in each type of occupation (as a main occupation). As expected, most individuals are self-employed in agriculture (61%). About 14% of the individuals are students, 12% do not work, and 7% are self-employed in other sectors. While almost nobody reports that agricultural work for others is their main occupation, about 5% of the individuals are employed in other sectors. Finally, about 6% of the individuals are seasonal migrants.

Most occupations are balanced across treatment groups, except for non-agricultural self-employment, which is more common in treated communities, and non-agricultural employment, which is more common in control communities. Seasonal migration is very low in treated communities (0.8%) and more likely in control communities (6%).

Table 8. Occupations

Variable	(1) Overall	(2) Treaded reservoirs	(3) Control reservoirs	(4) Diff	(5) Treated households	(6) Control Households	(7) Diff
Self-employed in agriculture	0.610	0.587	0.609	-0.022	0.626	0.695	-0.069
	(0.345)	(0.388)	(0.347)	(0.039)	(0.377)	(0.308)	(0.056)
Self-employed in other sectors	0.072	0.112	0.061	0.051***	0.087	0.034	0.053**
	(0.175)	(0.209)	(0.166)	(0.019)	(0.178)	(0.108)	(0.022)
Agricultural worker	0.006	0.006	0.000	0.006**	0.000	0.000	0.000
	(0.064)	(0.045)	(0.000)	(0.003)	(0.000)	(0.000)	(0.000)
Worker in another sector	0.047	0.028	0.071	-0.043**	0.047	0.029	0.019
	(0.148)	(0.107)	(0.200)	(0.019)	(0.171)	(0.120)	(0.023)
Student	0.144	0.143	0.165	-0.022	0.125	0.173	-0.047
	(0.212)	(0.211)	(0.229)	(0.024)	(0.218)	(0.242)	(0.041)
Does not work	0.120	0.123	0.088	0.035*	0.113	0.061	0.053*
	(0.219)	(0.222)	(0.177)	(0.021)	(0.233)	(0.151)	(0.029)
Seasonal migrant	0.058	0.008	0.057	-0.048***	0.007	0.031	-0.024
	(0.161)	(0.048)	(0.169)	(0.016)	(0.049)	(0.103)	(0.016)
Observations	1,444	110	307	417	47	152	199

Notes: Columns 1, 2, 3, 5, and 6 report means and standard deviations (in parenthesis). Columns 4 and 7 report differences in means and the respective standard errors (in parenthesis). $* p < .10$, $** p < .05$, $*** p < .01$.

4.2.3. Household income

As for the sources of livelihoods, the main sources of income for the households in the sample are crop farming and livestock keeping (self-consumption of crops is included). The average household income was reported to be around 11,000 Ghana cedis, which corresponded to about 900 USD at the time of the survey (Table 9).

Treated households report higher crop income and lower income from livestock compared to the control group (both at the community and individual levels), but the difference is not statistically significant.

Income from aquaculture is very limited. Only some households in the treatment group report some aquaculture income, which was generated by participation in private aquaculture activities, not part of this project.

Table 9. Household income

Variable	(1) Overall	(2) Treaded reservoirs	(3) Control reservoirs	(4) Diff	(5) Treated households	(6) Control Households	(7) Diff
Total household income	10976	8698	7568	1130	15200	10476	4724
	(24589)	(11480)	(14223)	(1470)	(22560)	(22424)	(3845)
Employment	294	387	228	159*	310	178	132
	(861)	(1268)	(579)	(91)	(814)	(564)	(107)
Crops	7951	6014	4890	1123	12403	6537	5865
	(23322)	(11163)	(12456)	(1318)	(22560)	(21428)	(3713)
Livestock	1356	1146	1529	-384	1361	1788	-427
	(3525)	(1839)	(4232)	(405)	(2745)	(3750)	(609)
Fishing	116	16	35	-19	119	102	17
	(667)	(193)	(193)	(21)	(519)	(363)	(69)
Aquaculture	7	22	0	22**	166	0	166***
	(121)	(187)	(0)	(11)	(489)	(0)	(39)
Business	1252	1114	885	229	840	1869	-1029
	(4109)	(2157)	(3128)	(314)	(1686)	(5045)	(776)
Observations	1,444	110	307	417	47	152	199

Notes: Columns 1, 2, 3, 5, and 6 report means and standard deviations (in parenthesis). Columns 4 and 7 report differences in means and the respective standard errors (in parenthesis). $* p < .10$, $** p < .05$, $*** p < .01$.

4.2.4. Wealth

In this section, we consider wealth indicators such as house characteristics and asset ownership (Table 10). Comparing the treatment and control groups, it appears that treated communities are wealthier than control communities, with a difference of 3 standard deviations. Households in treated communities are more likely to own smartphones, TVs, fridges, motorbikes, and computers or tablets.

Table 10. Wealth

Variable	(1) Overall	(2) Treaded reservoirs	(3) Control reservoirs	(4) Diff	(5) Treated households	(6) Control Households	(7) Diff
Wealth index	0.000	2.375	-0.765	3.140***	3.587	1.074	2.513**
	(6.858)	(7.716)	(6.574)	(0.752)	(5.682)	(6.736)	(1.117)
Asset ownership							
Mobile phone	0.900	0.841	0.909	-0.068**	0.915	0.940	-0.025
	(0.301)	(0.367)	(0.288)	(0.034)	(0.282)	(0.238)	(0.043)
Smartphone	0.435	0.566	0.452	0.113**	0.638	0.521	0.117
	(0.496)	(0.498)	(0.499)	(0.054)	(0.486)	(0.501)	(0.085)
Radio	0.501	0.366	0.458	-0.092*	0.383	0.515	-0.132
	(0.500)	(0.484)	(0.499)	(0.054)	(0.491)	(0.501)	(0.085)
TV	0.342	0.629	0.349	0.279***	0.809	0.371	0.437***
	(0.475)	(0.485)	(0.478)	(0.052)	(0.398)	(0.485)	(0.080)
Fridge	0.133	0.244	0.146	0.097**	0.298	0.204	0.094
	(0.339)	(0.431)	(0.354)	(0.041)	(0.462)	(0.404)	(0.071)
Bicycle	0.649	0.587	0.542	0.045	0.617	0.641	-0.024
	(0.477)	(0.495)	(0.499)	(0.054)	(0.491)	(0.481)	(0.083)
Motorbike or tricycle	0.342	0.615	0.305	0.310***	0.723	0.461	0.262***
	(0.474)	(0.489)	(0.461)	(0.051)	(0.452)	(0.500)	(0.084)
Car, tractor, or truck	0.015	0.009	0.007	0.001	0.043	0.012	0.031
	(0.120)	(0.092)	(0.085)	(0.010)	(0.204)	(0.109)	(0.023)
Knapsack sprayer	0.419	0.459	0.358	0.101*	0.511	0.389	0.121
	(0.494)	(0.501)	(0.480)	(0.053)	(0.505)	(0.489)	(0.084)
Irrigation pump (solar)	0.004	0.018	0.008	0.010	0.000	0.018	-0.018
	(0.060)	(0.134)	(0.089)	(0.011)	(0.000)	(0.133)	(0.020)
Irrigation pump (diesel)	0.053	0.027	0.035	-0.008	0.000	0.060	-0.060*
	(0.224)	(0.164)	(0.185)	(0.019)	(0.000)	(0.238)	(0.036)
Sewing machine	0.135	0.141	0.148	-0.007	0.043	0.186	-0.143**
	(0.342)	(0.349)	(0.355)	(0.039)	(0.204)	(0.390)	(0.061)
Computer or tablet	0.029	0.081	0.013	0.068***	0.064	0.018	0.046
	(0.168)	(0.274)	(0.113)	(0.019)	(0.247)	(0.133)	(0.028)
Observations	1,444	110	307	417	47	152	199

Note: the *wealth index* includes indicators for high-quality walls, roof, and floor, house ownership, number of rooms and asset ownership indicators, all standardised to have mean zero and standard deviation 1. Columns 1, 2, 3, 5, and 6 report means and standard deviations (in parenthesis). Columns 4 and 7 report differences in means and the respective standard errors (in parenthesis). $* p < .10$, $** p < .05$, $*** p < .01$.

4.2.5. Time use

We consider the time spent on different activities by male and female household members (respondent, household head, spouse of household head) during the most recent working day in Table 11. We find that both males and females spent the largest amount of time during farm work, however, the time spent on farm work by men is 77 minutes higher than the time spent on the same activity by women. On the other hand, women spend more time doing chores, taking care of children and the elderly, and fetching water.

The treatment and control communities are different in many aspects. In treatment communities, both men and women spend more time taking care of others, performing religious activities, working for others, and enjoying leisure. Women in treatment communities also spend significantly more time fetching water. In contrast, in control communities, men and women spend more time on chores, farmwork, and associations than their counterparts in treated communities.

Table 11 - Time spent doing chores (in minutes)

Variable	(1) Overall	(2) Treaded reservoirs	(3) Control reservoirs	(4) Diff	(5) Treated households	(6) Control Households	(7) Diff
Male household member							
Chores and hygiene	95.605	99.985	117.547	-17.562*	97.953	99.963	-2.009
	(81.097)	(54.553)	(95.910)	(9.768)	(50.364)	(65.093)	(11.268)
Taking care of children/elderly	89.646	134.111	89.693	44.418***	149.070	81.903	67.167***
	(99.193)	(65.424)	(80.359)	(8.736)	(68.280)	(67.645)	(12.347)
Fetching water	44.741	56.574	65.372	-8.798	48.209	75.821	-27.612*
	(59.711)	(67.907)	(69.627)	(7.953)	(72.578)	(85.118)	(14.984)
Farm work	349.740	271.231	303.771	-32.539*	285.209	321.007	-35.798
	(181.276)	(163.659)	(171.441)	(19.455)	(152.709)	(180.524)	(31.732)
Work on business	87.174	81.926	88.199	-6.273	67.512	140.590	-73.078***
	(154.101)	(111.952)	(130.047)	(14.336)	(121.185)	(151.704)	(26.399)
Work for others	46.440	89.871	67.626	22.245	56.093	63.172	-7.079
	(117.081)	(149.237)	(130.830)	(15.775)	(116.184)	(123.136)	(22.127)
Studying	22.464	45.479	25.214	20.265***	34.651	23.657	10.994
	(59.176)	(63.747)	(48.921)	(6.233)	(65.505)	(44.643)	(9.187)
Leisure	136.111	175.705	138.758	36.947**	181.395	94.657	86.739***
	(126.710)	(99.901)	(143.011)	(15.049)	(59.402)	(89.340)	(15.140)
Religious activities	66.800	98.484	67.806	30.678***	103.000	74.030	28.970**
	(73.032)	(52.998)	(72.297)	(7.680)	(54.923)	(86.910)	(14.641)
Associations activities	38.510	51.167	53.292	-2.125	51.140	63.433	-12.293
	(64.111)	(56.928)	(78.451)	(8.316)	(61.672)	(91.500)	(15.533)
Sleeping/resting	443.733	320.338	393.369	-73.031***	357.419	378.470	-21.052
	(200.331)	(144.266)	(209.574)	(21.993)	(118.687)	(240.611)	(39.637)
Traveling	50.659	67.085	59.858	7.227	84.047	63.881	20.166
	(78.867)	(65.933)	(81.131)	(8.816)	(68.957)	(85.599)	(14.917)
Other	6.947	17.705	0.528	17.177***	0.000	2.687	-2.687
	(47.912)	(93.835)	(10.280)	(6.204)	(0.000)	(23.120)	(3.670)
Female household member							
Chores and hygiene	191.798	156.273	177.704	-21.430**	152.587	167.240	-14.653
	(91.498)	(68.239)	(99.254)	(10.376)	(71.670)	(66.240)	(11.814)
Taking care of children/elderly	144.810	181.658	137.012	44.646***	185.130	118.900	66.230***
	(94.768)	(77.602)	(99.626)	(10.656)	(80.134)	(70.447)	(12.736)
Fetching water	86.066	123.677	86.363	37.314***	123.587	91.167	32.420***
	(60.331)	(67.128)	(59.203)	(7.012)	(72.630)	(59.736)	(11.014)
Farm work	273.222	163.907	252.476	-88.569***	195.848	264.087	-68.239***
	(157.844)	(147.821)	(151.330)	(17.097)	(157.363)	(142.094)	(25.501)
Work on business	95.472	111.692	120.212	-8.520	67.022	166.500	-99.478***
	(137.512)	(126.184)	(140.304)	(15.504)	(120.140)	(137.236)	(23.346)
Work for others	19.132	60.720	29.386	31.334***	38.478	24.933	13.545
	(67.228)	(122.290)	(65.829)	(9.826)	(100.487)	(49.082)	(11.328)
Studying	12.085	30.380	22.642	7.738	27.065	20.767	6.299
	(41.734)	(54.282)	(44.759)	(5.433)	(65.884)	(41.778)	(8.476)
Leisure	116.733	184.634	120.336	64.298***	202.152	87.533	114.619***
	(111.239)	(93.963)	(103.884)	(11.496)	(72.226)	(79.958)	(13.685)
Religious activities	65.595	109.399	75.898	33.501***	96.500	69.800	26.700**
	(70.829)	(57.469)	(68.914)	(7.479)	(55.431)	(71.210)	(11.873)
Associations activities	34.336	40.056	57.658	-17.602**	38.043	59.133	-21.090*
	(61.024)	(50.668)	(75.523)	(7.864)	(44.077)	(78.502)	(12.594)
Sleeping/resting	418.661	320.314	353.005	-32.691	352.413	340.900	11.513
	(174.766)	(131.762)	(189.813)	(19.875)	(132.863)	(193.982)	(31.773)
Traveling	29.545	63.684	50.068	13.616	55.783	61.567	-5.784
	(60.445)	(70.212)	(77.990)	(8.620)	(64.689)	(84.424)	(14.043)
Other	3.452	2.041	0.000	2.041	0.000	0.000	0.000
	(31.104)	(26.147)	(0.000)	(1.614)	(0.000)	(0.000)	(0.000)
Observations	1,444	110	307	417	47	152	199

Notes: Columns 1, 2, 3, 5, and 6 report means and standard deviations (in parenthesis). Columns 4 and 7 report differences in means and the respective standard errors (in parenthesis). $* p < .10$, $** p < .05$, $*** p < .01$.

4.3. Health, Nutrition, and Food Security

4.3.1. Health

For each of the household members, we asked whether they had suffered from an illness in the 2 weeks prior to the survey (Table 12). We found that about 27% had been sick during that period. The most common types of diseases were reported to be vector-borne (malaria, yellow fever, and sleeping sickness), affecting 22% of the individuals, while waterborne diseases (schistosomiasis, diarrhoea, cholera, typhoid, hepatitis A, dysentery) affected only 3% of the individuals in our sample.

People in treated and control communities were sick at similar rates. However, the incidence of waterborne diseases was higher in treated communities than in control communities.

Table 12 - Health

Variable	(1) Overall	(2) Treaded reservoirs	(3) Control reservoirs	(4) Diff	(5) Treated households	(6) Control Households	(7) Diff
Any illness in the past 2 weeks	0.266	0.282	0.248	0.034	0.253	0.255	-0.002
	(0.308)	(0.298)	(0.314)	(0.034)	(0.334)	(0.303)	(0.053)
Waterborne diseases in the past 2 weeks	0.033	0.078	0.024	0.054***	0.059	0.012	0.047***
	(0.099)	(0.151)	(0.092)	(0.012)	(0.158)	(0.050)	(0.015)
Vector-borne diseases in the past 2 weeks	0.219	0.199	0.213	-0.014	0.193	0.236	-0.043
	(0.285)	(0.256)	(0.299)	(0.031)	(0.309)	(0.297)	(0.051)
Observations	1,444	110	307	417	47	152	199

Notes: Columns 1, 2, 3, 5, and 6 report means and standard deviations (in parenthesis). Columns 4 and 7 report differences in means and the respective standard errors (in parenthesis). $* p < .10$, $** p < .05$, $*** p < .01$.

4.3.2. Food security

As presented in Table 13, food insecurity is severe in the study area, with 54% of households reporting being worried about not having enough food, more than 51% reporting not eating enough or skipping meals, and up to 25% reporting not eating for an entire day because of a lack of money and other resources.

Food insecurity is much more prevalent in control communities than in treated communities. Indeed, in the control community, over 61% of the households reported not having enough to eat, while only about 21% did so in treated communities.

Table 13 – Food security (in the past 12 months, did you or others in the household…)

Variable	(1) Overall	(2) Treaded reservoirs	(3) Control reservoirs	(4) Diff	(5) Treated households	(6) Control Households	(7) Diff
Worry about not having enough food	0.542	0.134	0.570	-0.436***	0.170	0.473	-0.303***
	(0.498)	(0.342)	(0.496)	(0.050)	(0.380)	(0.501)	(0.082)
Find yourself unable to eat healthy and nutritious food	0.577	0.177	0.605	-0.428***	0.234	0.497	-0.263***
	(0.494)	(0.383)	(0.490)	(0.050)	(0.428)	(0.502)	(0.083)
Eat only a few kinds of food	0.592	0.200	0.602	-0.402***	0.234	0.491	-0.257***
	(0.492)	(0.402)	(0.490)	(0.051)	(0.428)	(0.502)	(0.083)
Skip a meal	0.513	0.153	0.538	-0.385***	0.191	0.371	-0.180**
	(0.500)	(0.362)	(0.499)	(0.051)	(0.398)	(0.485)	(0.080)
Eat less than you should	0.550	0.209	0.607	-0.398***	0.170	0.425	-0.255***
	(0.498)	(0.409)	(0.489)	(0.051)	(0.380)	(0.496)	(0.081)
Run out of food stock	0.485	0.150	0.548	-0.398***	0.170	0.377	-0.207**
	(0.500)	(0.359)	(0.499)	(0.050)	(0.380)	(0.486)	(0.080)
Feel hungry but did not eat	0.426	0.155	0.501	-0.346***	0.170	0.395	-0.225***
	(0.495)	(0.363)	(0.501)	(0.051)	(0.380)	(0.491)	(0.080)
Go without eating for a whole day	0.248	0.159	0.274	-0.115**	0.170	0.156	0.015
	(0.432)	(0.368)	(0.447)	(0.046)	(0.380)	(0.364)	(0.063)
Observations	1,444	110	307	417	47	152	199

Notes: Columns 1, 2, 3, 5, and 6 report means and standard deviations (in parenthesis). Columns 4 and 7 report differences in means and the respective standard errors (in parenthesis). $* p < .10$, $** p < .05$, $*** p < .01$.

4.3.3. Food composition

Looking at food composition in Table 14, we see that 94% of the households had cereals and grains, 92% had green leafy vegetables. Fish is the most common source of proteins, consumed by 80% of households, while 32% consumed eggs or milk and other dairy products, and 38% consumed meat.

Treated communities consume more proteins (meat, fish, liver, eggs, and dairy) compared to control communities that, instead, consume more cereals and legumes.

Table 14 – Food composition (in the last 7 days, did your household consume…)

Variable	(1) Overall	(2) Treaded reservoirs	(3) Control reservoirs	(4) Diff	(5) Treated households	(6) Control Households	(7) Diff
Cereals and grains	0.941	0.929	0.977	-0.048**	0.979	0.970	0.009
	(0.235)	(0.258)	(0.151)	(0.020)	(0.146)	(0.171)	(0.028)
Roots and tubers	0.554	0.652	0.514	0.138**	0.745	0.611	0.134
	(0.497)	(0.479)	(0.501)	(0.054)	(0.441)	(0.489)	(0.082)
Pulses, legumes, nuts, and seeds	0.694	0.681	0.772	-0.091*	0.596	0.826	-0.231***
	(0.461)	(0.468)	(0.420)	(0.047)	(0.496)	(0.380)	(0.070)
Orange vegetables and tubers	0.293	0.550	0.343	0.207***	0.617	0.395	0.222***
	(0.455)	(0.500)	(0.475)	(0.053)	(0.491)	(0.491)	(0.084)
Green leafy vegetables	0.922	0.834	0.922	-0.088***	0.894	0.922	-0.029
	(0.268)	(0.374)	(0.268)	(0.033)	(0.312)	(0.269)	(0.048)
Other vegetables	0.872	0.858	0.835	0.023	0.851	0.940	-0.089*
	(0.334)	(0.350)	(0.371)	(0.040)	(0.360)	(0.238)	(0.046)
Orange fruits	0.128	0.353	0.155	0.198***	0.128	0.222	-0.094
	(0.334)	(0.480)	(0.363)	(0.043)	(0.337)	(0.417)	(0.069)
Other fruits	0.165	0.361	0.165	0.196***	0.426	0.251	0.174**
	(0.372)	(0.482)	(0.372)	(0.044)	(0.500)	(0.435)	(0.077)
Meat	0.381	0.573	0.414	0.159***	0.702	0.581	0.121
	(0.486)	(0.497)	(0.493)	(0.054)	(0.462)	(0.495)	(0.084)
Fish/seafood	0.800	0.886	0.803	0.084**	0.936	0.868	0.068
	(0.400)	(0.319)	(0.399)	(0.041)	(0.247)	(0.339)	(0.055)
Liver, kidney, etc	0.125	0.297	0.175	0.121***	0.234	0.263	-0.029
	(0.330)	(0.459)	(0.381)	(0.044)	(0.428)	(0.442)	(0.075)
Eggs	0.323	0.478	0.336	0.142***	0.426	0.449	-0.024
	(0.468)	(0.502)	(0.473)	(0.052)	(0.500)	(0.499)	(0.085)
Milk and other dairy products	0.338	0.664	0.292	0.372***	0.617	0.413	0.204**
	(0.473)	(0.474)	(0.456)	(0.050)	(0.491)	(0.494)	(0.085)
Oil, fat, and butter	0.814	0.707	0.810	-0.103**	0.766	0.904	-0.138**
	(0.389)	(0.457)	(0.393)	(0.045)	(0.428)	(0.295)	(0.056)
Sugar and sweetener	0.765	0.786	0.706	0.080*	0.851	0.862	-0.011
	(0.424)	(0.412)	(0.457)	(0.048)	(0.360)	(0.346)	(0.060)
Misc. condiments, spices, tea, coffee, etc.	0.498	0.490	0.407	0.083	0.468	0.479	-0.011
	(0.500)	(0.502)	(0.492)	(0.054)	(0.504)	(0.501)	(0.086)
Observations	1,444	110	307	417	47	152	199

Notes: Columns 1, 2, 3, 5, and 6 report means and standard deviations (in parenthesis). Columns 4 and 7 report differences in means and the respective standard errors (in parenthesis). $* p < .10$, $** p < .05$, $*** p < .01$.

4.4. Shocks and Coping Strategies

4.4.1. Shocks

About 67% of the households in the sample experienced shocks in the 12 months prior to the survey (see Table 15). The most common shocks experienced are increased food and input prices, both reported by 43-46% of the sample. Other common shocks include livestock disease or loss, experienced by 33% of the sample, and drought, experienced by 15% of the sample.

Interestingly, households in the control communities were more likely to experience shocks than the households in the treated communities, which might partly explain the lower income and the higher food insecurity discussed above.

Table 15 – Shocks experienced in the past 12 months

Variable	(1) Overall	(2) Treaded reservoirs	(3) Control reservoirs	(4) Diff	(5) Treated households	(6) Control Households	(7) Diff
Any shock in past 12 months	0.669	0.401	0.537	-0.136**	0.511	0.485	0.026
	(0.471)	(0.492)	(0.499)	(0.054)	(0.505)	(0.501)	(0.086)
Drought	0.145	0.000	0.069	-0.069***	0.000	0.174	-0.174***
	(0.352)	(0.000)	(0.253)	(0.023)	(0.000)	(0.380)	(0.058)
Flood	0.029	0.008	0.001	0.007	0.000	0.006	-0.006
	(0.168)	(0.089)	(0.033)	(0.006)	(0.000)	(0.077)	(0.012)
Locust	0.018	0.000	0.020	-0.020	0.000	0.012	-0.012
	(0.133)	(0.000)	(0.142)	(0.013)	(0.000)	(0.109)	(0.017)
Livestock disease/loss	0.327	0.074	0.231	-0.157***	0.170	0.269	-0.099
	(0.469)	(0.263)	(0.422)	(0.042)	(0.380)	(0.445)	(0.074)
Conflict/violence	0.003	0.000	0.010	-0.010	0.000	0.000	0.000
	(0.055)	(0.000)	(0.100)	(0.009)	(0.000)	(0.000)	(0.000)
Death of a household member	0.080	0.117	0.024	0.093***	0.128	0.018	0.110***
	(0.272)	(0.323)	(0.155)	(0.023)	(0.337)	(0.133)	(0.034)
Increased food prices	0.431	0.254	0.415	-0.161***	0.426	0.377	0.048
	(0.495)	(0.437)	(0.494)	(0.052)	(0.500)	(0.486)	(0.084)
Increased input prices	0.459	0.239	0.367	-0.128**	0.468	0.419	0.049
	(0.498)	(0.429)	(0.483)	(0.051)	(0.504)	(0.495)	(0.085)
Theft	0.073	0.033	0.028	0.005	0.000	0.036	-0.036
	(0.260)	(0.179)	(0.166)	(0.019)	(0.000)	(0.187)	(0.028)
Observations	1,444	110	307	417	47	152	199

Notes: Columns 1, 2, 3, 5, and 6 report means and standard deviations (in parenthesis). Columns 4 and 7 report differences in means and the respective standard errors (in parenthesis). $* p < .10$, $** p < .05$, $*** p < .01$.

4.4.2. Coping Strategies

Table 16 presents the coping strategies. In case of shock, the most common coping strategies were selling products, adopted by 46% of households, using savings (43%), and receiving help from family and friends (36%).

While households in the treated communities were more likely to sell products, engage in additional activities, and receive help from friends. In control communities, households often reduced consumption of food and non-food items and were more likely not to put in place any coping strategy.

4.5. Access to Water

4.5.1. Main sources of water

Boreholes are the main source of water for the households in the sample, regardless of use and season (dry or rainy) and are used by 60-70% of the households. Rainwater is used by 5-10% of the households only during the rainy season, and dam/reservoir water is used by 3-8% of the households during the dry season and more rarely during the rainy season (Figure 5).

Interestingly, households in treated communities are much more likely to use the water of the dam, especially during the dry season and much less likely to use boreholes, compared to households in control communities. For example, 30% of the households in the treated communities report using the reservoir as the main source of drinking water during the dry season, while none of the households in the control communities report doing so. Households in the sample typically take 9.6 minutes to reach the water source during the dry season and 9.3 minutes during the rainy season (Table 17).

Table 16 – Coping strategies (for those who experienced shocks)

Variable	(1) Overall	(2) Treaded reservoirs	(3) Control reservoirs	(4) Diff	(5) Treated households	(6) Control Households	(7) Diff
Sold ag and non-ag products	0.457	0.765	0.527	0.238***	0.792	0.284	0.508***
	(0.498)	(0.429)	(0.501)	(0.082)	(0.415)	(0.454)	(0.109)
Took up additional activities	0.136	0.549	0.121	0.428***	0.458	0.222	0.236**
	(0.343)	(0.503)	(0.327)	(0.063)	(0.509)	(0.419)	(0.108)
Help from family and friends	0.356	0.695	0.278	0.417***	0.667	0.333	0.333***
	(0.479)	(0.466)	(0.449)	(0.077)	(0.482)	(0.475)	(0.116)
Loan from family and friends	0.154	0.563	0.182	0.381***	0.542	0.272	0.270**
	(0.361)	(0.501)	(0.387)	(0.070)	(0.509)	(0.448)	(0.113)
Loan from a financial institution	0.030	0.080	0.015	0.066**	0.083	0.012	0.071*
	(0.169)	(0.275)	(0.120)	(0.028)	(0.282)	(0.111)	(0.040)
Bought on credit	0.157	0.026	0.122	-0.096*	0.042	0.185	-0.144
	(0.364)	(0.161)	(0.328)	(0.051)	(0.204)	(0.391)	(0.087)
Pre-sold harvest	0.059	0.034	0.026	0.008	0.083	0.049	0.034
	(0.235)	(0.183)	(0.158)	(0.028)	(0.282)	(0.218)	(0.057)
Used savings	0.433	0.422	0.496	-0.074	0.250	0.593	-0.343***
	(0.496)	(0.499)	(0.502)	(0.085)	(0.442)	(0.495)	(0.118)
Had insurance	0.008	0.098	0.002	0.096***	0.042	0.012	0.029
	(0.087)	(0.300)	(0.046)	(0.025)	(0.204)	(0.111)	(0.034)
Reduced food consumption	0.304	0.085	0.413	-0.327***	0.125	0.321	-0.196*
	(0.460)	(0.282)	(0.494)	(0.077)	(0.338)	(0.470)	(0.109)
Reduced non-food consumption	0.098	0.000	0.206	-0.206***	0.000	0.148	-0.148*
	(0.298)	(0.000)	(0.406)	(0.060)	(0.000)	(0.358)	(0.077)
Help from Government	0.009	0.007	0.000	0.007	0.042	0.000	0.042*
	(0.096)	(0.085)	(0.000)	(0.007)	(0.204)	(0.000)	(0.024)
Help from NGO	0.009	0.066	0.000	0.066***	0.000	0.000	0.000
	(0.095)	(0.252)	(0.000)	(0.020)	(0.000)	(0.000)	(0.000)
Migrated	0.009	0.000	0.000	0.000	0.000	0.000	0.000
	(0.092)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Didn't do anything	0.318	0.062	0.286	-0.224***	0.042	0.296	-0.255**
	(0.466)	(0.244)	(0.453)	(0.070)	(0.204)	(0.460)	(0.102)
Other	0.019	0.000	0.043	-0.043	0.000	0.000	0.000
	(0.136)	(0.000)	(0.204)	(0.030)	(0.000)	(0.000)	(0.000)
Observations	895	47	153	200	24	71	95

Notes: Columns 1, 2, 3, 5, and 6 report means and standard deviations (in parenthesis). Columns 4 and 7 report differences in means and the respective standard errors (in parenthesis). $* p < .10$, $** p < .05$, $*** p < .01$.

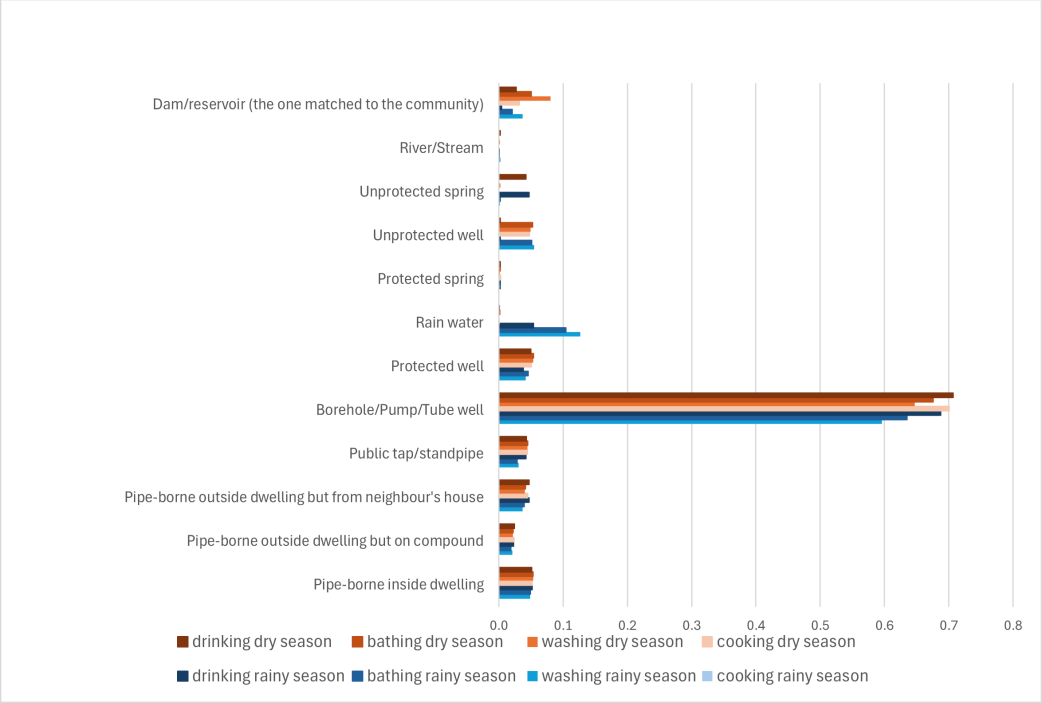

Figure 5: Sources of water

Note: The graph shows the share of households reporting each source of water as the main source for each use and season

A person getting water from the dam in Nansoni. Photo: Giulia Zane

Table 17– Main water sources

Variable	(1) Overall	(2) Treaded reservoirs	(3) Control reservoirs	(4) Diff	(5) Treated households	(6) Control Households	(7) Diff
Main source of water for:							
dry season cooking: Borehole	0.721	0.120	0.799	-0.679***	0.191	0.784	-0.593***
	(0.449)	(0.326)	(0.401)	(0.042)	(0.398)	(0.413)	(0.070)
dry season cooking: Dam	0.021	0.328	0.000	0.328***	0.362	0.000	0.362***
	(0.144)	(0.472)	(0.000)	(0.027)	(0.486)	(0.000)	(0.039)
rainy season cooking: Borehole	0.680	0.104	0.772	-0.668***	0.128	0.749	-0.621***
	(0.467)	(0.306)	(0.420)	(0.043)	(0.337)	(0.435)	(0.071)
rainy season cooking: Dam	0.004	0.044	0.000	0.044***	0.021	0.000	0.021*
	(0.063)	(0.206)	(0.000)	(0.012)	(0.146)	(0.000)	(0.012)
dry season washing: Borehole	0.659	0.111	0.779	-0.668***	0.149	0.760	-0.612***
	(0.474)	(0.315)	(0.416)	(0.042)	(0.360)	(0.428)	(0.071)
dry season washing: Dam	0.073	0.445	0.013	0.433***	0.362	0.012	0.350***
	(0.260)	(0.499)	(0.112)	(0.031)	(0.486)	(0.109)	(0.042)
rainy season washing: Borehole	0.605	0.097	0.742	-0.645***	0.106	0.719	-0.612***
	(0.489)	(0.297)	(0.438)	(0.044)	(0.312)	(0.451)	(0.073)
rainy season washing: Dam	0.036	0.178	0.016	0.161***	0.043	0.006	0.037*
	(0.187)	(0.384)	(0.127)	(0.025)	(0.204)	(0.077)	(0.020)
dry season bathing: Borehole	0.693	0.114	0.785	-0.671***	0.149	0.766	-0.618***
	(0.461)	(0.320)	(0.412)	(0.042)	(0.360)	(0.424)	(0.070)
dry season bathing: Dam	0.041	0.408	0.007	0.401***	0.383	0.006	0.377***
	(0.199)	(0.494)	(0.084)	(0.030)	(0.491)	(0.077)	(0.041)
rainy season bathing: Borehole	0.650	0.098	0.759	-0.661***	0.085	0.737	-0.651***
	(0.477)	(0.299)	(0.429)	(0.043)	(0.282)	(0.442)	(0.071)
rainy season bathing: Dam	0.020	0.085	0.007	0.078***	0.021	0.006	0.015
	(0.140)	(0.281)	(0.084)	(0.018)	(0.146)	(0.077)	(0.017)
dry season drinking: Borehole	0.728	0.117	0.792	-0.675***	0.170	0.778	-0.608***
	(0.445)	(0.323)	(0.406)	(0.042)	(0.380)	(0.417)	(0.070)
dry season drinking: Dam	0.018	0.308	0.000	0.308***	0.383	0.000	0.383***
	(0.132)	(0.464)	(0.000)	(0.027)	(0.491)	(0.000)	(0.039)
rainy season drinking: Borehole	0.709	0.106	0.773	-0.667***	0.149	0.754	-0.606***
	(0.454)	(0.310)	(0.420)	(0.043)	(0.360)	(0.432)	(0.071)
rainy season drinking: Dam	0.003	0.035	0.003	0.032***	0.021	0.000	0.021*
	(0.056)	(0.185)	(0.055)	(0.012)	(0.146)	(0.000)	(0.012)
Time to water dry season	9.598	14.547	8.177	6.370***	15.404	9.641	5.764***
	(9.044)	(9.609)	(8.118)	(0.932)	(10.815)	(9.865)	(1.726)
Time to water rainy season	9.274	9.320	7.746	1.575**	10.011	8.635	1.376
	(8.789)	(7.052)	(7.244)	(0.783)	(8.227)	(7.545)	(1.318)
Observations	1,444	110	307	417	47	152	199

Notes: Columns 1, 2, 3, 5, and 6 report means and standard deviations (in parenthesis). Columns 4 and 7 report differences in means and the respective standard errors (in parenthesis). $* p < .10$, $** p < .05$, $*** p < .01$.

4.5.2. Water Security

The households in the same were chosen among those living in proximity to dams large enough to hold water all year around. Therefore, it is not surprising that water security in this sample is quite high (Table 18). Nonetheless, we find that 10% of the sample worried about not having enough water for their domestic needs and 13% worried about not having enough water for their productive needs in the 12 months prior to the survey. Moreover, 18% of the households worried about climate events that could affect water availability, such as drought or floods.

Restrictions to water use for drinking and domestic purposes were experienced by 2-10% of the sample, and 3-7% of the sample reported that their production suffered because of problems with water.

The main aspect of water insecurity for this sample, however, is migration caused by lack of water (or dry season migration), which affected 20% of the households.

In general, treated communities seem to worry less about problems with water and report less dry season migration (6% vs 17% in control communities). However, households in treated communities are more likely to report that their non-agricultural activities suffered because of problems with water, that access to water restricts their agricultural decisions and that access to water generates conflict within the community.

Table 18 – Water security (in the last 12 months, did you or someone in your household…)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variable	Overall	Treaded reservoirs	Control reservoirs	Diff	Treated households	Control Households	Diff
Worry about not having enough water for domestic needs	0.104	0.065	0.104	-0.039	0.043	0.090	-0.047
	(0.306)	(0.247)	(0.305)	(0.032)	(0.204)	(0.287)	(0.046)
Were thirsty but did not drink because of problems with water	0.037	0.079	0.041	0.038	0.064	0.042	0.022
	(0.189)	(0.272)	(0.199)	(0.024)	(0.247)	(0.201)	(0.036)
Restrict the use of water for cooking because of problems with water	0.025	0.059	0.025	0.034*	0.021	0.012	0.009
	(0.156)	(0.237)	(0.157)	(0.020)	(0.146)	(0.109)	(0.020)
Go without washing hands or body because of problems with water	0.024	0.071	0.017	0.054***	0.000	0.012	-0.012
	(0.153)	(0.258)	(0.129)	(0.019)	(0.000)	(0.109)	(0.017)
Go without cleaning the house or utensils because of problems with water	0.101	0.071	0.110	-0.039	0.000	0.114	-0.114**
	(0.301)	(0.258)	(0.313)	(0.033)	(0.000)	(0.319)	(0.048)
Worry about not having enough water for productive needs	0.128	0.071	0.129	-0.059*	0.000	0.156	-0.156***
	(0.334)	(0.258)	(0.336)	(0.034)	(0.000)	(0.364)	(0.055)
Agricultural production suffered because of problems with water	0.065	0.083	0.048	0.034	0.000	0.078	-0.078*
	(0.247)	(0.277)	(0.215)	(0.025)	(0.000)	(0.269)	(0.041)
Non-agricultural production suffered because of problems with water	0.027	0.047	0.012	0.036**	0.021	0.012	0.009
	(0.161)	(0.213)	(0.107)	(0.016)	(0.146)	(0.109)	(0.020)
Had to temporarily migrate because of problems with water	0.206	0.059	0.166	-0.107***	0.021	0.240	-0.218***
	(0.405)	(0.237)	(0.373)	(0.037)	(0.146)	(0.428)	(0.066)
Restrict agricultural decisions because of problems with water	0.022	0.056	0.010	0.046***	0.000	0.006	-0.006
	(0.148)	(0.231)	(0.101)	(0.016)	(0.000)	(0.077)	(0.012)
Conflict with community members because of problems with water	0.022	0.041	0.005	0.036***	0.000	0.006	-0.006
	(0.147)	(0.200)	(0.071)	(0.013)	(0.000)	(0.077)	(0.012)
Feel excluded from decisions related to water	0.023	0.030	0.017	0.012	0.000	0.024	-0.024
	(0.150)	(0.170)	(0.131)	(0.016)	(0.000)	(0.153)	(0.023)
Worry about climatic events impacting access to water	0.183	0.056	0.192	-0.136***	0.021	0.323	-0.302***
	(0.386)	(0.231)	(0.394)	(0.039)	(0.146)	(0.469)	(0.072)
Observations	1,444	110	307	417	47	152	199

Notes: Columns 1, 2, 3, 5, and 6 report means and standard deviations (in parenthesis). Columns 4 and 7 report differences in means and the respective standard errors (in parenthesis). $* p < .10$, $** p < .05$, $*** p < .01$.

4.6. Uses of the Reservoir and Perceptions

4.6.1. Uses of the Reservoir

On average, survey respondents lived 1.6km from the reservoir, a distance that they reported covering in about 18 minutes (Table 19). The most common use of water from the reservoir (Figure 6) is construction (e.g., plastering), which is reported by 85% of the households, followed by livestock drinking, reported by 55% of the households, and vegetable irrigation (22%). The majority of households transport water by hand, typically on the head (40%), or by motorbike or tricycle (34%) (Figure 7).

Households in treated communities are more likely to use the reservoir for drinking, domestic uses, irrigation, bathing, mining, recreational activities, and processing agricultural products. Households in control communities are more likely to use it for fishing, livestock watering, and construction.

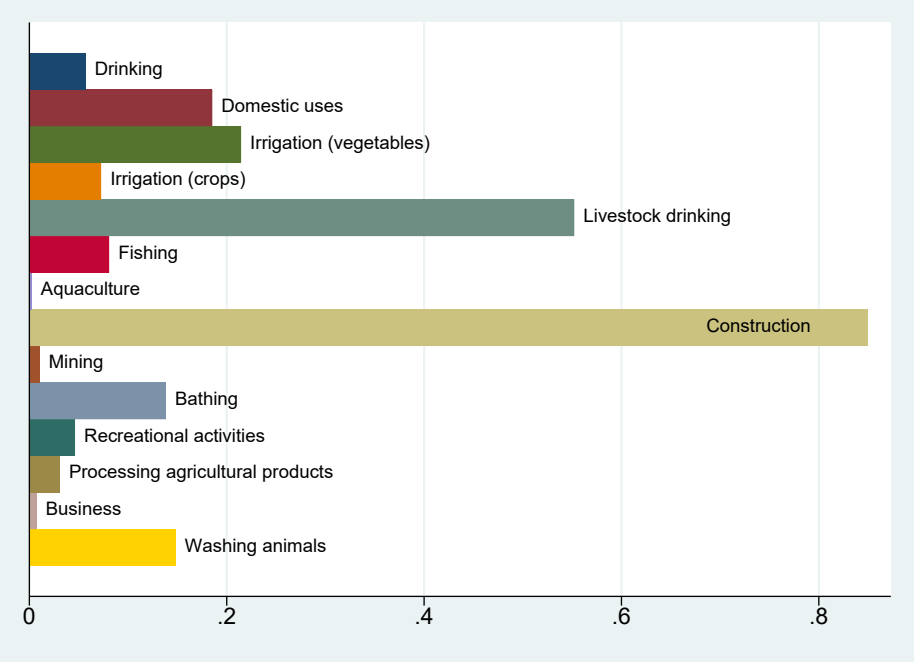

Figure 6: Uses of the reservoir

Note: The graph shows the share of households using the reservoir for each activity

Table 19 - Uses of the reservoir

Variable	(1) Overall	(2) Treaded reservoirs	(3) Control reservoirs	(4) Diff	(5) Treated households	(6) Control Households	(7) Diff
Distance from reservoir (km)	1.557	1.655	1.725	-0.070	1.620	1.581	0.039
	(1.895)	(1.613)	(1.626)	(0.198)	(1.800)	(1.435)	(0.278)
Distance from reservoir (minutes)	18.084	14.826	17.335	-2.509*	17.619	16.338	1.281
	(14.143)	(11.300)	(12.989)	(1.520)	(13.600)	(11.858)	(2.206)
Use water from the reservoir for:							
Drinking	0.057	0.511	0.034	0.477***	0.489	0.024	0.465***
	(0.232)	(0.502)	(0.182)	(0.033)	(0.505)	(0.153)	(0.047)
Domestic uses	0.185	0.577	0.183	0.394***	0.532	0.150	0.382***
	(0.389)	(0.496)	(0.387)	(0.046)	(0.504)	(0.358)	(0.068)
Irrigation (vegetables)	0.215	0.354	0.204	0.149***	0.319	0.192	0.128*
	(0.411)	(0.480)	(0.404)	(0.046)	(0.471)	(0.395)	(0.071)
Irrigation (crops)	0.073	0.141	0.093	0.048	0.043	0.096	-0.053
	(0.260)	(0.350)	(0.291)	(0.034)	(0.204)	(0.295)	(0.048)
Livestock drinking	0.552	0.459	0.600	-0.141***	0.532	0.647	-0.115
	(0.497)	(0.501)	(0.491)	(0.054)	(0.504)	(0.480)	(0.083)
Fishing	0.081	0.006	0.057	-0.051**	0.043	0.054	-0.011
	(0.273)	(0.076)	(0.231)	(0.022)	(0.204)	(0.227)	(0.038)
Aquaculture	0.002	0.066	0.001	0.064***	0.489	0.006	0.483***
	(0.049)	(0.249)	(0.033)	(0.015)	(0.505)	(0.077)	(0.042)
Construction	0.849	0.736	0.850	-0.113***	0.745	0.844	-0.100
	(0.358)	(0.443)	(0.358)	(0.042)	(0.441)	(0.364)	(0.065)
Mining	0.010	0.029	0.000	0.029***	0.085	0.000	0.085***
	(0.101)	(0.170)	(0.000)	(0.010)	(0.282)	(0.000)	(0.023)
Bathing	0.138	0.563	0.159	0.404***	0.532	0.090	0.442***
	(0.345)	(0.498)	(0.367)	(0.044)	(0.504)	(0.287)	(0.059)
Recreational activities	0.046	0.176	0.047	0.129***	0.319	0.000	0.319***
	(0.210)	(0.383)	(0.212)	(0.029)	(0.471)	(0.000)	(0.038)
Processing agricultural products	0.031	0.188	0.013	0.175***	0.234	0.018	0.216***
	(0.173)	(0.392)	(0.112)	(0.025)	(0.428)	(0.133)	(0.040)
Business	0.007	0.008	0.007	0.000	0.000	0.012	-0.012
	(0.086)	(0.089)	(0.086)	(0.009)	(0.000)	(0.109)	(0.017)
Washing animals	0.148	0.255	0.218	0.037	0.255	0.174	0.082
	(0.356)	(0.438)	(0.413)	(0.046)	(0.441)	(0.380)	(0.067)
Means of transport of water from the reservoir							
Solar pump	0.006	0.035	0.001	0.034***	0.000	0.006	-0.006
	(0.077)	(0.185)	(0.033)	(0.011)	(0.000)	(0.077)	(0.012)
Diesel pump	0.027	0.016	0.031	-0.016	0.000	0.072	-0.072*
	(0.161)	(0.125)	(0.174)	(0.018)	(0.000)	(0.259)	(0.039)
Car or Truck	0.006	0.000	0.002	-0.002	0.000	0.012	-0.012
	(0.075)	(0.000)	(0.047)	(0.004)	(0.000)	(0.109)	(0.017)
Motorbike or Tricycle	0.342	0.220	0.383	-0.163***	0.340	0.299	0.041
	(0.474)	(0.416)	(0.487)	(0.051)	(0.479)	(0.460)	(0.079)
Bicycle	0.061	0.071	0.040	0.030	0.085	0.048	0.037
	(0.240)	(0.257)	(0.197)	(0.023)	(0.282)	(0.214)	(0.040)
Livestock	0.083	0.008	0.078	-0.070***	0.000	0.120	-0.120**
	(0.276)	(0.089)	(0.268)	(0.025)	(0.000)	(0.326)	(0.049)
By hand/on Head	0.401	0.550	0.348	0.201***	0.447	0.413	0.034
	(0.490)	(0.500)	(0.477)	(0.053)	(0.503)	(0.494)	(0.085)
Canal	0.006	0.000	0.007	-0.007	0.000	0.000	0.000
	(0.078)	(0.000)	(0.082)	(0.008)	(0.000)	(0.000)	(0.000)
Observations	1,444	110	307	417	47	152	199

Notes: Columns 1, 2, 3, 5, and 6 report means and standard deviations (in parenthesis). Columns 4 and 7 report differences in means and the respective standard errors (in parenthesis). $* p < .10$, $** p < .05$, $*** p < .01$.

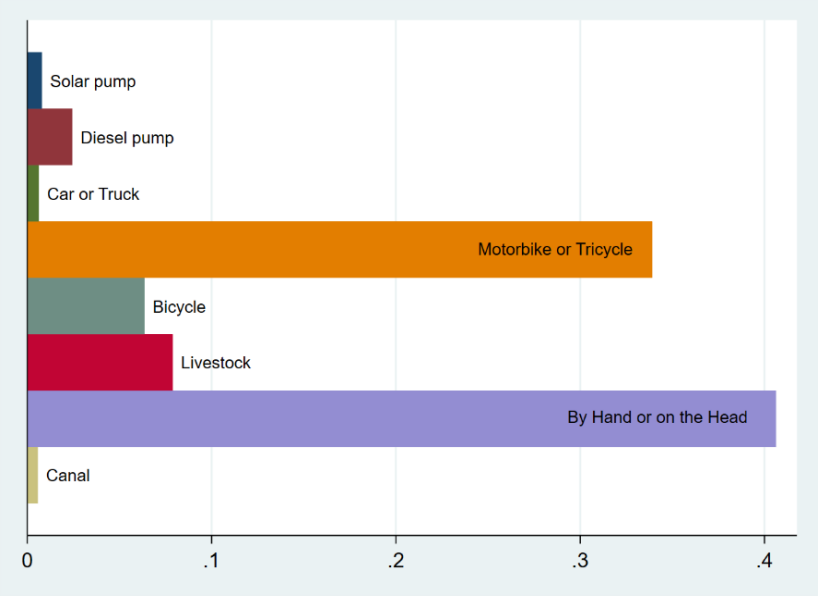

Figure 7: Main means of transport of water from the reservoirs

Note: The graph shows the share of households using different means to transport water from the reservoir.

4.6.2. Perception of quality of water

Households participating in the survey were asked about their perceptions of the quality of water in the reservoir and responses are presented in Table 20. On average, respondents the quality of water to be insufficient for domestic uses (scoring 2.15 out of 5), while they agreed that water is generally good for irrigation and fish (with scores of 3.7-3.8). Most of the respondents disagreed with the statement that the reservoir brings illness and diseases to the community.

The quality of the water in the reservoirs is perceived to be better in treatment communities than in control communities, scoring higher in all criteria.

Table 20 - Perceptions of water quality (1 completely agree – 5 completely disagree)

Variable	(1) Overall	(2) Treaded reservoirs	(3) Control reservoirs	(4) Diff	(5) Treated households	(6) Control Households	(7) Diff
The quality of the water of the reservoir is low and it is not suitable for domestic uses	2.147	2.545	2.055	0.490***	3.213	1.916	1.297***
	(1.564)	(1.627)	(1.496)	(0.167)	(1.654)	(1.471)	(0.259)
The quality of the water of the reservoir is low and it is not suitable for irrigation	3.680	3.873	3.752	0.121	4.468	3.754	0.714***
	(1.610)	(1.449)	(1.608)	(0.170)	(1.018)	(1.638)	(0.261)
The quality of the water of the reservoir is low and it is not suitable for the fish	3.790	4.112	3.773	0.339**	4.511	3.814	0.696***
	(1.535)	(1.346)	(1.549)	(0.163)	(0.882)	(1.597)	(0.252)
Irrigation from water in the reservoir is restricted to a limited number of farmers	3.349	4.192	3.373	0.818***	4.617	3.090	1.527***
	(1.621)	(1.413)	(1.569)	(0.166)	(1.033)	(1.646)	(0.263)
The reservoir brings illness and diseases to the community	4.044	3.835	4.101	-0.267*	4.234	3.737	0.498**
	(1.345)	(1.447)	(1.229)	(0.141)	(1.146)	(1.510)	(0.246)
The reservoir supports a healthy ecosystem near the community	1.918	1.862	1.977	-0.115	1.638	1.790	-0.152
	(1.156)	(1.145)	(1.185)	(0.128)	(1.031)	(1.182)	(0.197)
Observations	1,444	110	307	417	47	152	199

Notes: Columns 1, 2, 3, 5, and 6 report means and standard deviations (in parenthesis). Columns 4 and 7 report differences in means and the respective standard errors (in parenthesis). $* p < .10$, $** p < .05$, $*** p < .01$.

4.6.3. Perceptions of Aquaculture

The subset of respondents that knew what aquaculture was (almost 98% of the sample) was asked a set of questions about their perceptions of aquaculture as a livelihood option (Table 21). Almost everyone (94%) said that aquaculture could be a livelihood option and a large majority strongly agreed that it could lead to generating high income in a relatively short amount of time. They also agree that it requires high investment and training and that it is a risky business. Finally, they disagree that there is no demand for fish in the community.

Perceptions in treatment and control communities are similar, with the exception that the treatment communities are less likely to "strongly" agree that aquaculture requires complex training and more likely to "strongly" disagree that there is no demand for fish in the community.

Aquaculture cages installed by the project in Nalerigu dam. Photo: Barbara van Rijn

Table 21 - Perceptions of aquaculture (1 completely agree – 5 completely disagree)

Variable	(1) Overall	(2) Treaded reservoirs	(3) Control reservoirs	(4) Diff	(5) Treated households	(6) Control Households	(7) Diff
Do you consider aquaculture as an alternative livelihood option?	0.938	0.937	0.933	0.003	1.000	0.899	0.101
	(0.242)	(0.246)	(0.250)	(0.038)	(0.000)	(0.302)	(0.089)
Aquaculture can generate high incomes in a relatively short time	1.236	1.233	1.306	-0.073	1.300	1.179	0.121
	(0.627)	(0.673)	(0.803)	(0.107)	(0.853)	(0.527)	(0.115)
Aquaculture requires high investment costs	1.696	1.669	1.743	-0.074	1.675	1.421	0.254*
	(0.939)	(0.779)	(0.939)	(0.125)	(0.997)	(0.731)	(0.149)
Aquaculture is a risky business (due to illness of fish, risk of theft, etc.)	2.306	2.226	2.036	0.190	1.900	1.800	0.100
	(1.260)	(1.265)	(1.135)	(0.160)	(1.150)	(1.020)	(0.197)
Aquaculture requires complex training	2.167	2.111	1.808	0.303**	2.575	1.579	0.996***
	(1.251)	(1.019)	(0.968)	(0.134)	(1.357)	(1.019)	(0.206)
There is no demand for fish in my community	4.231	4.932	4.187	0.745***	4.800	4.271	0.529**
	(1.360)	(0.438)	(1.336)	(0.165)	(0.883)	(1.373)	(0.240)
Observations	1,444	110	307	417	47	152	199

Notes: Columns 1, 2, 3, 5, and 6 report means and standard deviations (in parenthesis). Columns 4 and 7 report differences in means and the respective standard errors (in parenthesis). $* p < .10$, $** p < .05$, $*** p < .01$.

5. SUMMARY OF THE FINDINGS

Although fish constitutes the most common source of proteins for the households in the sample, fishing and aquaculture are rarely practised. The most common source of livelihood is by far crop farming, practised by over 94% of households, followed by livestock keeping, practised by 71% of households. Petty trading is practised by 13% of the sample, about 9% received salaries and wages, and 5% conduct artisanal activities. Finally, almost 5% practice fishing or aquaculture.

Perceptions of aquaculture in the region appear to be positive, with 94% of the households who knew about aquaculture reporting it could be an alternative livelihood option for their sample and expecting it could be profitable. High investment and training requirements appear to be obstacles to higher adoption.

Compared to control communities, treated communities were found to have more diversified livelihood sources, higher wealth, and less food insecurity. Households in treated communities were less likely to be crop farmers and more likely to engage in petty trading. Wealth differences were found to be related to higher ownership of electronics (smartphones, laptops, TVs, and fridges) and motorbikes in treated communities. Food insecurity in the control communities was found to be very high, with about 50-60% of households reporting almost all types of deprivation.

Differences between the treatment and control groups do not necessarily invalidate the Impact Evaluation design, but they do suggest that we should be cautious in interpreting the results. The proposed difference-in-difference design only requires that the *changes* in outcomes from before to after the program would have been the same in the absence of the program. However, this assumption is less likely to hold when treatment and control groups are very different at baseline. To strengthen the credibility and robustness of the findings, it is crucial to complement the analysis with methods that adjust for observable differences between groups, such as propensity score matching. However, even with these adjustments, unobserved factors may still bias the results, underscoring the need for cautious interpretation and transparency about the study's limitations.

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