Baseline Report for the Millennium Challenge Account's Alatona Irrigation Project

February 2011

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Executive Summary

The main objective of this report is describe some of the rich set of information on characteristics of individuals, households and villages in the Alatona zone, plus comparable information from nearby villages, attained in the baseline survey of 2008-2009. This baseline report also outlines the overall design of Alatona Irrigation Project, the evaluation strategy proposed to estimate the project's impacts on beneficiaries, and provides details on the methodology used for data collection, including the sampling strategy and the questionnaire development. A reader most interested in the contents of the data can skip to section Community Descriptive Statistics. While the main focus of the report is the description of individuals, households and villages in the Alatona zone, we also include statistics on individuals, households and villages in nearby villages with irrigation (*irrigated villages)* and without irrigation *(non-irrigated villages*). The motivation for collecting information outside of the Alatona stems from the overall evaluation strategy explained in the report. The purpose of including the statistics from the irrigated and non-irrigated villages in this report provides a way to frame the statistics about the Alatona zone. This way we can gain insights into the zone both in absolute terms but also relative to nearby geographic areas.

As the Alatona Irrigation Project's primary objective is to increase agricultural production and reduce poverty, we note the striking differences that comes out of the data between Alatona households and those in the rest of the sample is in terms of agricultural production. There is very little agricultural output, of any crop, in the Alatona villages. These differences in production are driven by fewer hectares cultivated, since Alatona households cultivated an average of 0.35 hectares, while the irrigated and non-irrigated households cultivated 2 and 2.6 hectares, respectively. Differences between the irrigated villages and the Alatona are driven primarily by rice production; 5.2 tons per hectare in irrigated households in contrast to the 319 kilograms which are produced per hectare in the Alatona. When we examine agricultural income derived from crop sales, households in the Alatona received 30,537 FCFA during the 2008/2009 agricultural season while households in irrigated villages and non-irrigated villages generated 408,595 FCFA and 150,376 FCFA in agricultural revenue.

Differences in access to water and toilet facilities are equally striking as differences in agricultural production. Thirty-one percent of Alatona households used improved deep wells (boreholes), while villages outside of the Alatona had a higher level of access to improved deep wells, with 64 percent and 44 percent having access in irrigated and non-irrigated comparison households, respectively. Stark differences in toilet facilities are also present comparing the Alatona villages to the irrigated and non-irrigated villages. Sixty-four percent of Alatona

households have no toilet or latrine facilities and use the outside environment to evacuate human waste. Only 4-8 percent of households in the comparison group had no toilet or latrine facility.

Households in the Alatona also differ from households in the irrigated and non-irrigated villages in levels of human capital. Among the most striking statistics from the baseline data is the level of education among adults in the sample and current child enrollment. In irrigated villages, 25 percent of men had completed some education, while only 10 and 1.6 percent of men in the non-irrigated villages and the Alatona, respectively, had completed any education. Women from the irrigated areas had the highest levels of educational attainment with 10 percent having some education, while women in non-irrigated comparison villages had only a 2.8 percent educational achievement rate. Only 1.2 percent of women in the Alatona villages had any schooling. When we consider the educational participation rate of school-age children, we find the same pattern for children as we find for adults. 50 percent of boys in irrigated areas were currently enrolled while 41 percent of all girls of school age where enrolled. In comparison, 38 percent of boys and 24 percent of girls from non-irrigated comparison villages were enrolled. In the Alatona villages, 3 and 1.5 percent of boys and girls were enrolled. These statistics are striking as they suggest for both adults and children in the Alatona villages a persistent lack of access to school. They also suggest strong differences in investments in education made by households for boys relative to girls. This suggests that the Alatona Irrigation Project, in creating new communities and building schools to increase access to education, should also emphasize the importance of equal access to education.

The data also reveal interesting patterns in asset ownership. In the Alatona, women hold more assets than men do, but hold fewer assets than women in either the irrigated or non-irrigated villages. As total asset ownership among households in the Alatona is quite low, household durables - such as cooking materials and other household objects - are likely held by women, whereas men may hold fewer of these types of durable assets when households are poor. The value of assets held by women is also higher than the value of assets held by men in the Alatona. In the villages outside of the Alatona, we observe the same pattern that women own more assets than men; however, men have higher-valued assets than women have. Livestock, which is an additional form of assets but reported separately as livestock holding is of interest in its own right, shows the opposite trend. Both in terms of tropical livestock units and value of livestock, men have higher livestock holdings and values of these holdings than women. Most striking among all these asset comparisons is the high level of livestock holdings and value among men in the Alatona villages. These holdings are almost four times those reported by households in the irrigated and non-irrigated villages. Changes in livestock holdings over time, both in the Alatona and outside, will be of interest in the evaluation of the AIP.

These differences between the Alatona and households found in irrigated and non-irrigated villages are investigated in the report to highlight the attention that should be placed on some of these striking statistics in the final evaluation. The report covers additional information on numerous village characteristics, such as access to infrastructure, credit and health services, and on household and individual characteristics, including food and non-food expenditure, housing conditions, use of agricultural inputs and agricultural capital.

Acknowledgements

The authors would like to thank the tireless efforts of the Millennium Challenge Account- Mali and the Millennium Challenge Corporation. We have especially benefitted from interactions and insights from Madeleine Gauthier, Annette Richter, Tigana Kalilou, Abou I. Diawara, and Cheick Aliou Soumare, among many others. Nouhoum Traore provided excellent research assistance during his time at Innovations for Poverty Action-Mali. We appreciate the assistance of the Office du Niger and many staff members who assisted us in the formative stages of this research. The Environment and Social Development Company (ESDCO) conducted the fieldwork to collect the baseline data. The Centre d'Appui à la Recherche et à la Formation (CAREF) provided technical assistance with data entry and verification. Most importantly, we appreciate the cooperation and patience of survey respondents and community leaders who provided the information reported in this document and welcomed us with the finest forms of Malian hospitality.

Acronyms and Abbreviations

AIP	Alatona Irrigation Project
CAREF	Centre d'Appui à la Recherche et à la Formation
ESDCO	Environment and Social Development
IFPRI	International Food Policy Research Institute
IPA	Innovations for Poverty Action
MCA-Mali	Millennium Challenge Account-Mali
MCC	Millennium Challenge Corporation
ON	Office du Niger
PAP	Project Affected People

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Introduction

The Millennium Challenge Corporation (MCC) Compact in Mali, like the larger mission of the MCC, seeks to reduce poverty through economic growth. This report provides a description of the baseline survey, which is a key component in the methodology to rigorously evaluate a component of the Compact in Mali, the Alatona Irrigation Project (AIP). The AIP provides financing to significantly increase irrigated areas in the Office du Niger (ON) irrigation scheme in the Segou region of Mali. Only 4 percent of total cultivated area is under irrigation in Sub-Saharan Africa (World Bank 2007), which suggests the potential effect that increased irrigation investment may have on agricultural productivity and poverty by expanding the number of total irrigated hectares. However, irrigation projects are not all uniformly successful over the long term and differ along critical dimensions, including the manner in which they are targeted, the support that the program provides to beneficiaries in assisting them to adapt to new irrigation schemes, and the community organizations that are organized to provide facilities for social learning, management of common resources, and marketing of agricultural surpluses.

The baseline report is organized as follows: the first section provides a brief overview of the activities of the AIP and the expected impacts, which will guide our analysis of the baseline data that were collected before the project began implementation in 2008-2009. We outline the objectives of the baseline survey in the third section and provide a brief summary of the impact evaluation design in the fourth section of the report. This evaluation design motivated the questionnaire design of the baseline survey, which is outlined in detail in the fifth section of the report. The sixth section of the report provides information regarding the sampling strategy and the stratification used in the sampling to ensure that multiple comparisons between different subgroups of interest could be made with the beneficiaries of the AIP. The seventh and eighth sections present village and household characteristics, respectively, from the baseline survey. In our presentation of the village characteristics from the baseline survey, we provide information at the village level on access to infrastructure and basic services. The section utilizes the village questionnaire to provide a profile of village agricultural production, community organizations and village food prices. In our presentation of the household characteristics from the baseline survey, we provide a profile of household characteristics including the household composition, human capital, household welfare, and agricultural production. The data are disaggregated into three main groups: Alatona villages, irrigated villages and non-irrigated villages. The choice to sample households outside the Alatona, in both irrigated and non-irrigated villages, was driven by the impact evaluation strategy. As will be discussed in more detail in section four, some households interviewed in the non-Alatona villages will be selected as a 'comparison' group for the Alatona households. Comparison group households will be selected if they share similar characteristics to Alatona households at baseline. For the purposes of this report, we show the

descriptive statistics for the Alatona, irrigated and non-irrigated villages to provide context in how to interpret the information about the Alatona. This provides insights into how, for example, schooling rates vary across these groups. The finding that the Alatona has a low schooling rate is even more profound if we see that nearby areas have much higher schooling rates. In many cases, we also present the statistics by gender. The last section of the report provides a brief conclusion.

Brief Overview of the Alatona Irrigation Project

On November 13, 2006, the United States of America, acting through the Millennium Challenge Corporation (MCC), and the Government of the Republic of Mali signed a Compact aimed at sustained poverty reduction and economic growth. The Mali Compact consists of the Airport Improvement project and the Alatona Irrigation project. Each project includes multiple activities that are managed and implemented according to project level work plans. The Millennium Challenge Account (MCA Mali) is the local accountable entity that manages the program implementation. MCA Mali includes a General Director and Director of Operations, project directors (Alatona and Airport), transversal directors for Monitoring and Evaluation, Environmental and Social Assessment, Procurement, Administration and Finance, as well as a legal adviser. Moreover, a Procurement Agent and a Fiscal Agent (both contracted to the Emerging Markets Group) manage procurement and financial activities, respectively. The board of directors supervises and approves the various activities implemented within the MCA Mali framework. In addition, each project has an advisory board that provides guidelines and recommendations for improving project implementation.

The objective of the Alatona Irrigation Project is to increase agricultural production and productivity, improve land rights security and modernize irrigated production systems. The project was re-scoped in 2009 as costs were greater than the estimated budget and is now expected to provide 5,200 irrigable hectares instead of 16,000 in the Office du Niger zone. As in the original design, the project will introduce innovative agricultural, land tenure and water management practices. The project objective is documented in the MCA Mali Compact of 2006 and its follow-up amendments.[1] The project includes six activities:

1. *Niono-Goma Coura Road Activity* will rehabilitate and pave 81 km of the Niono-Diabaly-Goma Coura Road.

[1] http://www.mcc.gov/mcc/bm.doc/compact-111306-mali.pdf

2. *Irrigation Activity* includes (i) the development of the irrigation system of the Alatona zone through the construction of a primary canal and networks of secondary and tertiary canals and drains; (ii) expansion of the main conveyance system of the Office du Niger canal by removal of the central island separating the two branches of *Canal Adducteur*; the widening of the Sahel canal over 23 km and raising the banks of the Fala of Molodo along approximately 8 km; and (iii) implementing a more efficient water management system in the Office du Niger.

3. *Land Activity* includes (i) creating land parcels from the 5,200 hectares of irrigated farm land, specifically mapping and registration of 5-hectare parcels and market garden plots for women; (ii) implementing a land rights education program and an information and awareness campaign targeted at rural populations that will disseminate information on opportunities to acquire titled land in Alatona and help land recipients understand their rights and obligations; (iii) updating the land registry system in partnership with the National Directorate for State Property and Cadastre; and (iv) allocating plots through the creation of a selection commission and development of selection criteria and a lottery system for assigning land parcels. Households that receive land through the lottery are known as New Settlers.

4. *The Community Activity* includes (i) resettlement and compensation of about 800 families living presently in the Alatona zone and that will be affected by irrigation works – these individuals are also known as the project affected people (PAPs); and (ii) development of social infrastructure and equipment that will facilitate the provision of health and education services.

5. *Agriculture Activity* includes (i) setting up an applied agricultural research grant facility that provided subsidies for field-level, applied technology research; (ii) informing and training farmers on improved farming practices for irrigated production; (iii) supporting the development and management of farmers' and women's producer organizations; and (iv) supporting to the development and management of secondary level water user associations.

6. *Financial Activity* includes (i) a loan guarantee fund for Alatona farmers; (ii) capacity building for financial institutions active in the zone; and (iii) direct grant support for farmers to facilitate their access to a first loan.

With the current target of 5,200 hectares of irrigated land, all project affected people will be compensated and resettled on 5-hectare parcels as originally planned. However, a significantly smaller number of New Settler concessions will benefit from access to newly irrigated parcels. Within the larger Compact Goal, the objective of the AIP is to "increase agricultural production

and productivity in the Alatona zone of the Office du Niger." In line with the Monitoring and Evaluation plan at MCA, the following outcomes fall within the larger objective:

- Increased agricultural yields
- Diversification in favor of higher value crops
- Irrigated agricultural production in the dry season
- Farm products that are effectively marketed
- Reduction in transport costs.

With this brief overview of the AIP in mind and its targeted objectives, we turn to the objectives of the baseline survey as part of a broader strategy to evaluate the impact of the AIP.

Objectives of the Baseline Survey

The objectives of the baseline survey are to provide the necessary data needed to evaluate the Alatona Irrigation Project after its completion, as well as to provide the baseline value of a number of indicators that are used to monitor project outcomes during implementation. Specifically, the AIP baseline survey was designed to:

1. Collect multi-topic household and village-level information on households in the project's intervention zone as well as surrounding areas from which a valid comparison group of households with similar characteristics could be constructed.

2. Provide baseline information to support a variety of evaluation methodologies, including randomized control trials and propensity score matching on specific areas of the project interventions, such as agriculture, credit, land tenure, gender, household consumption, labor supply and poverty.

3. Support the construction of key indicators for monitoring project interventions during implementation.

Review of the Evaluation Design

The AIP project will not only create additional hectares of land as part of the Office du Niger system, it will also introduce a number of additional innovations, such as providing land titles to beneficiaries and improving water management systems. The impact of providing irrigated land with the additional benefits brought by the AIP will be evaluated for both New Settlers and PAPs by estimating the overall impact of the project for each group separately. We first list below a set of research hypotheses that can be answered using the current evaluation design; we then explain each one in more detail. Additional hypotheses will be investigated through the impact evaluation but we highlight here what we view as the most important ones. We note that there are a number of key research questions that cannot be addressed in this impact evaluation because of the limitations of the methodology. We will come back to this.

In addition to the impact evaluation, MCA will commission special studies and a final evaluation that will use the baseline data. Finally, IPA – through its partnership with the International Food Policy Research Institute – has secured funding for a qualitative evaluation of the AIP that will focus on the women's and farmer's associations.[2]

Evaluation Hypotheses

1. Access to irrigation will increase agricultural production in PAP villages relative to their baseline production levels.
2. Gains in agricultural income among PAP villages will lead to increases in consumption per capita, asset and livestock holdings, and input utilization.
3. Access to irrigation will increase the demand for inputs (fertilizer and seed), agricultural capital, and household and hired agricultural labor.
4. AIP will increase women's incomes in the AIP and influence women's empowerment.
5. The provision of land titles will increase productivity in the AIP by increasing household investment in their plots and access to credit to finance these investments.

Hypothesis 1: Overall impact: Access to irrigation will increase agricultural production in PAP villages.

[2] Those interested in a more detailed description of that work should contact Andrew Dillon.

Because PAP villages will be resettled, the package of inputs, including irrigated plots, inputs, and access to credit, will be packaged as the "treatment" intervention. Because all PAP households receive the same package of inputs and all have the choice of applying for credit, there is likely no credible evaluation strategy to isolate the effects of a single element of the treatment. However, the totality of the treatment should impact agricultural production by increasing the quality of land, in a number of dimensions, to which a farmer has access. This gain in quality through increased control of water access breaks the farmer's dependence on rainfall as the primary source of water supply for his or her crops.

Hypothesis 2: Distribution of the gains in agricultural income: Gains in agricultural income among PAP villages will be distributed among increases in consumption per capita, asset and livestock holdings, and input utilization.

We expect the gains in agricultural income to be large relative to the initial state of the PAP villages. These gains will not be entirely consumed and will depend heavily to whom they accrue within the household (see our hypotheses with respect to gender). The existing literature on the impact of irrigation has shown reductions in poverty associated with access to irrigation (Dillon 2008; Fan and Hazell 2000; Hussain 2007; Ut et al. 2000; Van Den Berg and Ruben 2006). Consumption will likely increase, as some of the gains in agricultural production will be consumed within the household and a portion of income from this production will be used to purchase food. Some of the gains will be saved via either asset accumulation or livestock holdings, while the rest of the gains may be re-invested in the plots to further increase their productivity in the future.

Hypothesis 3: Access to irrigation will increase the demand for inputs (fertilizer and seed), agricultural capital, and household and hired agricultural labor.

With access to irrigation, complementary inputs, such as seed and fertilizer, which require stable water control, become profitable investments for small farmers (Morris et al. 2007). Without sufficient rainfall, improved seed or fertilizer has low potential to increase the productivity of a plot. Thus, the cost of these inputs is not recovered at harvest. Extension advice to farmers that is consistent with soil research on the right "mix" of inputs has shown the best results. In experimental studies in Kenya, Duflo et al. (2008) illustrate that despite experimental farm estimates that illustrate high rates of return to fertilizer, the over-prescription of fertilizer to farmers can actually be unprofitable under normal field conditions.

The mix of these seed and fertilizer inputs is not only constrained by lack of irrigation and the appropriate mix of inputs, but also supply constraints. Since the AIP will provide many of these inputs for farmers in the first years of the intervention, these supply side constraints will not limit farmers and may stimulate private input market development as farmers will be well aware of their benefits after the input subsidies from AIP are phased out. Increased participation in farmers' cooperatives may also assist farmers in organizing bulk fertilizer orders to reduce the transportation and administrative costs of importing fertilizer. The evaluation will be able to compare input use within the Alatona both to farmers within irrigated areas and to farmers in non-irrigated areas who undertake agriculture in more similar ways to what Alatona farmers did prior to the AIP.

In addition to fertilizer and seed inputs, the increased area to cultivate for AIP beneficiaries will increase demand for household and hired agricultural labor. Some of this demand for increased labor will be offset by the household's investment in labor-saving capital, such as carts and mechanized tillers, which will be made possible by increased access to credit. Nevertheless, farmers may have to increase the time spent in the field and the amount of time other household members spend in agriculture. Dillon (2008) illustrates that there are large negative effects on child agricultural labor in response to negative production shocks in northern Mali. That is, when labor demand increased due to a crop loss shock, children's participation in the farm sector increased while their participation in other activities decreased. Because irrigation will increase the demand for labor, it is possible child labor will increase when the amount of irrigated land owned by the household increases. However, demand for labor may also be met by hiring seasonal agricultural laborers. This tradeoff depends on the income effects of increased agricultural production, which may permit households to simultaneously purchase more hired labor and keep children in school. Since the AIP intervention also involves the construction of village schools, households may choose to invest in their children's human capital as opposed to using their agricultural labor. Overall, the distribution of labor among household members and hired labor will be an empirical question that will be analyzed in this evaluation.

Hypothesis 4: AIP will increase women's incomes in the AIP and potentially influence women's empowerment.

One objective of the AIP is to provide new economic opportunities for women. This is accomplished through the provision of women's gardens to all AIP households and by providing additional points to women to qualify for the lottery. The market gardens will be titled like the

main agricultural land, but the title will be held through women's associations to ensure that women can maintain control over the land. All AIP beneficiaries will receive 0.5-hectare plots for women in each household to use for gardening, in addition to the 5-hectare plots provided to the household as a whole.

Since household women will also benefit from the main farm land, we expect women's income and well-being to be positively influenced by the total project impacts. The social infrastructure provided by the project may also lead to positive gains for women in absolute and relative terms to men.[3] All these project components – in addition to women's gardens and the organization of women into associations – should lead to improvements in women's income. Although we are unlikely to be able to separate the impact of the women's gardens or the organization of women's gardens into larger women's associations from the additional project benefits, we can explicitly measure the impact of the project for women. We will measure these impacts in terms of economic well-being (own income, assets owned by women including livestock) and by using some measures of empowerment. The empowerment questions ask about women's ability and women's ability to make decisions about children's schooling, children's health and food preparation. Recognizing that these measures would only capture a small fraction of what women's empowerment means, a qualitative study – which is beyond the scope of this report – will have an explicit focus on gender. The strength of the impact evaluation will be to look at the economic empowerment of women through the AIP.

Hypothesis 5: The provision of land titles will increase productivity in the AIP by increasing household investment in plots and access to credit to finance these investments.

Providing full land titles to all AIP beneficiaries represents a significant departure from current ON policy. Therefore, an ideal impact evaluation would isolate the impact of providing land titles within the estimated total project impacts. However, there are serious methodological difficulties in rigorously evaluating this project component. In particular, there is no variation within the project on who will receive titles. All AIP recipients will simultaneously receive numerous benefits, including titles, extension services, improvements in financial services, and technical assistance for improved farmer organizations to name a few. Therefore, it will be a significant challenge, and perhaps impossible, to disentangle these effects. However, as the details about the timeline for when titles will be provided are determined during the project

[3] For example, the availability of pumps in the village will particularly help women because the time saved from having to fetch water from far distances could then be used for other activities, including agriculture.

period, the evaluation team will continue to search for an evaluation strategy that would allow us to estimate the impact of the land titles themselves.

A possible strategy would use the fact that not everyone will receive land titles during the Compact period. The reason for this is simply that the Cadastre is unable to map all the land during the project period. Therefore, farmers will receive their titles over time. In order for this to facilitate an evaluation strategy to estimate the impact of land titles on productivity, we would need the following assumptions to be valid.

1. Those farmers who receive titles early are not systematically different from those that receive titles later. We will only be able to determine this once the Cadastre Office has established its work plan. The ideal scenario, to understand the role of land titles and potentially for fairness, would be to randomize the order at which titles are provided at the village level.

2. Having a title in hand has a much larger impact on investment and productivity than the expectation of a title.

In order to address the second concern, we may be able to explicitly analyze one mechanism through which land tenure may affect productivity and income: access to credit. Since only those farmers with an actual title will be able to use the land as collateral, we may be able to estimate the returns to this one aspect of holding a land title.

Impact Evaluation Strategy

The key distinction between impact evaluation and other monitoring and evaluation techniques is that impact evaluation seeks to isolate the causal relationship between interventions and the welfare or well-being of beneficiaries. In any impact evaluation, a primary concern in estimating program impacts is to ensure that the impact estimated is truly due to the project and not potentially biased by unobserved factors in the data. Since there are many factors influencing households' consumption, income and well-being in a given year, a simple before-and-after comparison can lead to a misleading or incorrect assessment of project impacts. Suppose, for example, that the price of rice fluctuated dramatically between 2008 and 2012. Our measures of both expenditures and output would be affected: a before and after comparison would risk confounding the effect of the price fluctuation with the effect of the AIP. The price of rice is

fairly observable, so we could perhaps adjust our measures of expenditure and output accordingly, but there are numerous other factors that may have changed between 2008 and 2012 that we may not know about or may not be able to quantify precisely. This makes it almost impossible to disentangle the direct effect of the AIP from other changes that affected the Alatona households during this time period. The following diagram demonstrates this idea when a fall in the price of rice would lead to artificially lower income. This particular case is a possible scenario that would affect Alatona households as increased production in rice within the Alatona may lead to a fall in the price of rice.

Figure 1: Demonstration of Evaluation Challenge

A simple before and after comparison of households in the Alatona may erroneously infer a near zero impact of the program (B compared with A). By having an additional comparison group, we can see what would have happened to the Alatona households if the AIP was not introduced. A correctly chosen comparison group would give the measure C; i.e., that income went down in Y3 due to the decline in the price of rice. With C in hand, we can calculate the true impact of the AIP as the difference between B and C.

Unobserved factors could also cause certain segments of the population to be more likely to participate, or self-select, into the program. This makes comparisons across just two populations – those who received a program and those who did not – problematic. To estimate the impact of an intervention while recognizing the problem of selection bias, one needs the difference of the

outcome variable of interest at time *t* between a state where the household receives treatment and a state where the household does not receive treatment, denoted by the superscripts 1 and 0. However, this is impossible to estimate because a household exists in one of two mutually exclusive states: either it has access to the intervention or it does not. The evaluation problem is one of missing data, because of the impossibility of assigning the same household to both treatment and non-treatment groups. The challenge of impact evaluation, therefore, is to identify suitable comparison groups to compare with beneficiaries and hence construct the *counterfactual*.

Randomized experiments enable the cleanest construction of the counterfactual. That is, construction of a group that is comparable with respect to the pre-treatment characteristics of the households that received the treatment. In a well-designed experiment, a legitimate counterfactual group provides an answer to the evaluation question, "What would have happened to those who received the treatment had they never been treated?" However, randomized experiments are not always possible or plausibly implemented to ensure the absence of selection bias. In the case of the AIP, allocation of irrigated land to the PAPs was guided by the ethical rights of the resettled population leading to the fact that all eligible households in the resettlement villages will receive treatment. It was therefore necessary to come up with a non-randomized design. For the PAP beneficiaries, we will employ a difference-in-differences nonexperimental evaluation strategy. For the New Settler population, we will implement a randomized evaluation contingent on the implementation of the planned land lottery. The baseline data collected and reported here will be used primarily to evaluate the effects of AIP on the PAP population. Hence, we describe in brief detail the construction of the matched difference-in-differences estimation strategy.

The idea behind the strategy is that we can use observable characteristics to identify households outside the Alatona who look similar to those in the Alatona and use them as the comparison group. One way to do this statistically is called *propensity score matching*. As highlighted above, there may be important characteristics that differ between the beneficiaries and the comparison group that we cannot observe. The use of baseline and follow-up data together helps to minimize, but not completely remove, this concern using a *difference-in-differences* technique. The intuition behind a difference-in-differences approach is that two groups may differ in their initial level of, for example, income. Suppose, however, that their income is changing over time at the same rate. We can use information about the initial difference between the two groups before the AIP began to understand the rate of income change that would have occurred if AIP was never introduced. Combined with propensity score matching, difference-in-differences estimators are our best chance at measuring the causal impact of AIP given the limitations

imposed by the project design. A more detailed description of the methodology can be found in the Appendix D.

To give the reader a more concrete picture of how the technique will be used to evaluate AIP, we give examples of the type of information that can be used from the baseline to construct the comparison group. The baseline was designed to have detailed information on, for example, household size, household assets including household durables and total livestock units, the age of the household head, the level of education of the household head and his or her spouse, ethnicity, and landholdings in 2008. This information was gathered by interviewing individuals in Alatona households and then individuals in households in the geographic areas surrounding the Alatona. The sample of the baseline is described in more detail below. We will also use village characteristics such as distance to the nearest road, distance to the Niger River, and the log price for transporting a sack of rice to Mopti, a regional center. The comparison group will be comprised of households that are as similar as possible in these measured dimensions to PAP households. The statistical technique used to combine the many characteristics into one index measure to compare across the PAP and potential comparison households is also described in the Appendix.

PAP households will be matched to households in non-irrigated areas to understand how the program has affected them relative to households with households with which they were similar before the start of the program. This will provide us with the overall impact of the project. The reason we also collect data from households in irrigated areas is to provide us a second comparison group with which we can better understand the dynamics of adopting irrigation. A second comparison group will also be created to estimate whether PAP household welfare levels have risen at the end of the project to the welfare levels of households in irrigated areas. This will provide evidence about how quickly households adapt to irrigated agriculture and whether agricultural yields are similar between Alatona households and households in irrigated areas.

This report provides a description of the data collected in the baseline. There will be clear differences between the PAPs and households in the irrigated and non-irrigated villages. We provide the statistics from the entire baseline in order to give a fuller picture of how the PAPs compare with others in the same geographic area. For example, understanding what the average number of assets owned by PAP households means is easier if there are comparable statistics for nearby areas. It is essential to highlight that IPA has not yet done the propensity score matching technique to select the households that will serve as comparison households. The ultimate comparison group will look much more similar to the Alatona households than the entire sample of non-Alatona households presented in this report. The baseline sample was constructed to

sample randomly from a large geographic area in order to maximize the likelihood of finding individual households that are similar to Alatona households. Therefore the reader should not worry that the differences between households in the Alatona, irrigated and non-irrigated villages will undermine the evaluation strategy.

Having briefly described the evaluation strategy, we now turn to the description and analysis of the baseline data by first describing the questionnaire design and data collected.

Questionnaire Design of the Baseline Survey

The questionnaire design links the objectives of the AIP with the evaluation strategy, which is essential to the production of a quality data set useful for the AIP evaluation. The survey instrument was designed as three distinct questionnaires: community, men and women. Tables 1 and 2 describe each of the components of the questionnaires and their corresponding modules.

The community questionnaire collected demographic and physical characteristics of the community in addition to information about the functioning of markets (migration and agriculture), access to infrastructure and the quality of the infrastructure (health and education) that exists. In the Agriculture module, community level information with respect to the functioning of farmers' cooperatives, access to agricultural inputs, and management of irrigation plots (collection of water fees, community level investment, land tenure and transactions) was collected. Table 1 provides details of the baseline community questionnaire with a module-by-module description.

Table 1: Baseline Community Questionnaire Structure

Module	Description
1. Cover page/Village leader characteristics	Information on GPS location of the community, respondents, enumerator names and date of interview. Questionnaire posed to village head, with complementary information collected from school, health and agriculture officials.
2. Community groups	Types of community groups, their membership composition (men and women) and leadership within the village.
3. Agricultural organizations	The objective of agricultural organizations that exist in the village, the duration of the organization in the village, and the type of agricultural investments they make in the community.
4. Agriculture	Information on the agricultural season and agricultural practices of the community including wage labor rates, tenancy arrangements, primary crops, access to extension services, use of agricultural capital, collection of water fees and farmer cooperatives.
5. Crops cultivated	An agricultural calendar of major crops in the village.
6. Agricultural credit	The sources of agricultural credit available to village residents and the interest rates offered in the village by these institutions.
7. Savings and credit	The types of savings that village residents use to store wealth and the types of non-agricultural credit available in the village
8. Education	Information on the school infrastructure of the community including access to schools and their quality, school-specific characteristics and the costs of schooling. (Some school characteristics need to be asked of regional education officials.)
9. Health	Information on the health infrastructure of the community including access to medical facilities and their quality, availability of medicines, and common illnesses in the community.
10. Transportation	Information on access to infrastructure, travel times to different locations and the means of transportation used.
11. Village development and project interventions	Information on the community's history of the development project interventions led by the village and other organizations.
12. Infrastructure	Information on access to electricity and water sources.

Module	Description
13. Shocks	The types of positive and negative events that have been influential in the life of the village.
14. Prices	Market prices of food items and agricultural inputs.
15. GPS coordinates of village infrastructure	GPS coordinates of schools, health centers, portable water sources, roads and other socially important locations in the village.

The household questionnaire is composed of a male and female questionnaire that contains the necessary modules to measure agricultural production, poverty via the construction of a consumption aggregate (composed of food expenditures, non-food expenditures, the value of clean water and sanitation facilities, and the discounted present value of assets), non-farm revenues, labor supply, and credit and savings behavior. A module on social networks will ascertain how men and women in households within the village are connected and how households are connected to other villages; this will permit us to measure the effects of networks on adaptation to a new technology (irrigation and inputs). A module on economic shocks documents various types of economic shocks that may explain variation in indicators capturing household well-being, such as food consumption, and are uncorrelated with the project interventions. It should be noted that this questionnaire design reflects the AIP's program design, which targets program interventions to both men and women in the household. Hence in the baseline, it is necessary to measure agricultural production, income, and asset holdings, among others, for men and women separately to ensure that we can evaluate how the AIP impacted households as a whole but also male and female members specifically within the household. Table 2 provides additional information on the sections of the male and female questionnaire with a module-by-module description.

The survey is targeted to households, not concessions. We discuss below how we delineated PAP concessions into separate households. The definition of a household used is similar to a standard household definition used in panel data in developing countries. The specific wording is:

> A household is composed of the group of people living in the same dwelling space who eat meals together and have at least one common plot together or one income generating activity together (for example, herding, business or fishing) and acknowledge the authority of a man or women who is the head of household.

The definition itself highlights the motivation for focusing on households instead of concessions. We measure agricultural output at the plot level, for each plot within a household: therefore this

measure corresponds to income for all individuals who work communally on those plots. To measure food consumption, we interview the woman who cooks most often for the households. Therefore our measure of food consumption, an important indicator of wellbeing, only applies to individuals who eat together. In some cases, the concession and the household may be identical concepts. In those cases, a PAP concession was interviewed as a single household. However, in cases where there are multiple groups who consume food independently (or who farm or engage in an income generating activity as a separate group) within a concession, those groups are treated as separate households. Since we know which households make up a given concession, we will be able to also look at outcomes at the concession level. Here we focus only at the household-level to be comparable to the way the data was collected in the irrigated and non-irrigated villages.

Table 2: Baseline Household Questionnaire Structure

Module	Description
Men's Questionnaire	Questionnaire posed primarily to the male household head, with some individual male responses to selected questions
1. Household information	General household information
2. Household composition	Interview together with the female respondent on the members of the household
3. Household education	Educational attainment of all household members
4. Health	Self-reported incidences of illness, medical expenses, and type of treatment sought for all household members
5. Migration	Migration of current household members and migrant remittances
6. Housing characteristics	Physical characteristics of household dwellings
7. Assets	Durable household assets possessed by men
8.Agricultural assets	Agricultural assets owned by the household's men
9. Agricultural production	Production, input utilization, and marketing of production surpluses on land owned or managed by men
10. Agricultural knowledge	Agricultural knowledge of the lead male farmer in the household

Module	Description
11. Grain purchases and sales	Information on recent grain purchases and sales of grains
12. Social networks	Networks of relatives and contacts of male household members
13. Risk aversion	A measure of the risk aversion of the male lead farmer
14. Herding	Livestock holdings, revenue from livestock and costs of holding livestock of male household members
15. Non-agricultural enterprises	Non-farm sources of income, costs of non-farm activities of male household members
16. Household labor supply	Domestic and labor market activities of male household members
17. Savings	Savings behaviors of male household members
18. Social networks	Information on male household members' links within villages and between other villages
19. Credit and loans given	Credit and lending behavior of male household members
20. Income transfers	Transfers of income to male household members
21. Agricultural stocks	Stocks of agricultural commodities held by the household
22. Non-food expenses	Expenditures on household items, clothing, and personal expenditures of male household members
23. Economic shocks	Household-specific and macroeconomic shocks including agricultural shocks, illnesses, and other macroeconomic shocks such as price increases or changes in government policy that have affected the household
24. Social capital	Social capital of male household members
Women's Questionnaire	Questionnaire posed primarily to female household head, with some individual female responses to selected questions
1. Household information	General household information
2. Women's assets	Durable household assets possessed by women
3. Agricultural capital	Agricultural assets owned by the household's women

4. Agricultural production	Production, input utilization, and marketing of production surpluses on land owned or managed by women
5. Agricultural knowledge-women	Agricultural knowledge of the lead female farmer in the household
6. Social networks	Networks of relatives and contacts of female household members
7.Risk aversion	A measure of the risk aversion of the male lead farmer
8. Herding	Livestock holdings, revenue from livestock and costs of holding livestock of female household members
9. Non-agricultural Enterprises	Non-farm sources of income, costs of non-farm activities of female household members
10. Household labor supply	Domestic and labor market activities of female household members
11. Savings	Savings behaviors of female household members
12. Credit and loans given	Credit and lending behavior of female household members
13. Income transfers	Transfers of income to female household members
14. Non-food expenditures	Expenditures on household items, clothing, and personal expenditures of the female household members
15. Food consumption	Interview together with the household head on food expenditures and quantities consumed by the household
16. Food transfers	Food received from other households
17. Social capital	Social capital of female household members
18. Women's empowerment	Questions on the status of women in the household
19. Children's and women's health	Information on children's health and vaccinations, women's birth history and HIV knowledge

Sampling Strategy

The sample design of any survey is paramount to providing a representative image of the characteristics of the population of interest to the study. In the case of the Alatona Irrigation Project, which involves multiple types of interventions (access to irrigation, agricultural inputs, credit, schools), the baseline survey data will serve as the basis to track changes in beneficiary households' well-being as the benefits of the project are realized by comparing beneficiary households with a group of comparison households.[4] As such, we are not simply interested in providing accurate information about how villages in the Alatona change throughout the course of the project; we are also interested in measuring and attributing changes that the project induces in household welfare separately from macroeconomic trends or idiosyncratic shocks to certain villages or households. This requires a more sophisticated study and sampling design to ensure that adequate impact evaluation can be conducted.

As described above, the impact evaluation will use propensity score matching to estimate impacts of the project among the PAPs. In order to conduct this analysis, a valid comparison group to the beneficiary households must be constructed with households that do not receive any of the project benefits or interventions. With propensity score matching, the fidelity of the impact estimates relies on the construction of legitimate comparison groups in which households with similar characteristics to those in the beneficiary group can be matched to construct the comparison group.

This evaluation methodology requires high quality data and a carefully constructed comparison group. In developing the sample design, we took several trips not only to the Alatona villages that will be affected by the project, but also to neighboring villages within and outside of the Office du Niger to qualitatively assess the types of household characteristics that may be used as relevant matching criteria. After our qualitative trips, we selected communes which we felt would provide adequate numbers of households and a diversity of household characteristics to ensure a legitimate construction of the comparison group. After this decision was made it was necessary to ensure there was an accurate listing of villages within each commune and households within each village with which we could select a sample. This process of constructing the sample frame was undertaken in September and October 2008. Lastly, once we were able to construct the sample frame, we made several decisions about the sampling strategy to ensure a valid comparison group could be constructed from the baseline sample. In

[4] We refer to comparison households because the primary unit of administration for the baseline survey is the household. However, the survey also collects a significant amount of individual-level information on household members, including women.

consultation with MCC and MCA-Mali, the sample also takes into account MCA and MCC's needs for baseline data as a basis for other monitoring and evaluation activities outside the impact evaluation. In particular, IPA ensured that all PAP households would be interviewed, as requested by MCA.

The rest of this section describes the process by which we made decisions concerning the construction of the sample for the AIP baseline survey. We then discuss some methodological issues in detail regarding the sampling for the baseline. The solutions to these methodological sampling issues were informed by our qualitative work in June 2008. Based on this qualitative work, we were able to develop a preliminary sampling plan and evaluate the quality of national data to use in the construction of a sampling frame. Unfortunately, the data – as in many developing countries – were inadequate for the purposes of our survey. We therefore describe the methods we used to construct the sample frame from village and household listing exercises. The remaining portions of this section describe the stratification we used to ensure equal partitioning of relevant characteristics throughout the comparison group and the sample selection; and provide basic descriptive characteristics of the sample, such as the fraction of villages using primarily rain-fed agriculture.

Sampling Methodology

The purpose of random sampling is to ensure that the distribution of characteristics in the population of interest is replicated in the sample of households selected to be studied. A simple random sample requires a complete listing of all households in the survey area. With the Resettlement Action Plan (RAP) census data, we have a complete census of the concessions[5] in the Alatona, but we did not have a complete listing of households, known as the sample frame, in the neighboring communes. Note that all PAP households were attempted to be interviewed in the baseline but only a sample of households outside the Alatona were included in the baseline study. To create an accurate sample frame in non-Alatona villages, it was necessary to undertake listing exercises of both villages and households. To minimize costs and ensure tractability in the field, we first enumerated all villages in the survey area and selected villages in a first stage. In a second stage, a complete census of households in the selected villages was completed, after which we randomly sampled some of these households for the baseline study. This process is

[5] The household survey uses a definition of household that is not the same as the definition of the concession used in the RAP. Therefore, as part of the work of the baseline survey, the survey firm ESDCO did a listing exercise to categorize each concession into one or more households. It is our understanding that ESDCO had no problems undertaking this exercise and it was made clear to residents of the Alatona that the designation of households would not impact their project benefits.

known as two-stage cluster sampling – randomly sampling villages first (which are the clusters) and then households from the selected villages. It preserves many of the same advantages as random sampling with probability proportional to size. Often we are also interested in particular characteristics of a population that we want to ensure have sufficient sample size with which we can make meaningful comparisons. This designation of subgroups within the population, or strata, ensures sufficient sample size. For reasons of tractability in the field and our particular interest in the impact evaluation of the AIP, we designed a stratified, two-stage cluster sample for the baseline survey.

The theory of stratified, two-stage cluster sampling is not much more complex than taking a random sample, but in practice it requires careful attention in the analytical stages to correct for the correlations that may exist in the data from selecting households from the same village. One advantage of stratified, two-stage sampling is that it increases the sampling efficiency by lowering sampling variance. This increases the likelihood that one is able to detect the impacts of a project because the characteristics of interest are adequately represented in the sample. For example, with a non-stratified sample, rain-fed agriculture may represent only 20 percent of the agricultural systems used by households in the population. For the purposes of our evaluation, we want to ensure adequate representation of these households, so that we can compare changes in their well-being to changes within Alatona households that at the start of the AIP were also rain-fed farmers. By designating different strata, we increase the relative distribution of households with these characteristics in the sample.

Power Calculations

In the sample design, we were also careful to ensure that the number of households in the sample would be sufficient to statistically identify differences between groups. Without power calculations to simulate the necessary sample sizes to detect program impacts, the baseline study could suffer from insufficient observations with which to make meaningful analyses. According to power calculations we undertook as part of the evaluation design, a significance level of 0.05, power of 0.90 and assumed effect size of 0.20 standard deviations necessitate a sample size of approximately 1,060 under randomized control trial (RCT) conditions. An effect size of 0.20 standard deviations is considered a small effect size. Dillon (2008) finds a larger effect on household consumption, of about 0.40 standard deviations, among households in northern Mali. However, one of the most common mistakes in power calculations is being too ambitious and therefore designing an under-powered study. In addition, the evaluation of the PAPs is not an RCT, and the design also calls for disaggregating the effects into various sub-groups and looking

for effects that may be more subtle than the main impact. Therefore, a sample size above 1,000 was required.

Since a propensity score matching technique is necessary to evaluate the impact of the AIP on the PAPs and given the diversity of livelihoods and asset levels within the PAPs, we need to have a diverse pool of potential-comparison households to select from in order to find good matches.[6] Moreover, we expect that the distribution of characteristics will differ across PAP and non-PAP villages. Therefore, we are allowing for a match rate of 50 percent within the non-PAP sample. In this case, in order to detect a minimum effect size of 0.20, we will need 500 treatment households and a sample size of 1,000 non-PAP households. In order to allow for disaggregating PAPs by the variables of interest, such as initial experience with irrigated rice cultivation or agriculture in general, we propose increasing the number of PAP households interviewed to 800 and non-PAP households to approximately 1,600.

Construction of the Sample Frame: Village and Household Listing

To develop the sample frame for the baseline survey, we used the list of communes identified during our preliminary research trip (June 2008) provided in Appendix A. The communes were selected to ensure sufficient variation among livelihood strategies (level of sedenterization, rice versus millet cultivation, women's involvement in agriculture, etc.). Our criteria were to select communes for the comparison groups, including all communes with villages that are participating in the Office du Niger irrigation scheme and all peripheral communes to the ON communes that are practicing rain-fed millet agriculture and pastoralism north of the city of Segou's longitudinal position in the *cercles* of Macina, Niono and Segou.

Among the three *cercles* (Macina, Niono, and Segou) included in the sample frame, a total of 32 communes are included in the baseline survey. The *cercle* of Macina has seven communes included in the sample frame. From the 1998 Census, there were 175 villages in the Macina *cercle*. The estimated total population of Macina villages in the sample frame was accordingly 148,523, although the population figures are now out-dated. In the *cercle* of Niono, 11 communes are selected in which there should be 202 villages with a population of 195,059 according to the 1998 Census. Lastly, the *cercle* of Segou has 14 communes selected, and there should be 225 villages with a population of 195,824.

[6] For example, some households engage primarily in pastoralism, while many others do rain-fed agriculture, and others engage in some form of small-scale rice production, either through renting land in the ON or Fala.

We checked the lists of villages located in the communes from the 1998 Malian Census with other administrative records we found in 2008 at the offices of prefets and mayors with whom we met over the course of our trips. We found errors of both omission and inclusion, most of which would normally be expected to arise in communities over a 10-year period. To construct an accurate sample frame, we needed to establish the villages currently located in each commune and their characteristics. This would permit the first-stage selection of villages to be stratified according to the evaluation design.

In September 2008, IPA undertook the process of listing villages in each commune. Shortly after the listing of villages was finalized, we selected the first-stage sample of villages, so that households in the selected villages could be enumerated. After the first stage, the number of villages/towns in the comparison group equaled 115 and the 33 Alatona villages in the beneficiary group were also retained in the sample. The selection of these villages is described in the next sub-section. The second stage of listing households within villages or towns was undertaken in all selected villages/towns defined in the first stage. However, the size of the village/town required adaption of the sampling methodology. It was infeasible to list all households in large towns and also inconsistent with the principal of sampling with probability proportional to size. To overcome this issue, we divided towns according to approximately equal units along natural divisions in the town, usually its neighborhoods. In towns with approximately 3,000 or greater population, we sampled 25 percent of the town's neighborhoods. With this list of first-stage villages/towns, each household in the selected village/town was enumerated. These lists were then used to select the second-stage households with which the baseline survey will be administered. In the next section, we describe fully the process by which we selected villages/towns in the first stage and households in the second stage. The following figure describes the sampling process.

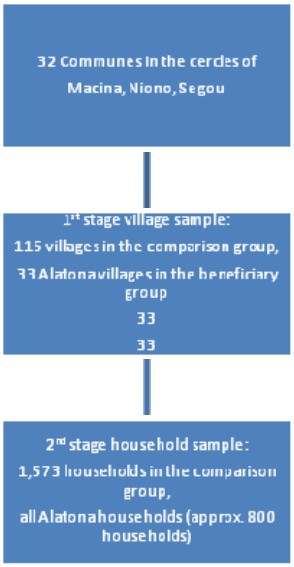


Figure 2: Two-Stage Sampling

Stratification and Sample Selection

After receiving the lists of villages within communes, villages were divided into two strata by primary crop cultivated: rice, or rain-fed millet and sorghum. Within these strata, villages were divided into rainfall zones (North, Middle, and South as described below) to capture differences in potential agricultural production across zones due to more and potentially higher frequency rainfall. For the control group villages, an 18 percent sample (115 villages) was chosen from the list of villages constructed from the enumeration activities at the beginning of the trip. All 33 PAP villages in the Alatona project zone are also included in the sample. The total number of villages included in the baseline survey is 148.[7]

An 18 percent sample was chosen to maximize variability of characteristics across the comparison group zone, as a broad range of household types are necessary to ensure comparability for matching purposes with the households in the Alatona zone. Given our power calculations, we also faced a tradeoff between the number of villages surveyed and the number of households surveyed in each village. A decrease in the number of villages surveyed implies an increase in the number of households surveyed in each village. However, variation in the types of households in any one village is less than the variation one might expect to see in

[7] Two villages, Massabougou and Rounde Mody, were mis-classified in the 1998 Recensement du Mali. Massabougou is in fact a neighborhood of the town of Diabaly, and Rounde Mody is a synonym for the village in the Alatona Beldenadji. Accordingly, both of these "villages" have been removed from the sample and there are now 113 villages outside the PAP villages in the sample. These villages are indicated by **** in Appendix B.

household types across villages. Variation in household types is critical within a sample, but a sample that contains only one household per village also does not allow sufficient variation at the village level to estimate the effects of village level characteristics on a household's well-being either. Therefore a balance between number of villages and number of households within each village must be met using the power calculations as the target for the total number of households to be interviewed. To meet the target of households in the comparison group given from the power calculations, the number of households per village was set to be 14 per village. This gave us a theoretical sample size after the first-stage selection of villages of 1,610 households. Unfortunately, after listing households within the first-stage selected villages, several villages had fewer than 14 households within the village. Thus the initial targeted sample size was 1,573 households, very close to our conservative power calculation sample size. All households in the Alatona are included.

Descriptive Characteristics of the Sample Drawn

To better describe the sample within the overall characteristics in the sample frame, Table 3 gives some comparative statistics for villages in the sample relative to all villages in the sample frame.

As can be seen below, there is a slightly higher percentage of villages in the northern and central rainfall zones, i.e., closer to the Alatona, in the selected villages than in the sample frame. However, there are a sufficient number of villages in the southern zone so that IPA will have flexibility to select matched households that are more geographically distant from the Alatona in case there are significant project spillovers to all villages in the northern zone.

Table 3: Descriptive Statistics of the Sample (Percent)

	Sample	Sample Frame
Northern rainfall zone[a]	24.35	22.85
Central rainfall zone[b]	37.39	35.21
Southern rainfall zone[c]	38.26	41.94
Where the main activity is rain-fed agriculture	54.78	53.21
Where millet/sorghum is the main crop	53.91	53.05
Where rice is the main crop	40.00	39.12

Notes

a The northern rainfall zone is composed of villages in the communes of Dogofry, Diabaly, Sokolo, Toridaga Ko, Sirifila Boundy, Mariko, and Yeredon Saniona.

b The central rainfall zone is composed of villages in the communes of Niono, Kala Siguida, Siribala, Pogo, Monimpebogou, Boky were, Kolongo, Souleye, N'Koumandougou, Macina, and Kokry center.

c The southern rainfall zone is composed of villages in the communes of Dougabougou, Sandsanding, Sibila, Saloba, Dioro, Baguindadougou, Diganibougou, Farako, Farakou Massa, Sama Foulala, Togou, Pelengana, Boussin, and Markala.

The majority of the sample is comprised of villages where rain-fed agriculture is the primary activity. Consistent with this, in more than 50 percent of villages in the sample and more generally in the sample frame, millet or sorghum is the main crop in the village.[8] In 40 percent of the sample, rice was described as the main crop in the village. Figure 3 illustrates the Alatona zone, which is the primary area where the project intervenes.

[8] These are village-level statistics and, as such, we expect to find households that farm exclusively millet even in villages where the primary crop is rice and vice versa. Many households may also farm both rice and millet. To give an example, among villages in the sample where rice was listed as the primary crop, 30 percent listed sorghum as the second main crop.

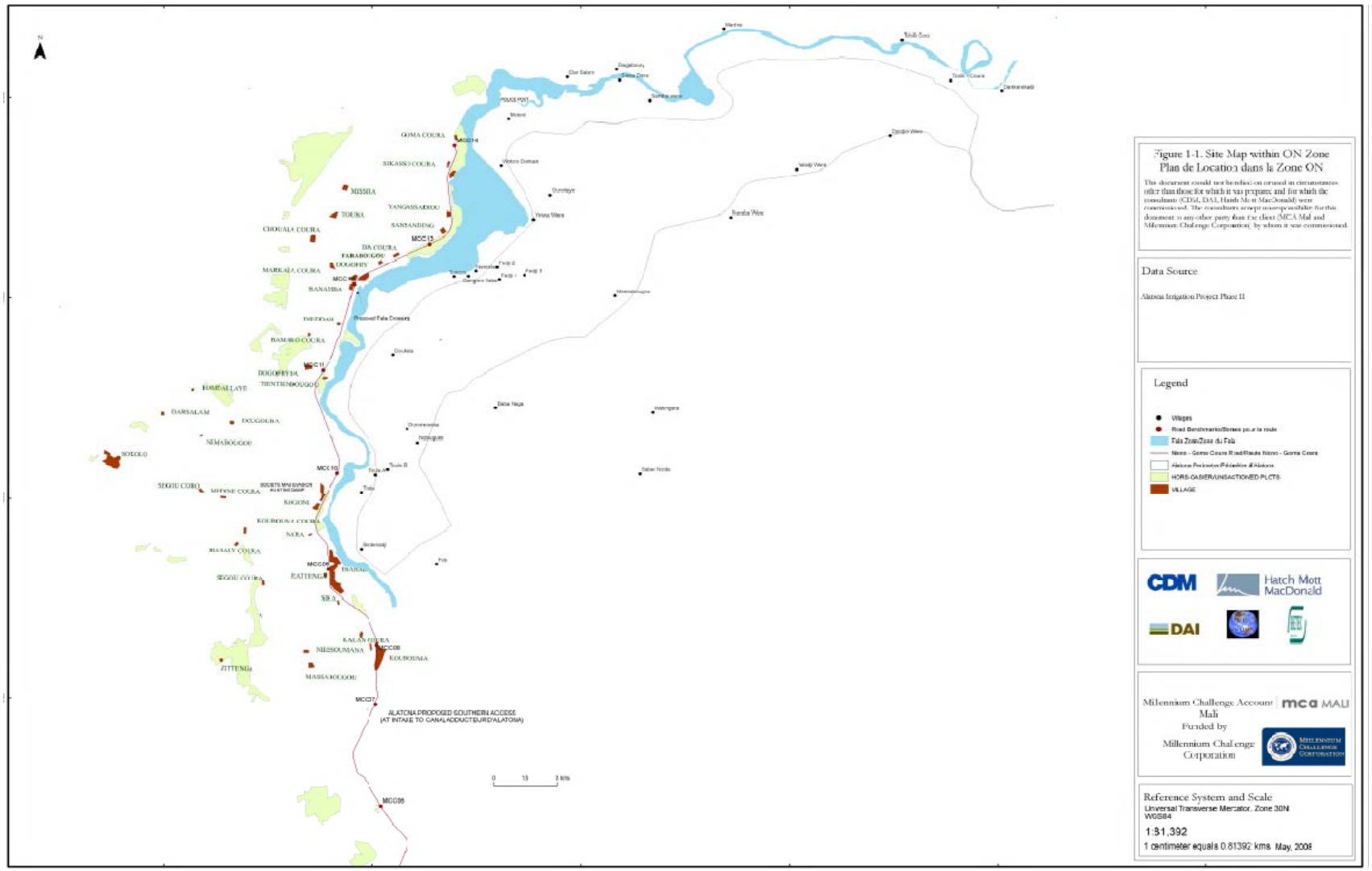


Figure 3: Alatona Map

Community Descriptive Statistics

In this section of the report, we begin our descriptive analysis of the baseline data collected to create a profile of community characteristics among households in the Alatona zone, irrigated villages, and non-irrigated villages. The statistics for the irrigated and non-irrigated villages are provided to help the reader further interpret the statistics on the PAPs. We focus on three areas of these community characteristics: access to infrastructure and services in the communities; a profile of agriculture; and a profile of community organizations.

Village Infrastructure and Access to Services

Access to infrastructure and basic services, such as health and schools, is fundamental to the well-being and future growth potential of communities. In our baseline survey, we measure access to infrastructure using two different measures of access: distance as measured in physical distance between communities and markets, and distance in terms of the time necessary for travel. Table 4 reports comparative statistics related to market and bus station access in terms of distance in kilometers (Panel A) and travel time in hours (Panel B) within the three groups of villages: Alatona villages, irrigated villages and non-irrigated villages. The table reports the mean of each variable for each type of village. For example, the first column and first row of Panel A tells us that the Alatona villages are on average 14.86 kilometers from the nearest daily market. In irrigated villages, the figure is only 5.46 kilometers. The second row in the table provides the standard deviation of the distance for each of the village groups. Following our example, the standard deviation of distance to the nearest village market in the Alatona is 8.86 kilometers. This gives us a sense of how much variation there is within the Alatona villages: a large standard deviation means there are many villages which are far from the mean (either larger or smaller). The irrigated villages have lower average distances to the nearest market and there is also less variability across villages within the irrigated villages compared to within the Alatona. All subsequent tables are structured this way, though standard deviations were only reported when we felt they were useful and interesting.

The reported information shows that the Alatona villages consistently have the highest average distances in kilometers (to daily markets, weekly markets, and bus stations). The comparison between the irrigated and non-irrigated villages shows that although the irrigated villages tend to be closer to daily markets, the distance to weekly markets is almost the same for the two types of villages. Consistent with the statistics on the distance in kilometers, the distances in hours

indicate that the Alatona villages face, on average, the highest travel time, followed by the non-irrigated villages.

Table 4 also provides information on village infrastructure with respect to access to electricity (Panel C), sources of drinking water in the dry season (Panel D), and sources of drinking water in rainy season (Panel E) for the three groups of villages. The results show that about one-third of irrigated villages have electricity; in stark contrast, less than one-tenth of non-irrigated villages have access to electricity. Even more striking, no village within the Alatona villages had electricity at the time of the baseline. The comparison at the village level shows that although some villages have access to electricity, households within those villages sparsely use it. Only approximately 6 percent of villages that reported access to electricity have more than 50 percent of the households that use electricity in those villages. Similarly, irrigated villages seem to have better access to potable water as the main source of drinking water. A higher fraction of irrigated villages have access to borehole water, and a high proportion of the Alatona and non-irrigated villages use well water as the main source of drinking. Finally, only villages in the Alatona zone use rainwater as a drinking source in the rainy season. Given the known health benefits of potable water, these differences in access to water represent a significant difference in well-being in the irrigated versus Alatona and non-irrigated villages.

Table 4: Village Infrastructure

	Alatona villages	Irrigated villages	Non-irrigated villages
	(1)	(2)	(3)
Panel A: Market access: distance (kilometers)			
Distance to nearest daily market	14.86	5.46	8.6
	(8.86)	(4.74)	(7.60)
Distance to nearest weekly market	16	7.65	10.44
	(12.90)	(4.56)	(7.25)
Distance to nearest bus/car transportation station	13	7.54	9.11
	(12.41)	(9.74)	(8.46)
Distance to nearest bus station (bus for Segou)	15.48	8.33	10.73
	(13.94)	(9.34)	(8.30)
Panel B: Market access: distance (hours)			
Distance to nearest daily market	1.77	0.56	2.14
	(1.14)	(0.57)	(1.84)
Distance to nearest weekly market	4.69	0.96	1.92
	(5.97)	(0.96)	(1.67)
Distance to nearest bus/car transportation station	4.26	1.11	2.01
	(6.87)	(1.22)	(1.64)
Distance to nearest bus station (bus for Segou)	4.96	1.16	1.16
Panel C: Electricity (percent)			
Percentage of villages with electricity	0.0	34.09	10.29
Percentage of villages where more than 50 percent use electricity	0.0	6.67	na
Panel D: Drinking water sources in dry season (percent)			
Tap water	3.13	0	1.47
Borehole	21.88	84.09	55.88
Well	68.75	36.36	61.76
River/lake	25	0	0
Panel E: Drinking water sources in rainy season (percent)			
Tap water	3.13	0	1.47
Borehole	18.75	84.09	55.88
Well	65.63	34.09	60.29
Rain	25	0	0
River/lake	28.13	0	4.69

Notes:

1 The sample size of villages/observations, listed in order for Alatona, irrigated and non-irrigated villages, respectively, in each panel is as follows:
Panel A: Distance to daily market: 7, 13, and 10 observations; distance to weekly market: 30, 40, and 61 observations; bus stations: 20, 30, and 60 observations; bus stations (to Segou): 29, 34, and 61 observations.
Panel B: Distance to daily market: 8, 16, and 9 observations; distance to weekly market: 30, 45, and 58 observations; bus stations: 20, 39, and 61 observations; bus stations (to Segou): 29, 44, and 62 observations.
Panel C, D and E: 32, 44, and 68 for all variables except "percentage of villages where more than 50 percent use electricity, which has 15 observations.

2 The average distance to a given place is computed with respect to all the transportation means used in the village.

3 Standard deviations are in parentheses.

Public transportation means that are regularly available to villagers in the data are summarized in Table 5. The most prevailing means of transportation in the Alatona villages are donkey carts, followed by bicycles and motorcycles. Although motorcycles are the predominant mode of transportation in the irrigated villages, villages in that zone tend to have better transportation infrastructure: up to 61 percent of them use buses. In contrast, only 25 percent of villages in the Alatona reported having access to a bus as a regular means of transport. The non-irrigated villages have a more similar level of access to bus transportation as the irrigated villages, with 54 percent having regular access to transportation by bus.

Table 5: Transportation

	Alatona villages	Irrigated villages	Non-irrigated villages
	(1)	(2)	(3)
Panel A: Means of transport regularly Available (percent)			
Bus/minibus/cars	25.00	61.36	54.41
Taxi	0	2.27	1.47
Boat/canoe	12.50	2.27	4.41
Moto/motorcycle	56.25	81.82	70.59
Donkey carts	93.75	70.45	73.53
Bicycles	65.63	59.09	55.88
Panel B: Transport costs in FCFA of a sack of rice			
To Bamako	3031	1515.79	1570.24
	(1298.60)	(447.23)	(615.85)
To Segou	2100	1076.316	904.38
	(741.62)	(389.51)	(487.60)
To Mopti	3500	2340	1625
	na	(976.22)	(176.78)
To Niono	1218.75	975	952.27
	(618.72)	(868.32)	(395.35)
To Diamarabougou	1500	937.5	757.14
	(707.11)	(291.04)	(325.69)

Notes:

1 The sample size of villages/observations, listed in order for Alatona, irrigated and non-irrigated villages, respectively, in each panel is as follows:

Panel A: 32, 44, and 68 observations.

Panel B: To Bamako: 8, 38, and 42 observations; to Segou: 5, 38, and 51 observations; to Mopti: 1, 5, and 2 observations; to Niono: 8, 28, and 22 observations; to Diamarabougou: 2, 20, and 21 observations.

2 Standard deviations are in parentheses.

The cost of transporting a sack of rice from a village to a major city outside the study area and to the capital city is also provided in Panel B of Table 5. Although there are many aspects of the overall cost of transportation, the cost of a sack of rice should be a good indicator of transportation costs for commodities and the overall expenses of shipping agricultural commodities to alternative markets. The statistics show that villages in the Alatona zone incur the highest cost to all destinations, which is not surprising given that Table 4 shows that villages in the Alatona zone tend to be the most remote. Panel A in Table 5 indicates reduced access to large-scale transport such as buses. The cost of transporting rice in the Alatona may require multiple modes of transportation (donkey cart to a town or village with truck access, for example) or higher cost of transport, both of which will increase the total cost of transporting agricultural goods to the market. These statistics will be interesting to monitor as road infrastructure is installed in the Alatona. We would expect to see decreases in transportation costs as well as transportation times after the project has been fully implemented.

Village infrastructure and access to transportation are important components of villagers' everyday life. However, the next generation's ability to be successful depends crucially on access to schooling and health facilities. Panel A in Table 6 presents information related to access to schools. School accessibility is a key determinant of children's school enrollment, especially since transport is not always easily accessible or affordable. It is important to mention that some schools listed as accessible by a village may not be in that village. For example, there is no school in the Alatona zone; yet, about one-third of villages in that zone declare having access to primary schools. Therefore, measures of access may not correspond precisely with actual enrollment rates: if children or their parents find it too difficult or time consuming for the children to walk to the nearest school, access alone may not ensure enrollment. These data do not provide precise information on distance to school, which would also be interesting. Similar to the finding related to infrastructure, villages in the irrigated area tend to have the best access to formal schools; approximately 94 percent of those villages have access to primary schools. The corresponding figures for the non-irrigated and Alatona villages are approximately 70 and 34 percent, respectively. It is also useful to recall that one school can be attended by children from several villages. For example, all 11 Alatona villages that report having access to formal schools referred to the same schools. The statistics on secondary school accessibility also show that villages in the irrigated area are by far the ones with the greatest access.

Table 6: Village Access to School and Health Facilities

	Alatona villages	Irrigated Villages	Non-irrigated villages
	(1)	(2)	(3)
Panel A: Access to schools (percent)			
Access to schools:			
Primary	34.38	88.64	73.53
Secondary	0	21.28	6.25
Superior	0	0	0
Professional	0	2.27	1.47
Panel B: Access to health facilities (percent)			
Hospital	0	4.55	5.88
Clinic	0	4.55	1.47
Health center	72.72	81.81	70.58
Dispensary	21.21	29.55	36.76
Health post	na	2.27	1.47
Traditional practioner	6.06	4.55	1.47
Panel C: Distance to health facilities (km)			
Hospital	na	62	11.5
	na	na	(12.40)
Clinic	na	5	5
	na	na	na
Health center	22	13.96	13.63
	(28.63)	(15.02)	(9.11)
Dispensary	18.67	7.92	7.75
	(14.01)	(6.14)	(5.58)
Health post	na	2	7
	na	na	na

Notes:

1 The sample size of villages/observations in each panel is as follows:
Panels A and B: 32, 44, and 68 observations for Alatona, irrigated villages and non-irrigated villages, respectively.
Panel C: Hospital: 1 observation for irrigated villages and 4 observations for non-irrigated villages, respectively.
Clinic: 1 observation for irrigated villages and 1 observation for non-irrigated villages.
Health center: 24, 45, 49 observations for Alatona, irrigated villages, and non-irrigated villages, respectively.
Poste de sante/dispensaries: 9, 13, and 24 observations for Alatona, irrigated villages, and non-irrigated villages
Health post: 1 observation for irrigated villages and non-irrigated villages.

2 Distance to tradi-praticien is not mentioned because tradi-praticiens are located in the village.

3 Standard deviations are in parentheses.

4 Several villages can access the same health center.

Information related to villages' access to health facilities in the study area is provided in Panel B in Table 6. Health centers are the most prevalent health facilities in all villages in the data. The overall picture is that all villages in the study area tend to have limited access to advanced health facilities. None of the villages in the Alatona zone report access to hospitals. For the irrigated and non-irrigated areas where access to hospitals is mentioned, the percentages of villages that have access to that type of health facility is only approximately 4 and 6 percent for the irrigated and non-irrigated villages, respectively. Another form of health facility widely used after health centers is dispensaries, which provide medicines and limited health consultations. Consistent with the descriptive statistics on distances to major places, villages in the Alatona area face longer distances to commonly used health facilities. The comparison between the irrigated and non-irrigated villages shows that the two village groups face similar distances to reach a health center or dispensary.

The AIP will likely be more successful if farmers have access to credit in order to pay for inputs. Access to other financial tools, including savings accounts, is also likely to be helpful in developing the Alatona region. Therefore we present here information on the most typical types of savings used in the study villages at baseline as well as a list of the most commonly used financial institutions for formal credit. Panel A in Table 7 presents statistics related to types of savings frequently used in villages. As one might expect, 100 percent of the Alatona villages raise livestock for savings purposes. This form of saving is also the most popular in the irrigated and non-irrigated villages. The most common form of savings after livestock holding is gold holding in the Alatona villages and grain stock in the irrigated and non-irrigated villages. With the exception of the irrigated area, where about 11 percent of the villages use savings accounts, formal savings forms (savings accounts and checking accounts) are almost nonexistent in all the study areas. Information related to top financial institutions for formal credit in the study areas is reported in Panel B in Table 7. The results show that financial institutions for formal credit in the selected villages in the study areas are predominantly run by credit and savings banks in the irrigated villages and by the village community in the Alatona and non-irrigated villages. Of particular interest, the data also show that there are no sources of formal credit available in the Alatona villages.

Table 7: Utilization of Savings and Credit in Baseline Villages (Percent)

	Alatona villages	Irrigated villages	Non-irrigated villages
	(1)	(2)	(3)
Panel A: Type of savings frequently used in village			
Gold	34.38	4.55	1.47
Land	0	2.27	2.94
Livestock	100	72.73	83.82
Stock of grains	21.88	47.73	29.41
Housing	0	2.27	1.47
Cash holding	9.38	15.91	4.41
Savings account	0	11.36	4.41
Checking account	0	0	1.47
Rotating savings association/tontine	3.13	25.00	11.76
Others	0	6.82	5.55
Panel B: Top four financial institutions for formal credit			
Credit and saving banks	0	67.86	50
Community (tontine, gpe, gie, group)	75	21.42	50.00
Government	0	7.41	12.50
Private bank	0	3.57	6.25

Notes:
The sample size of villages in each panel is as follows:
Panel A: 32, 44, and 68 observations for Alatona, irrigated villages and non-irrigated villages, respectively.
Panel B: 4, 28, and 16 observations for Alatona, irrigated villages and non-irrigated villages, respectively.

Village Agriculture

In creating a profile of the communities in our baseline study, one of the most important features is the types of agricultural systems that are practiced in the three types of villages. We review differences across the groups (Alatona, irrigated comparison villages and non-irrigated comparison villages) in land tenure and access to irrigation, characteristics of the agricultural labor market, crop choice, and access to agricultural extension services to create an overview of agricultural practices.

Types of land tenure in each village group are presented in Panel A in Table 8. This information shows that most families in all three study areas exploit their own land or rent land from

someone else. A more detailed analysis shows that the most prevailing form of land tenure in the non-irrigated area is proper ownership of the land that is cultivated. As for the irrigated villages, the most common form is renting land from someone else. This tendency is certainly driven by the fact that families in the irrigated villages rent land from the Office du Niger (ON) on shorter-term contracts or informally rent land from other farmers who hold a long-term contract with the ON. The fraction of villages in which there is sharecropping is quite high in the irrigated villages, especially compared with the Alatona and non-irrigated villages where sharecropping is a relatively rare type of land contract. The statistics in the same panel also show that families in all groups are engaged in the agricultural labor market, although Alatona has the lowest percentage of villages that report agricultural wage labor.

Panel B in Table 8 provides information on access to irrigation. Unlike land tenure, which tends to be similar across the study zones (especially for the irrigated and non-irrigated villages), access to irrigation is highly unequal. Although all the villages in the irrigated group have access to irrigation, only around 50 percent of the villages in the non-irrigated area and less than 25 percent of villages in the Alatona zone have access to irrigation. Types of irrigation available to villages that report access to irrigated land are presented in Panel C in Table 8. As one might expect, up to 88 percent of the irrigated villages have access to irrigation through the Office du Niger. Although the Alatona and non-irrigated villages are outside the Office du Niger, some portions of households in those zones have access to irrigation through the Office du Niger, implying that households residing in those zones rent land from the Office du Niger. Irrigation by the Office du Riz is only available to the non-irrigated village group as would be expected given the geographic distance between Alatona and the Office du Riz zone, which is closer to Segou.

The statistics in Panel D in Table 8 provide information on water fees charged by the irrigation source. The average water fee in the irrigated villages is approximately 65,000 FCFA per hectare; the corresponding figures in the Alatona and non-irrigated villages are about 44,000 and 45,000 FCFA, respectively. Although this figure seems to be higher in the irrigated villages, it is useful to recall that the corresponding standard deviation is substantially lower in the irrigated villages than it is in the Alatona and non-irrigated villages. The purchase price of a hectare of irrigated land by irrigation source is presented in Panel F in Table 8. Unlike the statistics on the water fees imposed by the irrigation source, the average rental price of a hectare of irrigated land seems to be lower in the irrigated villages, as would be expected. There is greater variation in rental prices, which are not subject to direct ON regulation because renting is done in the informal market. The prices for renting a hectare of irrigated land range from 90,000 FCFA to 125,000 FCFA.

Table 8: Land Tenure and Irrigation in Baseline Villages

	Alatona villages	Irrigated villages	Non-irrigated villages
	(1)	(2)	(3)
Panel A: Type of land tenure (percent)			
Owners	53.13	50.00	92.65
Payment of a fixed amount	18.75	77.27	30.88
Sharecroppers	9.38	47.73	8.82
Leasing land to those who exploit it for a fixed amount	3.13	63.64	16.18
Allowing sharecroppers to exploit land	0.00	45.45	3.57
Working in agriculture for a wage	18.75	86.36	76.47
Panel B			
Access to irrigation (percent)	24.24	95.45	52.24
Panel C: Irrigation access and types, all villages (percent)			
Office du Niger irrigation	15.15	84.09	27.94
Office du Riz irrigation	0	9.09	14.7
Non-mechanical irrigation	0	0.00	1.47
Traditional irrigation	0	2.27	2.94
Panel D: Irrigation access and types, villages with irrigation (percent)			
Office du Niger irrigation	62.50	88.10	52.78
Office du Riz irrigation	0	9.52	27.7
Non-mechanical irrigation	0	0.00	1.64
Traditional irrigation	0	2.38	5.56
Panel E: Irrigation costs in FCFA/ha by type			
Office du Niger	44017.5	64582.43	58943.33
	(20180.88)	(17734.10)	(19136.86)
Office du Riz	na	14416.67	14277.78
	na	(1876.39)	(2025.02)
Panel F: Purchase price in FCFA of a hectare of irrigated land by type			
Office du Niger	500000	450000	500000
	na	(63247.55)	Na
Panel G: Rental price in FCFA of a hectare of irrigated land by type			
Office du Niger	125000	98581.82	89000
	na	(42505.45)	(19052.00)
Office du Riz	na	Na	37500
	na	Na	(31819.81)

Notes:

1 The sample size of variables/observations in each panel is as follows. Numbers are reported for Alatona, irrigated villages and non-irrigated villages, respectively: Panels A, B and C: 32, 44, and 68; Panel D: 8, 42, and 36, and 12 non-irrigated villages for the variable "Office du riz;" Panel E: Office du Niger: 4, 37 and 15; Office du Riz: 3 and 9 observations in irrigated villages and non-irrigated villages, respectively.

2 Standard deviations are in parentheses

Descriptive statistics on the agricultural labor market are summarized in Table 9. Recall from Table 8 that Alatona had a lower percentage of villages that reported that villagers supplied labor to the market. Table 9 shows that irrigated and non-irrigated villages are more likely to hire agricultural labor from the market compared with the Alatona villages. In both irrigated and non-irrigated areas, 100 and 89 percent of villages, respectively, hired agricultural labor, while only 38 percent of villages in Alatona hired agricultural labor. The analysis in terms of hired labor by type of crop activity shows that households that hire labor use it for all types of crop activity except sowing. Panels C, D and E report the average daily wages paid in the three village groups for men, women, and children, respectively. It appears from the descriptive statistics in Panel D that women in the Alatona villages are not usually employed in the agricultural sector except for harvesting. Comparison of the average daily wage across village groups shows that the average agricultural labor wage is higher in irrigated villages than in Alatona and non-irrigated villages for all types of crop activity. Consistent with findings in other settings related to wage differentials between men and women, the baseline data show that the average daily labor wage for men is higher than that of women regardless of the type of crop activity. The most salient difference is noted in plowing, where the average daily wage for men is approximately 73 and 168 percent higher than the average daily wage for women in the irrigated and non-irrigated villages, respectively. Given that plowing is a labor intensive activity, it is intuitive that men would earn a larger premium over women for this activity compared with activities that require less physical strength, such as weeding. Panel E describes the rates of child labor but note 4 highlights that many of these numbers are based on few observations and do not account for the exact age of the child.

Table 9: Characteristics of the Agricultural Labor Market

	Alatona villages	Irrigated villages	Non-irrigated villages
	(1)	(2)	(3)
Panel A			
Hired agricultural labor (percent)	37.50	100.00	89.23
Panel B: Hired labor by crop activity (percent)			
Plowing	75.00	62.79	72.41
Planting	33.33	74.42	62.07
Sowing	16.67	36.36	29.31
Weeding	83.33	79.07	81.03
Harvesting	58.33	81.40	93.10
Panel C: Cost of men's labor in FCFA			
Plowing	1714.29	1983.05	1644.27
	(906.33)	(1635.27)	(1196.98)
Planting	875	1108.64	853.23
	(250.00)	(438.07)	(223.77)
Sowing	1000	966.67	797.06
	(0.00)	(87.97)	(192.41)
Weeding	922.22	888.46	823.81
	(233.33)	(203.62)	(277.45)
Harvesting	955.88	1026.79	816.24
	(181.90)	(288.72)	(208.53)
Panel D: Cost of women's labor in FCFA			
Plowing	na	1059.33	733.33
	na	(342.87)	(464.58)
Planting	500	1005.95	782.93
	na	(411.68)	(284.52)
Sowing	na	968.75	775
		(88.39)	(203.54)
Weeding	300	854.17	752.78
	na	(198.24)	(221.94)
Harvesting	916.67	1016.13	779.59
	(144.34)	(232.16)	(264.36)
Panel E: Cost of children's labor in FCFA			
Plowing	1142.86	1164.22	1141.67
	(1281.74)	(1478.72)	(891.08)
Planting	500	711.11	756.1
	(0.00)	(239.83)	(296.69)
Sowing	500	750	771.43
	na	(250.00)	(248.09)
Weeding	1006.25	767.86	940.91
	(849.55)	(229.22)	(583.43)
Harvesting	944.44	816.67	892.73
	(110.24)	(196.23)	(624.23)

Notes:

1 The sample size of villages/observations in each panel is as follows. Again observations are

reported for Alatona, irrigated and non-irrigated villages in that order:
Panel A: 32, 43, and 65 observations. Panel B: 12, 43, and 58.

2 Panel C: Plowing: 7, 19, and 35 observations; planting: 4, 47, and 62 observations; sowing: 2, 15, and 17 observations; weeding: 9, 26 and 42, observations; harvesting: 17, 56, and 117 observations.

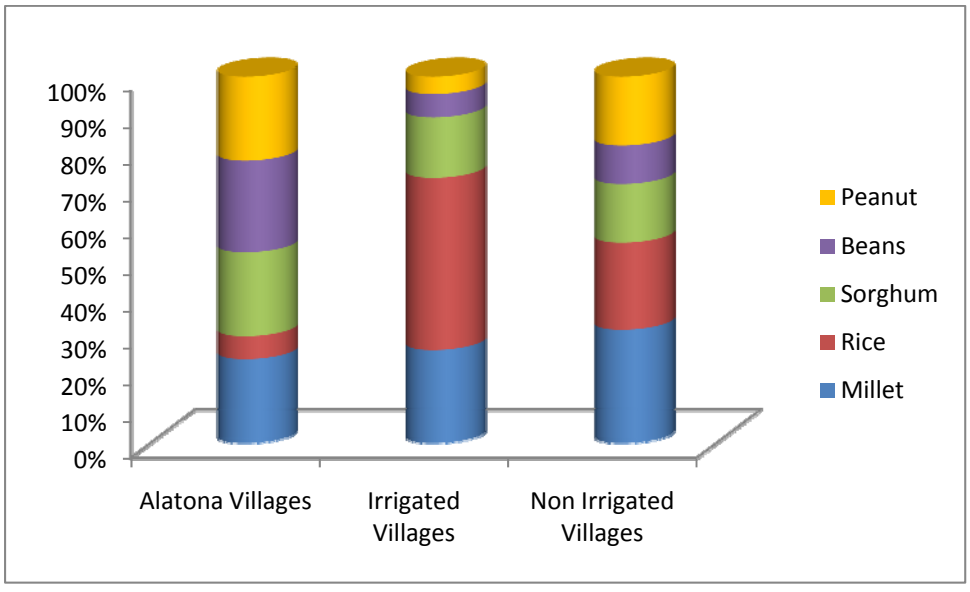
3 Panel D: Plowing: 3 observations for both the irrigated villages and non-irrigated villages; planting: 1, 43, and 41 observations; sowing: 9 and 8 observations for irrigated villages and non-irrigated villages, respectively; weeding: 1, 12 and 18 observations; harvesting: 3, 31, and 49 observations.

4 The sample sizes of variables in Panel E are as follows:
Plowing: 7, 9, and 12 observations for Alatona, irrigated villages and non-irrigated villages, respectively.
Planting: 4, 18, and 41 observations for Alatona, irrigated villages, and non-irrigated villages, respectively.
Sowing: 1, 5 and 7 observations for Alatona, irrigated villages, and non-irrigated villages, respectively.
Weeding: 8, 14 and 22, observations for Alatona, irrigated villages, and non-irrigated villages, respectively.
Harvesting: 9, 30, and 55 observations for Alatona, irrigated villages, and non-irrigated villages, respectively.

5 Standard deviations in between parentheses.

Figure 4 provides information related to the top five crops in the sample. Approximately 84, 45, and 30 percent of villages in the irrigated area cultivate rice, millet and sorghum, respectively. Thus, a greater proportion of households in those villages are engaged in rice production. A greater percentage of non-irrigated villages grow millet (82 percent), although rice is still a fairly common crop, with 63 percent of villages reporting rice as one of the top five crops in the village.

Figure 4: Top 5 crops at the village level



The fact that rice is more often named by irrigated villages than by non-irrigated and Alatona villages is not surprising, given the presence of the Office du Niger in those villages. By contrast, the proportion of households that cultivate each of the top five crops in the non-irrigated villages is less disproportionate. In the Alatona zone, villages are split almost equally between millet,

sorghum, beans, and peanuts. Less than 10 percent of villages in Alatona reported rice as one of the top five crops in the village.

A key input in agricultural production is agricultural knowledge that increases the farmer's ability to mix inputs and agricultural capital efficiently. One key intervention by the Malian government and local organizations is to increase agricultural knowledge through extension services. Access to extension, the type of advice provided, and the sources of extension services are summarized in Panels A, B, and C in Table 10. Although about 59 and 36 percent of the irrigated and non-irrigated villages, respectively, have access to extension services, only one village in the Alatona zone reports access to extension services. The data show that advice about access to agricultural inputs is by far the most commonly available extension service in the irrigated villages. The second and third most important objectives of extension services in the irrigated villages are information sharing and credit access, respectively. By contrast, the non-irrigated villages seem to have equal extension services focusing on access to agricultural inputs and access to credit.

Table 10: Crop Choice and Access to Agricultural Extension Services at the Village Level

	Alatona villages	Irrigated villages	Non-irrigated villages
	(1)	(2)	(3)
Panel A: Existence of extension services (Percent)			
Extension advice received	3.03	59.09	35.82
Panel B: Objectives of extension advice (Percent)			
Information sharing	100	23.08	4.17
Input access	0	46.15	45.83
Credit access	0	26.93	29.27
Marketing	0	3.85	12.50
Other objectives	0	11.54	16.67
Panel C: Source of extension advice (Percent)			
Government	0.00	53.85	20.83
NGOs	100.00	40.91	73.08
Farmers associations	0.00	7.69	0.00
Others	0.00	11.54	0.00

Notes:

1 The sample size of villages in each panel is as follows: Panel A: 31, 44, and 68 observations for Alatona, irrigated villages and non-irrigated villages, respectively. Panels B and C: 1, 26, and 24 observations for Alatona, irrigated villages and non-irrigated villages, respectively.

2 Information sharing consists of sharing information related to agricultural practices or new technologies.

3 Access to agricultural inputs comprises access to fertilizer, pesticides, insecticides, and other agricultural inputs.

The information in Panel C shows that both government and non-governmental organizations provide extension services in the irrigated villages. For villages in the non-irrigated group and Alatona, extension services are predominantly run by non-governmental organizations. Strikingly, no village in Alatona reported government extension services.

Panel B in Table 11 reports the availability of agricultural credit in the three village groups in the study areas. Agricultural credit can be either in cash or in kind. In-kind agricultural credit may consist of fertilizer, pesticides, insecticides, herbicides and other agricultural inputs. Agricultural credit is totally non-existent in the Alatona zone. The figures also show that much higher proportions of the irrigated villages have access to all available sources of agricultural credit compared with the non-irrigated villages. The striking difference is noticed in access to agricultural credit through savings and credit banks, where the percentage of the irrigated villages that have access to formal credit through that source is 50 percent, while the corresponding percentage in the non-irrigated villages is 10 percent. Finally, the statistics in Panel C show that borrowers in the irrigated villages face higher interest rates than those in the non-irrigated villages.

Panel A in Table 11 looks at agricultural associations in the study villages. Two-thirds of the Alatona villages reported no agricultural association, compared with only 5 percent of irrigated villages and 40 percent of non-irrigated villages. No village in Alatona reported that there was an agricultural association present in the village that facilitated access to agricultural inputs or credit. In sharp contrast, more than 85 percent of irrigated villages had an agricultural association that was involved in improving farmers' access to inputs and almost 60 percent had an association focusing on credit. (Note that the same association may serve multiple functions.) The agricultural associations that do exist in Alatona appear to be most focused on collective work. Collective work is also an important part of agricultural associations in the non-irrigated villages and, to a lesser extent, although not negligible, in the irrigated villages.

Note that the irrigated villages are the only group that has an association whose main objective is water fee collection, which is expected because of the presence of the Office du Niger in those villages. However, it is useful to mention that the proportion of villages that promote this type of activity is only about 6 percent, implying that, in general, water fee collection is mostly managed by structures other than the farmers' community.

Table 11: Agricultural Credit

	Alatona villages	Irrigated villages	Non-irrigated villages
	(1)	(2)	(3)
Panel A: Agricultural associations (percent)			
Villages with zero agricultural association	66.67	4.55	39.71
Information sharing (technology and agriculture)	20.00	76.19	53.66
Input access	0	85.71	43.90
Credit access	0	57.14	24.39
Collection of water fees	0	7.14	2.44
Assistance in marketing	10.00	11.90	4.88
Collective work	100.00	83.33	95.12
Other agricultural associations' activities	20.00	23.81	36.59
Panel B: Source of agricultural credit (percent)			
Savings and credit bank	0	50.00	10.29
Private bank	0	15.91	4.41
Government	0	11.36	2.94
Community (tontine, gpe, gie, groupement)	0	25.00	7.35
Panel C: Interest rates			
Minimum interest rate offered	na	11.53	10.29
		(11.27)	(5.20)
Maximum interest rate offered	na	15.34	10.29
		(11.69)	(4.31)

Notes:

1 The sample size of villages /observations in each panel is as follows:
Panel A: 30, 44, and 68 for Alatona, irrigated villages and non-irrigated villages, respectively.
Panel B: 29, 44, and 68 for Alatona, irrigated villages and non-irrigated villages, respectively.
Panel C: The sample sizes of variables in this panel are as follows:

2 Minimum interest rate: 39 and 7 observations for irrigated villages and non-irrigated villages, respectively.
Maximum interest rate: 37 and 7 observations for irrigated villages and non-irrigated villages, respectively.

3 Standard deviations are in parentheses.

Community Organizations

The last set of variables that we use to illustrate a profile of the communities in the Alatona, irrigated and non-irrigated comparison groups investigates the presence and type of development interventions and community groups that promote the welfare of the community. The statistics in Panel A in Table 12 provide information related to development interventions since 1998. The data show that a much higher fraction of the irrigated villages benefited from several development programs than villages in the Alatona and non-irrigated areas. It appears from the data that projects are predominantly run by the government across all village groups. Indeed, all programs in the Alatona villages are exclusively run by the government. There is also evidence of non-governmental organizations in the irrigated and non-irrigated villages, as 28 and 15 percent of the irrigated and non-irrigated villages, respectively, benefited from development programs implemented by these structures.

Panels B and C in Table 12 provide information related to the presence and type of community groups in each village group. Similar to the finding related to the presence of agricultural associations, the reported information shows that more villages in the irrigated and non-irrigated groups report the presence of community groups than villages in Alatona. In fact, while 100 and 80 percent of the irrigated and non-irrigated villages, respectively, have more than one community group, the corresponding figure for the Alatona villages is only about 38 percent. The types of community groups in the irrigated and non-irrigated villages are also more diversified than they are in the Alatona villages. The most important community groups are youth associations, agricultural associations, savings and credit associations, political party associations, and cooperatives. Cooperatives are most commonly found in irrigated villages. Cooperatives are the most formal type of community group, which is consistent with the image of the irrigated villages as having access to more formal institutions – health, schooling, financial – across the board.

Table 12: Development and Community Groups in Baseline Villages (Percent)

	Alatona villages	Irrigated villages	Non-irrigated villages
	(1)	(2)	(3)
Panel A: Development interventions			
Government	3.57	13.64	1.47
NGOs	na	29.55	13
Government and NGOs	na	2.27	2.94
Government and community	na	Na	Na
NGOs and community	na	2.27	1.47
Others	na	15.91	1.47
Panel B: Presence of community groups			
Villages with no community groups	31.25	0	5.88
Villages with one community group	31.25	0.00	14.71
Villages with more than one community groups	37.70	100.00	79.41
Panel C: Types of community groups			
Cooperatives	na	36.36	12.50
Agricultural associations	22.73	79.55	46.88
Work groups (other than gardening)	4.55	15.91	20.31
Gardening groups	4.55	11.36	14.06
NGOs	Na	6.82	1.56
Youth groups	59.09	77.27	79.69
Mutualist groups	22.73	20.45	32.81
Savings and credit associations	31.82	70.45	53.13
Political party associations	na	47.73	35.94
Business associations	na	na	1.56

Notes:
The sample size of variables in each panel is as follows:
Panel A: 28, 44, and 68 for Alatona, irrigated villages, and non-irrigated villages, respectively.
Panel B: 32, 44, and 64 for Alatona, irrigated villages, and non-irrigated villages, respectively.
Panel C: 22, 44, and 64 for Alatona, irrigated villages, and non-irrigated villages, respectively.

Household Descriptive Statistics

In the baseline survey, a significant amount of information regarding household characteristics was collected to compare the outcomes of similar households over time, disaggregate program impacts across relevant sub-groups (by gender, asset holdings, input utilization, land tenure, etc.) and compare relevant characteristics between treatment (Alatona villages) and comparison groups (irrigated villages and non-irrigated, rainfed agricultural villages). As the former two objectives can only be accomplished with a complementary follow-up survey, we focus our descriptive analysis on the latter. Again we report the summary statistics from all households in the irrigated and non-irrigated villages, even though in practice only some of them will be used as comparison households for the impact evaluation. The statistics are included here to provide additional information with which to interpret the statistics on the Alatona households. The household analysis investigates household composition, housing conditions, education and health of household members, household welfare including durable asset holdings, livestock holdings, food and non-food expenditures that are used to develop poverty indicators, and agricultural activities including land holdings, crop production, agricultural capital, inputs, and agricultural labor.

Household composition and demographic characteristics are important indicators of household structure that could affect program impact through the availability of different types of labor within the household. We investigate differences in household size and composition variables in Table 13 by disaggregating these variables as in the previous section into households residing in the Alatona villages, villages with access to irrigation, and villages with no access to irrigation. Two measures of household size are used in Table 13. The first household size variable reports the count of the household members, while the second variable weights different household members according to consumption requirements (Deaton and Zaidi 2002). Hence, men, women and children are weighted to produce an adult equivalency measure of household size, with children of course weighted less than adults. This is the equivalent number of adult consumption units in the household. We note several differences between the groups of villages in household composition. First, household size, using either the count of household members or the adult equivalent size, is smaller and statistically different in the Alatona communities compared with either the irrigated or non-irrigated villages. We do not observe differences between irrigated and non-irrigated villages, but households in the Alatona have 2.4 fewer members compared with households with irrigation in the comparison group. We return to this difference, and its potential implications for household poverty, when we discuss the data on food consumption.

Table 13: Household Composition

	Alatona villages	Irrigated villages	Non-irrigated villages
	(1)	(2)	(3)
Panel A: Household size			
HH size of those resident 6 months or more	7.90	10.37	10.87
	(3.95)	(6.89)	(7.4)
HH size of those resident 9 months or more	7.50	10.20	10.69
	(3.85)	(6.88)	(7.39)
Panel B: Age groups			
HH size in per adult equivalent units for those resident 6 months or more	4.85	6.00	6.37
	(2.17)	(3.60)	(3.78)
HH size in per adult equivalent units for those resident 9 months or more	4.36	5.90	6.23
	(2.31)	(3.60)	(3.79)
Number of women over 65 years old	0.14	0.19	0.24
	(0.35)	(0.43)	(0.47)
Number of men over 65 years old	0.10	0.14	0.16
	(0.31)	(0.39)	(0.39)
Number of men 18-65 years old	1.86	2.01	2.15
	(1.21)	(1.58)	(1.63)
Number of women 18-65 years old	1.85	2.41	2.57
	(1.18)	(1.79)	(1.95)
Number of girls 5-17 years old	1.31	1.88	2.09
	(1.34)	(1.83)	(1.96)
Number of boys 5-17 years old	1.40	1.87	1.79
	(1.32)	(1.81)	(1.75)
Number of girls 0-5 years old	0.67	0.92	0.99
	(0.80)	(1.12)	(1.31)
Number of boys 0-5 years old	0.61	0.86	0.92
	(0.82)	(1.1)	(1.13)
Female headed households (percent)	3.99	2.85	2.21704

Notes:

The sample size of the observations in each variable group is as follows:

Panel A: HH size of those resident 6 months or more: 745, 554, and 856 observations for Alatona, irrigated, and non-irrigated villages, respectively.

HH size of those resident 9 months or more: 706, 554, and 853 observations for Alatona, irrigated, and non-irrigated villages, respectively.

Panel B: 752, 562, and 857 for Alatona, irrigated, and non-irrigated villages, respectively.

Standard deviations are in parentheses.

Panel B in Table 13 explores the demographic characteristics of households. We observe that differences in household size appear to be driven primarily by higher numbers of women and girls in the non-Alatona villages than in the Alatona villages. Despite larger counts of women in the irrigated and non-irrigated villages, the percentage of female headed households is similar across both treatment and comparison groups, ranging from 2 to 4 percent. This is a low figure. While the baseline data does not provide any direct information as to the reasons for such low rates of female-headed households, we offer some speculation. This may reflect that an (almost) adult male – a son for example – will usually be reported as the household head even if a woman has significant decision-making ability. There is also the cultural practice where a man will often marry his brother's widow, driving down the rate of female headed households even when some of these marriages are in name-only.

In Table 14, we provide evidence about the housing conditions among households in the study villages, as well as the household's access to basic services such as potable water and electricity. We find large, statistically significant differences in dwelling characteristics between the Alatona households and those in the other villages. We use three primary characteristics to capture differences in dwellings: floor type, roofing material, and primary wall material. The first is the material used on the floor of the dwelling structure. The second variable is the material used for the roof of the house. Among all households in the survey, the most predominant floor material used to construct dwellings is *banco*, a mix of earth and cement that provides a more durable surface. However, a larger subgroup of the Alatona population uses earthen floors (26 percent) than those households in either irrigated areas (10 percent) or non-irrigated areas. By contrast, households in the comparison group are much more likely to have cement floors. Sixteen percent of households in the irrigated group and 10 percent of households in the non-irrigated group had cement floors, while only 1 percent of households in the Alatona had cement floors. Differences in roofing materials are as striking as differences in the floor construction material. Between 93 and 95 percent of households in both comparison groups used *banco* as their primary roofing material. Sixty percent of households in Alatona had *banco* roofing material; the remaining 40 percent used woven grass mats or sticks as roofing material. This is the least durable or protective roofing material and reflects a stark difference in welfare levels between the Alatona villages and the other villages. We also find a similar trend with 12 percent of households in Alatona using mats or sticks as their primary materials for walls, with the remaining households using *banco*. The majority of households in the comparison group used *banco* as their primary material for walls.

Table 14: Housing Conditions (Percent)

	Alatona villages (1)	Irrigated villages (2)	Non-irrigated villages (3)
Floor material (distribution among response options)			
Earthen	25.70	10.20	8.59
Banco	72.98	73.00	81.03
Cooked bricks	0.00	0.00	0.13
Cement	1.17	16.40	10.26
Other	0.15	0.40	0.00
Roofing material (distribution among response options)			
Thatched	40.00	0.61	3.59
Banco	59.26	95.35	93.21
Corrugated iron (tôle)	0.29	3.03	2.95
Terraced / cement	0.00	0.61	0.13
Animal skin	0.29	0.00	0.00
Other	0.15	0.40	0.13
Walls material (distribution among response options)			
Mats / sticks	12.06	0.40	1.54
Banco	86.47	97.78	97.04
Partially concrete (Semi dur)	0.15	1.21	0.77
Concrete (Dur)	0.15	0.61	0.26
Thatched (Epines)	0.59	0.00	0.39
Other	0.59	0.00	0.00
Main water source (distribution among options)			
River	0.00	0.20	0.13
Irrigation canals	0.15	1.00	0.13
Wells	31.86	13.86	24.58
Traditional Wells	29.22	15.46	27.80
Soak Pit	0.88	0.40	0.13
Borehole	30.54	64.46	43.50
Waste system			
Concrete latrine	2.50	12.53	14.25
Latrine without concrete	33.77	83.43	78.18
Bush	63.58	4.04	7.57
Other	0.15	0.00	0.00

Note:
Sample size is 752, 562, and 857 for Alatona, irrigated, and non-irrigated villages, respectively, for all variables.

Differences in access to water and toilet facilities are equally striking as differences in dwelling characteristics. A third of the Alatona group uses as the main water source improved deep wells, a third uses traditional uncovered wells, and the final third uses covered wells. Villages outside

of the Alatona have a higher level of access to improved deep wells, with a 34 and 13 percent point difference of irrigated and non-irrigated comparison group villages, respectively, with the rate of access to water source in the Alatona villages. Stark differences in toilet facilities are also present comparing the Alatona villages to the irrigated and non-irrigated villages. Sixty-four percent of Alatona households have no toilet or latrine facilities and use the outside environment to evacuate human waste. Only 4-8 percent of households in the comparison group had no toilet or latrine facility.

To summarize, the baseline data suggests that households in the Alatona have smaller households but live in worse living conditions, as measured by the quality of their floors, roofs and latrines and the type of drining water they can access, than households in the irrigated or non-irrigated villages.

Human Capital

We turn now to profile another important dimension of household wellbeing: human capital status among household members. Human capital includes education and health and there is substantial evidence that both are highly correlated with the long-term wellbeing of individuals and households. We investigate the characteristics of the baseline sample by comparing differences in educational status of men, women and current school-age children across the Alatona, irrigated comparison group and non-irrigated comparison group. After these comparisons, we investigate self-reported illnesses of men, women and children and their access to health facilities for treatment between the three baseline groups.

In Table 15, we present evidence from the baseline on the highest grade achieved for men, women and children in Panels A, B, and C, respectively. Stark differences in access to education are found among the three groups, but educational achievement is low in all three groups. In irrigated villages, 25 percent of men had completed some education, while only 10 and 1.6 percent of men in the non-irrigated villages and Alatona, respectively, had completed any education. However, even among men in the irrigated villages, only 13 percent of men had completed between the 1st and 5th grade level, while 9 percent had completed between the 6th and 9th grade level. With respect to women's educational attainment, the pattern between baseline groups is similar, although the level of educational attainment is lower in all groups. Women from the irrigated areas had the highest levels of educational attainment, with 10 percent having some education, while women in non-irrigated comparison villages had only a 2.8 percent educational achievement rate. Only 1.2 percent of women in the Alatona villages had any schooling. The low levels of education in the Alatona cannot be over emphasized.

Table 15: Educational Attainment (Percent)

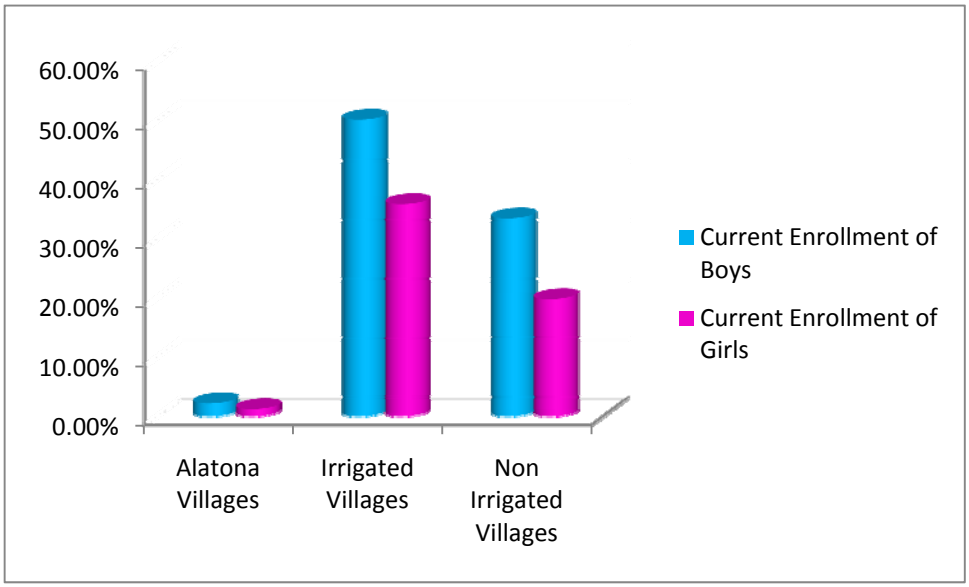
	Alatona villages	Irrigated villages	Non-irrigated villages
	(1)	(2)	(3)
Men (18 years and above)			
Education (1 if any)	1.58	24.82	10.44
No education	98.55	75.97	90.00
First to fifth grade	1.19	13.01	5.83
Sixth to ninth grade	0.20	9.36	3.64
First year high school or CAP	0.00	0.24	0.24
Second year high school or CAP/B	0.07	0.56	0.15
Third year high school	0.00	0.40	0.10
Four year BT	0.00	0.40	0.00
University	0.00	0.08	0.05
Total	100.00	100.00	100.00
Women (18 years and above)			
Education (1 if any)	1.16	10.14	2.76
Highest class completed	0.00	0.00	0.00
No education	98.91	90.27	97.32
First to fifth grad	0.88	5.89	1.96
Sixth to ninth grade	0.14	3.42	0.64
First year high school or CAP	0.07	0.14	0.04
Second year high school or CAP/B	0.00	0.21	0.04
Four year BT	0.00	0.07	0.00
Total	100.00	100.00	100.00

Note:
Sample size is 752, 562, and 857 for Alatona, irrigated, and non-irrigated villages, respectively, for all variables.

Perhaps things look brighter for the next generation? Figure 5 below shows the educational participation rate of school-age children. Unfortunately we find the same pattern for children as we find for adults. Fifty percent of boys in irrigated areas were currently enrolled while 41 percent of all girls of school age where enrolled. In comparison, 38 and 24 percent of boys and girls, respectively, from non-irrigated comparison villages were enrolled. 3 and 1.5 percent of boys and girls were enrolled in the Alatona villages. These statistics suggest a persistent intergenerational lack of access to education for both adults and children in the Alatona villages. They also suggest strong differences in investments in education made by households for boys relative to girls. It seems that the Alatona Irrigation project, in creating new communities and building schools to increase access to education, should also emphasize the importance of equal access to education. Educational differences potentially have impacts on agricultural production as well as being an indicator of welfare itself. Individuals with higher education are more likely to adapt to new technologies, so stark differences in education could have an impact on overall

project benefits. Tracking the impact of the AIP on school enrollment rates will be an important part of the impact evaluation.

Figure 5: Children's schooling enrollment (7 to 18 years old)



Access to health care and the effect of illness on individuals in the baseline survey are important dimensions of human capital, along with education. We report differences in self-reported illness over the previous month for men, women and children among the three baseline groups, as well as the type of facility that was consulted in response to the illness. These results on the health of household members are reported in Table 16. Between 11 and 14 percent of men in the baseline survey reported being ill in the previous month, with the highest percentage reported in Alatona. However, the rates of illness in both the Alatona and irrigated groups are similar. Among women, 17 percent in Alatona reported being ill in the previous month, while 12-13 percent of women in the non-Alatona groups reported an illness. These numbers suggest that illness rates are fairly similar across all households in the survey; this is consistent with the finding in Table 6 that all villages in the survey have fairly similar access to health centers and dispensaries.

Table 16: Health (Percent)

	Alatona villages	Irrigated villages	Non-irrigated villages
	(1)	(2)	(3)
MEN			
Self-reported illnesses (1 if any)	14.36	13.24	10.49
Type of medical facility consulted (distribution across types)			
Hospital	9.59	14.86	16.67
Health center (Centre de santé)	80.82	70.27	66.67
Dispensary	5.48	1.35	2.78
Private Clinic	1.37	4.05	1.39
Traditional Healer	1.37	5.41	12.50
Other	1.37	4.05	0.00
Total	100.00	100.00	100.00
WOMEN	16.85	12.95	11.56
Self-reported illnesses (1 if any)			
Type of medical facility consulted (distribution across types)			
Hospital	5.00	19.78	20.00
Health center	77.50	72.53	61.90
Maternal health center (Maternité)	5.00	0.00	6.67
Dispensary	1.25	2.20	5.71
Private Clinic	1.25	2.20	1.90
Traditional Healer	10.00	2.20	2.86
Other	0.00	1.10	0.95
Total	100.00	100.00	100.00
CHILDREN	8.84	8.98	7.23
Self-reported illnesses (1 if any)			
Type of medical facility consulted (distribution across types)			
Hospital	3.53	5.56	5.66
Health center	83.53	78.89	74.53
Maternal health center (Maternité)	1.18	1.11	6.60
Dispensary	1.18	2.22	8.49
Private Clinic	1.18	5.56	0.94
Traditional Healer	9.41	4.44	1.89
Other	0.00	2.22	1.89
Total	100.00	100.00	100.00

Notes:
1. There are 404, 447, and 684 observations for the Alatona, irrigated, and non-irrigated villages, respectively.
2. Standard deviations are in parentheses.

Illnesses among children were lower than those reported by either men or women. Children's illness rates varied between 7 and 9 percent among the three baseline groups. Of men who were ill in the previous month, the type of health facility most frequented among all three baseline groups was the health center (*centre de santé)*. However, men in the irrigated and non-irrigated comparison groups had higher rates of use of hospitals that provide more services and diagnostic capability than the health center (*centre de santé)*. These trends are generally true for both women and children as well. A particular difference primarily in the Alatona villages is the higher frequency of using traditional healers, where almost 10 percent of women and children visited a traditional healer while only 1 percent of men did. Men in the non-irrigated villages showed the highest use of traditional healers, with 12.5% of medical facility visits being to a traditional healer. More investigation into these differences in health care facility utilization is necessary to understand if severity of illness, costs, intra-household decision-making or cultural norms may drive these statistics.

Household Welfare

In this section, we examine measures of household welfare. Household welfare could be measured in terms of physical assets, livestock holdings, or formal savings. These asset based measures are complemented in our baseline analysis with an expenditure analysis of both food and non-food items. Following Deaton and Zaidi (2002), we then construct a consumption aggregate to measure household poverty levels and inequality at the dollar-a-day poverty line.

Table 17: Household Assets and Livestock Holdings

	Alatona villages	Irrigated villages	Non-irrigated villages
	(1)	(2)	(3)
Panel A: Assets			
Asset count--men	21.17	71.51	33.87
	(19.93)	(522.16)	(119.52)
Asset count--women	50.66	84.37	76.56
	(48.90)	(137.23)	(96.56)
Asset count--HH	70.91	155.47	109.70
	(57.52)	(568.91)	(159.97)
Asset value--men	96647.85	236051.2	177748.2
	(181747.7)	(660613)	(427515,3)
Asset value--women	201030	186224.1	149213.5
	(382618.6)	(364399.3)	(272,451.9)
Asset value--HH in FCFA	293950.9	421103.9	324631.1
	(3437393.3)	(826112.7)	(572618.5)
Panel B: Livestock			
Livestock count--men	41.53	11.59	13.41
	(66.66)	(17.83)	(24.31)
Livestock count--women	11.43	4.28	5.98
	(21.26)	(8.12)	(10.57)
Livestock count--HH	52.50	15.66	19.23
	(72.33)	(20.10)	(27.86)
Livestock count--large animals--men (bulls, cows, calfs, donkeys)	9.24	2.51	2.98
	(19.84)	(7.68)	(8.59)
Livestock count--large animals--women	1.062162	0.2924188	0.2847059
	(3.65)	(1.16)	(1.26)
Livestock value—men	1396741.0	341975.1	362710.1
	(2643153)	(1138104)	(952263.8)
Livestock value--women	202896.9	48039.5	84952.8
	(590797.6)	(159075.3)	(246213.6)
Livestock value--HH	1587113.0	384890.2	443682.2
	(2766990)	(1148005)	(1058786)

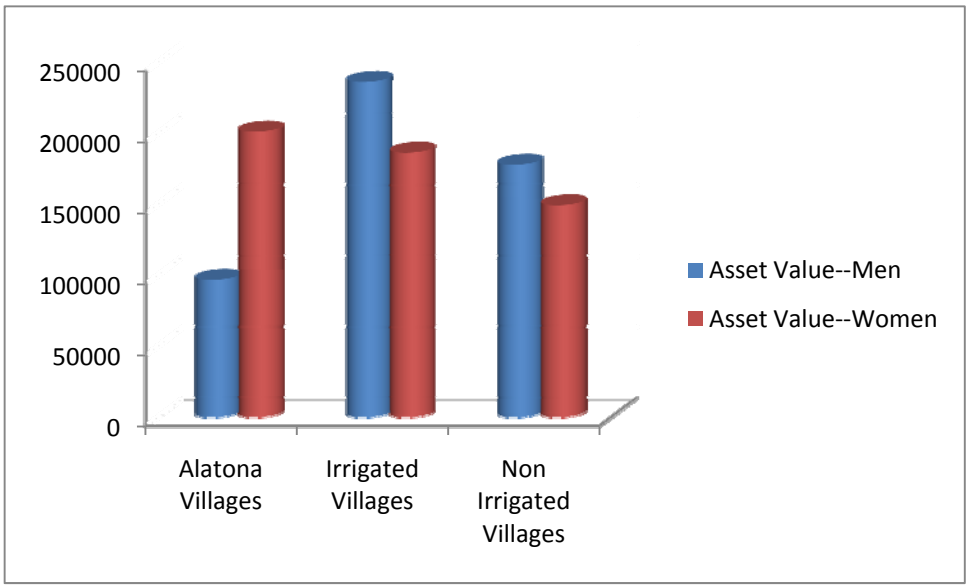
Notes:

1 The sample size of the observations in each variable group is as follows:
Panel A: Men's variables: 747, 560, and 847 observations for Alatona, irrigated, and non-irrigated villages.
Women's variables: 739, 561, and 849 observations for Alatona, irrigated, and non-irrigated villages.
HH variables: 751, 562, and 854 observations for Alatona, irrigated, and non-irrigated villages.
Panel B: Men's variables: 747, 553, and 847 observations for Alatona, irrigated, and non-irrigated villages, respectively, except "Livestock value—men," which has 554 observations.
Women's variables: 740, 559, and 851 observations for Alatona, irrigated, and non-irrigated villages, respectively, except "Livestock count--large animals—women," where the corresponding observations are 740, 554, and 850.

2 Standard deviations are in parentheses.

In Table 17, we report asset counts and values of assets for both physical assets and livestock holdings of men and women. Panel A provides the count and value of assets including both household durables and other physical assets. In the Alatona, women hold more assets than men, but hold fewer assets than women in either the irrigated or non-irrigated comparison groups. Since total household assets are quite low among households in the Alatona, household durables such as cooking materials and other household objects are likely held by women, whereas men may hold fewer of this type of durable assets when households are poor. Women also have a larger total number of assets, also driven by kitchen-related assets, in both the irrigated and non-irrigated villages. However, despite owning fewer assets than women, men in the irrigated and non-irrigated villages have higher-valued assets than women have. The patterns in asset values are also demonstrated in Figure 6.

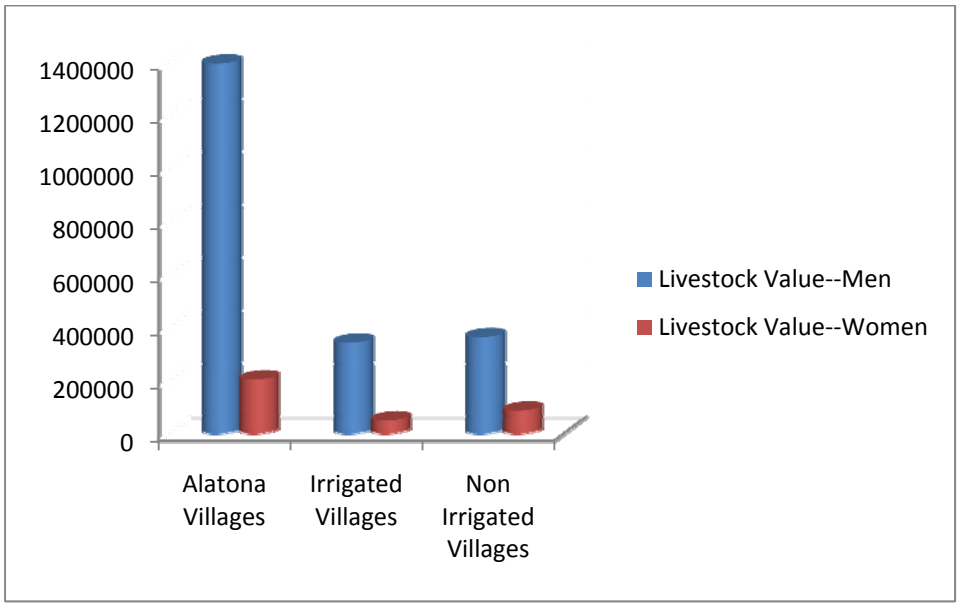
Figure 6: Asset Values in FCFA



Livestock holdings are another form of assets and are reported separately since they are of interest in their own right. One consideration in the design of the AIP was how PAPs were going to maintain their livestock holdings as former grazing land is converted into irrigated farm land. The data indicate that overall men have a larger savings portfolio in livestock than women. Both in terms of tropical livestock units and value of livestock, men have higher livestock holdings and values of these holdings than women. Most striking among all these asset comparisons is the high level of livestock holdings and value among men in the Alatona villages. These holdings are almost four times those reported by households in the comparison villages. The exact statistics, including standard deviations, are reported in Table 17. With respect to livestock holdings, households in the Alatona do appear to be better off than comparison group

households. To better illustrate these differences we also include Figure 7, which is a graphical representation of the same data.

Figure 7: Livestock Value



A key measure of household welfare can also be captured from household expenditures. Table 18 looks at non-food expenditure among households in the Alatona, irrigated and non-irrigated villages. Monthly household non-food expenditure is highest in the irrigated villages, followed by the non-irrigated villages and then the Alatona. The sampled households in the irrigated villages reported 77 percent more monthly non-food expenditure than households in the Alatona. We see the same pattern in monthly per capita expenditure and in per adult equivalency terms, which counts children less than adults since we anticipate their consumption to be lower. The remaining rows in the table give a more detailed breakdown of non-food expenditure: non-durables, clothing, transport and energy make up a large fraction of non-food spending. As anticipated given the enrollment reported earlier, schooling expenses are near zero in Alatona. By contrast, schooling expenses are non-trivial, over 900 FCFA per month, among households in irrigated villages. Recall however that there are on average 3.8 children between the age of 5 and 17 in the households located within irrigated villages, though only 43% were currently enrolled in school.

Table 18: Non-food Expenditures

	Alatona villages	Irrigated villages	Non-irrigated villages
	(1)	(2)	(3)
Non-food expenditures			
Monthly household non-food expenditure	13334	23565	15881
	(28603)	(34215.)	(20199)
Monthly per capita non-food expenditure	1775	2390	1497
	(2202)	(2680)	(1599)
Monthly per adult equivalent non-food expenditure	2754	3841	2412
	(3475)	(4177)	(2439)
House repairs	180	259	226
	(712)	(1126)	(2267)
Clothing	4211	5777	4242
	(4288)	(7974)	(5617)
Expenditures on personal items	718	244	216
	(2225)	(826)	(959)
Schooling expenses	50	914	271
	(475)	(2995)	(922)
Non-durables	2367	4161	3746
	(2086)	(5351)	(4263)
Transport	3611	6272	4099
	(24954)	(19367)	(10860)
Energy	1638	3965	2381
	(1826)	(5538)	(3262)
Tobacco and cigarettes	373	726	446
	(1099)	(2914)	(1385)
Payment for domestic work	181	1243	249
	(1383)	(6433)	(1718)

Notes:

1 There are 712, 549, and 813 observations for the Alatona, irrigated, and non-irrigated villages, respectively.
2 Standard deviations are in parentheses.

Food expenditure is a crucial measure of household well-being and represents a sizeable fraction of total expenditures, as is the case in many developing country contexts. Table 19 shows the average total food expenditure across the three types of villages, and by food categories including: cereals, root vegetables, pulses, meat, fruit, fish, milk and milk products, and oils and fats. These measures were constructed by using the reported quantities consumed in the previous 7 days of more than 40 specific food items. These are converted into expenditure values, in order to be comparable across households that consume different food items, by using the median prices reported by households who purchased those items. The first row, capturing total food expenditure, is at first surprising given the statistics on other aspects of life in the study villages. The sampled households in the irrigated villages reported the highest amount of food expenditure, as would be expected given the other data. However, the Alatona households' reported food expenditure is very close to that in the irrigated zone, and higher than households in the non-irrigated villages.

The last two rows in Table 19 show total monthly food expenditure in per capita and per adult equivalency terms. These measures suggest higher per capita, and per adult equivalency, food expenditure in the irrigated areas than in either the Alatona or non-irrigated areas. It is perhaps surprising that there is not a larger gap between the Alatona and non-irrigated areas and the irrigated villages, given the large differences in agricultural output we will discuss in the next section and differences in assets already discussed. There are three main reasons for this finding: (i) variation in prices; (ii) differences in diet; and (iii) differences in household size between the Alatona and comparison villages. First, prices are higher in Alatona due to higher transportation costs; this leads to higher expenditures among Alatona households, even if the quantity of consumption was the same. Second, as can be seen from the disaggregated measures of total expenditure, Alatona households consume more meat and dairy than households outside Alatona. Since these are expensive items, they drive up the food expenditure in the Alatona. Converting the food quantities into caloric equivalents would be an alternative way of creating a comparable aggregate across these areas but require strong assumptions about unobserved quality of different food items and cooking techniques. Measuring the calorie content of food items found in the Alatona and comparison villages was outside the scope of the baseline study

Table 19: Food Expenditures and Household Consumption Aggregates (FCFA)

	Alatona villages (1)	Irrigated villages (2)	Non-irrigated villages (3)
Food expenditures			
Total food expenditure	59,144	60,634	49,092
	(36,316)	(48,107)	(42,308)
Total expenditure—cereals	29,240	31,209	25,715
	(17,022)	(32,825)	(28,828)
Total expenditure--root vegetables	2,631	2,656	2,073
	(3,028)	(4,539)	(9,535)
Total expenditure—pulses	6,326	6,870	3,698
	(15,916)	(14,915)	(5,818)
Total expenditure—meat	8,136	6,362	6,266
	(15,433)	(12,088)	(17,742)
Total expenditure—fruit	603	1,391	1,763
	(2,812)	(3,092)	(5,872)
Total expenditure—fish	3844	6,562	6,005
	(3,444)	(6,040)	(5,495)
Total expenditure--milk and milk products	5,142	2,128	1,338
	(7,741)	(5,997)	(2,654)
Total expenditure--oils and fats	3,223	3,456	2,234
	(4,686)	(3,736)	(1,903)
Household dietary diversity index	7.38	7.44	7.10
	(1.17)	(1.21)	(1.43)
Total monthly household expenditure	130,054	189,183	156,791
	(75,427)	(157,148)	(124,741)
Monthly consumption aggregate[5] per capita	17,274	18,536	14,936
	(8,217)	(8,548)	(7,434)
Monthly consumption aggregate per adult equivalent	26,791	30,117	24,060
	(11,846)	(13,169)	(11,071)

Notes:

1 There are 652, 523, and 787 observations for the Alatona, irrigated, and non-irrigated villages, respectively.

2 Standard deviations are in parentheses.

3 We trim the top and bottom 1 percent of the distribution to account for potential outliers.

4 Per capita and adult equivalent measures are based on household residency for at least 6 months.

5 The consumption aggregate is a summary statistic that includes the use value of assets, food expenditures, nonfood expenditures, and water and sanitation access.

Finally, the per-adult equivalency and per capita measures are heavily influenced by the lower household size in Alatona. We would like to highlight a couple of points here that may explain differences in per adult equivalency differences in food expenditures. First, there may be sizeable returns to scale in food preparation, or the equivalency scales used are not perfect (i.e., the scales do not make an adult perfectly comparable to a child in how much they consume from the common bowl). If either, or both, of these factors are at play, the per-adult equivalency measures may not perfectly reflect household well-being. That is, Alatona households may not be as similar to the irrigated villages as these numbers reflect. However, the dramatic differences in household size in Alatona compared with the irrigated villages relate to a wider discussion about family size in the Office du Niger. If the amount of irrigated land in the family or household is fixed, there may be a tendency toward large household sizes.[9] The household may not cook enough food to fully reflect the larger household size, meaning some individuals in those households may be consuming substantially less than others or that everyone is eating less on average than in smaller households. Since we noted in the descriptive analysis of the household composition statistics that differences in household size between irrigated villages and the Alatona are driven by larger numbers of women in irrigated villages, lower food expenditures on an adult equivalency basis in irrigated villages may have a gender dimension if women are supplied with less food then men. Unfortunately it is very difficult to collect information about individual-specific food consumption given that Malians eat from a common bowl. The baseline data certainly do not imply that there is a causal relationship between household size and irrigation, but the differences in average household size, which affect per adult equivalency measures of food consumption, are nevertheless striking. IPA will continue to monitor the size of households in the Alatona over the course of the AIP along with household-level food consumption. It will be interesting to see if the Alatona villages start to look more similar to the irrigated villages in terms of household size and composition, and observe the implications for per adult equivalency food consumption, with the introduction of irrigation in the Alatona. The introduction of irrigation may also shift the Alatona villagers' diet away from meat and milk toward cereals, which will also affect per adult equivalency food expenditure. We will be watching these dynamics closely, in both the interim follow-up survey and in the end-line survey.

Table 20 uses these measures to provide poverty statistics after constructing a consumption aggregate. The consumption aggregate is constructed following Deaton and Zaidi (2002) using food expenditures, non-food expenditures, the use value of assets, and the use value of potable

[9] Large household sizes are also observed in Bambara areas in regions of Segou that do not have irrigation. Therefore, the differences in household size may reflect other cultural factors, such as ethnicity, rather than just economic factors like access to irrigation.

water and sanitation facilities for each household. The purpose of the consumption aggregate is to provide a summary statistic that encompasses multiple dimensions of the households welfare that can be valued monetarily. Overall the fraction of poor households is high. Using the $1/day metric,[10] usually defined as extreme poverty, around 40 percent of Alatona households are extremely poor. 44 percent of households in the non-irrigated villages outside Alatona are extremely poor, and 27 percent of households in the irrigated villages live on less than a dollar a day. Using the $2/day measure, more than 80 percent of households in the entire study fall below the poverty line. The poverty gap takes into account how far a household is from the poverty line, while the headcount measures just look at whether a household is above or below the line.[11] Although the poverty rate is only 6 percent different between the Alatona and irrigated villages, the poverty gap is twice as high in Alatona and the other non-irrigated areas than in the irrigated villages.

Table 20: Poverty Measures (Percent)

	Alatona villages (1)	Irrigated villages (2)	Non-irrigated villages (3)
Headcount poverty			
USD 1/day	39.64	26.62	44.23
USD 2/day	84.61	79.69	90.48
Poverty gap	11.36	6.06	12.17

Note:
The "1-dollar-a-day" and "2-dollars-a-day" lines are adjusted to include costs of sanitation and clean water.
1USD=413 FCFA on 3/15/2008.

A number of caveats apply to Table 20. Although the statistics in Table 20 are a convenient way to summarize poverty, expenditures – i.e., a monetary metric – are only one way to measure poverty. There is an inherent difficulty in valuing certain items that the household consumes such as services including health care or housing though these are certainly determinants of a household's welfare. Further, expenditures are only one way to describe household welfare. Measures of human capital such as schooling are captured less accurately in money metric measures of welfare as they induce positive spillovers within the household that may not be fully captured through expenditures. We therefore encourage readers to interpret the poverty statistics

[10] The poverty lines are actually $1.73 per adult equivalent and $3.46, respectively, although we use the common terminology of $1/day and $2/day because of their intuitive appeal.
[11] The poverty gap is the difference between the poverty line and the per-adult equivalence expenditure, divided by the poverty line – all squared.

with caution and to see that depicting poverty in this region is rather complex, as households in the Alatona (with high per adult equivalency food expenditure but poor quality housing, low school enrollment rates and few assets outside of livestock) appear to spend their money in systematically different ways than households outside of the Alatona (who have better housing characteristics, higher school enrollment rates, and larger asset holdings.) The poverty head count measure alone is simply not sufficient to capture all these key differences.

We also note that the poverty figures are broadly consistent with findings from the household survey Enquête Légère Intégrée auprès des Ménages (ELIM) 2006 for Segou. See Appendix E for summary statistics from the 2006 ELIM, which also shows the arguably surprising statistics that poverty rates are higher in Segou-Mopti than in Tombouctou-Gao-Kidal.

Agricultural Production

A key feature of many households in our baseline is their engagement in agricultural activities. In this section, we document differences among the baseline groups in land holdings, crop choice and production. To further investigate differences in production, we analyze differences in access to agricultural capital, agricultural inputs and agricultural labor. These statistics regarding the characteristics of agricultural production of the baseline households are summarized in Tables 21-24.

The first feature of agricultural production that we consider is the differences across baseline groups in the total hectares of land cultivated by households (Table 21). Alatona households cultivated an average of 0.35 hectares, while the irrigated and non-irrigated households cultivated 2 and 2.6 hectares, respectively. This of course reflects that fewer households in the Alatona have any land at all compared to households in the other areas, affecting the average landholding size. Land tenure systems across the baseline groups also differ considerably across the baseline groups. Households from the Alatona have access to land through two primary channels: inheritance rights and allocation from village or family elders. This pattern is similar to what we find in the non-irrigated comparison villages, although the proportion of households that have inheritance rights is larger among households in the non-irrigated comparison group. Land tenure in the irrigated comparison group is perpetuated through four primary channels including both inheritance and allocation from village or family elders, but as well through access to Office du Niger plots. Twenty-five percent of households had access to land through the Office du Niger. Although formally not permitted in the Office du Niger, 11 percent of households reported renting land from others. While these are not exclusively rentals of irrigated

plots, it is still suggestive of how common practice informal renting is within the Office du Niger. Of note is the lack of formal land transactions through land purchases or share-cropping across all three baseline groups. A much higher level of sharecropping was reported in the village questionnaire, as reported in Table 8. This likely reflects the fact that sharecropping is a type of land agreement which occurs periodically in these villages, at a given period in time few households are actually engaged in sharecropping.

Table 21 also shows striking differences in agricultural production across the three zones. The total production in kilograms (across all crops) is substantially higher in the irrigated villages than in either the Alatona or non-irrigated villages. Alatona production is by far the lowest in the sample. The differences between the irrigated villages and the Alatona are driven primarily by rice production. Households in the irrigated villages on average produced similar amounts of millet, but the irrigated villages produced substantially more rice. Households in the non-irrigated villages produced a much larger quantity of millet than the other villages.

The amount of production that is sold and the associated income from those sales also demonstrate interesting patterns. Households in irrigated villages sell a high fraction of their production, around 44% of total kilograms of production. Households in the Alatona and non-irrigated villages also sell a non-trivial share of their production, ranging from 25-30%. This suggests that these are not subsistence farmers living only off their own production, but that they are engaged with the market. The low levels of grain production in the Alatona are consistent with the statistics in the consumption section that meat and dairy products constitute the main components of the diets of those households.

Table 21: Land Holdings, Crop Choice and Production

	Alatona villages	Irrigated villages	Non-irrigated villages
	(1)	(2)	(3)
Land size			
Total land cultivated (hectares)	0.35	2.07	2.58
	(1.06)	(10.80)	(7.70)
Number of plots	0.61	0.70	0.77
	(0.61)	(0.89)	(1.06)
Land tenure, distribution by type (percent)			
Inheritance	48.47	24.56	55.71
Share-cropping	1.02	0.25	0.00
Rental	7.65	10.78	1.80
Allocation by village/owner	39.29	32.58	31.07
Purchase	1.02	1.25	0.13
Office du Niger	1.02	25.31	6.80
Office du riz	0.00	1.50	0.90
Main agricultural season			
Total production in kilograms	1278	7240	5688
	(2671)	(8653)	(6720)
Total production of the top three crops, in kg (selected from the frequency distribution of cultivated crops)			
Millet	396	412	2829
	(1006)	(1167)	(3386)
Rice	319	5261	1312
	(1298)	(7240)	(3426)
Sorghum	163	58	169
	(480)	(319)	(524)
Total kg sold (all crops)	216	2521	1094
	(843)	(3542)	(1982)
Total income from (all) crop sales	30537	408595	150376
	(83094)	(586057)	(279438)

Notes:

1 There are 752, 562, and 857 observations for the Alatona, irrigated, and non-irrigated villages, respectively.

2 Standard deviations are in parentheses.

Table 22: Agricultural Capital

	Alatona villages	Irrigated villages	Non-irrigated villages
	(1)	(2)	(3)
Panel A: Possession of Ag Equipment (1 if any) (percent)			
Item list			
Draft animals	29.61	28.93	31.82
Combine	0.00	1.45	0.37
Wheelbarrow	1.37	2.71	0.83
Cart	32.57	33.27	33.40
Plow	35.99	28.03	32.10
Sheller	0.00	2.89	0.93
Reaper	0.23	0.36	0.00
Tiller	0.23	2.17	0.56
Value. income from rental and payment for renting equipment in FCFA (including zeros)			
Value of agricultural equipment	57364	199639	232414
	(143261)	(552148)	(471193)
Rental income from equipment	1258	14655	1041
	(15661)	(192845)	(10760)
Payment for renting equipment	3454.4	26032.3	8879
	(20473)	(108457)	(37748)

Notes:

1 There are 752, 562, and 857 observations for the Alatona, irrigated, and non-irrigated villages, respectively.

2 Standard deviations are in parentheses.

Table 22 provides information on household agricultural asset holdings and the value of these assets. The most commonly held agricultural assets include draft animals, carts, and plows. These assets are employed by households primarily for land clearing, preparation and transportation of harvested agricultural commodities. A small percentage of households in the irrigated comparison group have motorized *moto-cultivateurs* (a mechanized tiller) or machines for processing agricultural products such as rice huskers and threshers. In Panel B, we report the values of agricultural capital, rental income and payments for renting agricultural capital. Households in both the irrigated and non-irrigated areas have significantly higher levels of access to agricultural capital than Alatona households. Across all three groups, households spend more on renting equipment than receiving income from renting out their agricultural capital, but again both rental income and payments for renting equipment are highest in the irrigated group. The magnitude of payments and frequency of these transactions suggest an active agricultural capital market.

In addition to employing agricultural capital to increase agricultural production, agricultural households use inputs such as fertilizer, pesticides/herbicides, and manure. In Table 23, we present differences in input utilization and expenditures on these items from the baseline sample. Input utilization varies widely between the three groups in the baseline survey. In the irrigated group, fertilizer utilization is reported by 83 percent of households whereas only 37 and 24 percent of households in the non-irrigated comparison group and Alatona, respectively, reported using fertilizer. Pesticide use and manure use were also highest in the irrigated comparison group households. Even the use of manure, which may be more readily available in non-irrigated villages, is highest in the irrigated villages. Expenditure on inputs echoes the patterns from usage: households in irrigated villages spent the most on fertilizer, pesticides / herbicides / insecticides and manure, as these are complementary inputs in irrigated rice production. Input expenditure is a fairly low fraction of income from crop sales, as can be seen by comparing expenditures on agricultural inputs in Table 23 with total income from all crops in the final row in Table 21. Though irrigated production necessitates higher input costs, increased production revenue generated from using these inputs means that the costs are more than recovered by irrigated producers.

Table 23: Agricultural Inputs

	Alatona villages	Irrigated villages	Non-irrigated villages
	(1)	(2)	(3)
Input utilization (fraction)			
Fertilizer	0.24	0.83	0.37
	(0.43)	(0.38)	(0.48)
Pesticides/herbicides/insecticides	0.08	0.22	0.15
	(0.28)	(0.42)	(0.36)
Manure	0.04	0.10	0.04
	(0.19)	(0.30)	(0.19)
Expenditures (FCFA)			
Fertilizer	7965	98299	16063
	(22489)	(126195)	(49038)
Pesticides/herbicides/insecticides	221	930	469
	(1194)	(3006)	(19911)
Manure	67	243	69
	(459)	(1067)	(611)

Notes:

1 There are 404, 447, and 684 observations for the Alatona, irrigated, and non-irrigated villages, respectively.

2 Standard deviations are in parentheses.

A critical complement to land, capital and chemical inputs in the agricultural production process is labor. As farm labor demand is time sensitive to the crop cycle, Table 24 shows agricultural labor used on the household's own farm for different phases of the crop cycle: planting and land preparation, weeding and harvesting. The table also shows the average number of days that men, women and children spend on family labor, labor provided by relatives and hired labor. Panel A shows hired labor; most of the hired labor occurs during the planting / land preparation phase and at harvest time. Consistent with the patterns for production quantities, households in the irrigated villages hire the most labor. However, the non-irrigated villages report hiring a similar number of man-days as in the irrigated villages report. The average number of days of hired women's labor is actually slightly higher in the non-irrigated villages at harvest time. There is little hired child labor in any of the village groupings. We also note that Alatona households hire many fewer laborers as is consistent with the low production totals found in Table 21.

Table 24: Agricultural Labor

	Alatona villages	Irrigated villages	Non-irrigated villages
	(1)	(2)	(3)
Panel A: Hired labor			
Planting, land preparation			
Number of days--men	14.03	29.89	26.21
	(22.56)	(72.78)	(50.13)
Number of days--women	3.33	25.39	23.74
	(9.73)	(46.89)	(39.26)
Number of days--children	3.98	3.09	3.77
	(11.01)	(8.11)	(25.86)
Weeding			
Number of days--men	2.85	2.70	2.37
	(15.48)	(12.61)	(17.36)
Number of days--women	0.43	1.36	1.31
	(3.28)	(6.10)	(5.94)
Number of days--children	0.10	0.04	0.08
	(1.32)	(0.56)	(1.01)
Harvesting			
Number of days--men	15.78	26.47	24.79
	(22.41)	(56.39)	(41.36)
Number of days--women	4.24	17.49	22.09
	(10.96)	(24.84)	(27.49)
Number of days--children	3.55	15.41	30.77
	(9.79)	(52.78)	(86.14)
Panel B: Family labor (household members)			
Planting, land preparation			
Number of days--men	8.40	26.82	23.99
	(13.31)	(53.86)	(43.07)
Number of days--women	3.36	10.77	9.20
	(8.00)	(39.75)	(22.92)

	Alatona villages	Irrigated villages	Non-irrigated villages
	(1)	(2)	(3)
Number of days--children	4.08	91.98	73.87
	(8.96)	(228.57)	(233.28)
Weeding			
Number of days--men	30.52	48.06	38.83
	(121.69)	(137.73)	(106.33)
Number of days--women	3.26	6.07	6.67
	(9.72)	(17.78)	(15.27)
Number of days--children	1.66	68.99	35.11
	(5.61)	(154.73)	(126.16)
Harvesting			
Number of days--men	14.05	14.75	26.65
	(38.72)	(32.98)	(44.15)
Number of days--women	4.43	8.36	11.41
	(13.21)	(21.96)	(25.03)
Number of days--children	2.24	6.03	13.72
	(7.40)	(17.75)	(36.06)
Panel C: Relatives			
Planting, land preparation			
Number of days that relatives worked	1.89	1.28	1.00
	(5.47)	(6.03)	(5.36)
Number of days that exchange labor was engaged on the plot	0.56	1.33	0.59
	(3.34)	(4.38)	(2.72)
Weeding			
Number of days that relatives worked	40.96	26.94	10.03
	(138.33)	(104.88)	(57.37)
Number of days that exchange labor was engaged on the plot	0.83	1.57	0.75
	(6.68)	(16.22)	(4.18)
Harvesting			
Number of days that relatives worked	3.02	7.61	7.97
	(28.99)	(48.65)	(53.27)
Number of days that exchange labor was engaged on the plot	0.83	1.85	1.59
	(3.28)	(10.15)	(6.35)

Notes:
1 There are 471, 542, and 828 observations for the Alatona, irrigated, and non-irrigated villages, respectively.
2 Standard deviations are in parentheses.

Panel B in Table 24 shows the number of day household members worked in household agricultural production. The patterns are similar to hired labor for land preparation / planting. For harvesting, there are more labor days devoted to harvesting in non-irrigated villages for men, women and children than in the irrigated villages. Finally, Panel C in Table 24 shows that non-

household, non-hired labor is an important input to farming for sample households. Although few relatives worked to assist with land preparation and planting, relatives did contribute to weeding, especially in the irrigated villages.

Conclusions

This baseline report has outlined the overall design of the Alatona Irrigation Project and the evaluation strategy proposed to estimate the project's impacts on beneficiaries. The baseline survey produced a rich set of information on characteristics of individuals, households and villages in the Alatona zone, in neighboring villages with irrigation, and nearby villages without irrigation. Households from within the irrigated and non-irrigated villages will be selected to serve as comparison households using the propensity score matching technique, which will allow us to assess changes in the Alatona households caused by the AIP with some credibility. We anticipate most of the comparison households will be selected from the non-irrigated villages. The households in the irrigated comparison villages will primarily permit a comparison of the dynamics of adaptation to irrigation by the households in Alatona, as households in the irrigated comparison groups will provide a benchmark of comparative irrigated agricultural production.

The analysis of the baseline data has investigated differences across the three groups in the baseline sample. Our analysis indicates that there are differences between the three groups that will require the initial endowments of households to be taken into consideration as we estimate the impact at the end of the project. Given that we have detailed information on these initial characteristics of households, the econometric strategy will focus on changes in the households over time accounting for these initial conditions. The matching methodology will also allow the evaluation team to select individuals in the non-irrigated and potentially irrigated villages that have similar characteristics to households in Alatona. The richness of the data will be an asset to this process.

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Appendices

Appendix A: Sample Frame: Selected Communes

Region	Cercle	Commune	Villages per commune	Commune[12] population
Segou	Macina	Boky Were	14	13030
		Kokry Centre	17	11056
		Kolongo	37	24836
		Macina	22	31655
		Monimpebougou	33	27838
		Solaba	42	31020
		Souleye	10	9088
		Subtotal Macina	175	148523
	Niono	Diabaly[13]	29	20340
		Dogofry	19	15818
		Kala Siguida	15	12816
		Mariko	21	14900
		Niono	21	40513
		Pogo	17	8087
		Siribala	19	15441
		Sirifila Boundy	15	21547
		Sokolo	18	17010
		Toridaga-ko	17	16824

[12] Number of villages and population size are from the 1998 General Census.
[13] Diabaly and Dogofry are the two communes in which the the PAPs reside.

		Yeredon Saniona	11	11763
		Subtotal Niono	202	195059
	Segou	Baguindadougou	14	6534
		Boussin	15	8700
		Diganibougou	23	10653
		Dioro	29	20539
		Dougabougou	7	14483
		Farako	11	10640
		Farakou Massa	8	9789
		Markala	30	37114
		N'Koumandougou	15	9861
		Pelengana	26	19561
		Sama Foulala	7	6949
		Sansanding	15	19445
		Sibila	15	13010
		Togou	10	8546
		Sub-total Segou	225	195824
		Sample Frame Totals	602	539406

Appendix B: Sample Frame: Selected Villages

Cercle	Commune	Village name	Population
Macina	Boky Were	Niamana	671
Macina	Boky Were	Boky Were	3465
Macina	Kokry	Lagho	38
Macina	Kokry	Sandsanding Coura	357
Macina	Kokry	Kokry bozo	2047
Macina	Kolongo	Nassambougou	201
Macina	Kolongo	Oughigouya	281
Macina	Kolongo	Dioron Coura	302
Macina	Kolongo	Nemabougou	608
Macina	Kolongo	Tilleby Ouadie	725
Macina	Kolongo	Bolibana	
Macina	Kolongo	Niaro	2066
Macina	Macina	N'Gueda	366
Macina	Macina	Guena	373
Macina	Macina	Timema	1424
Macina	Macina	Macine	5464
Macina	Macina	Siami	532
Macina	Monimpebougou	Talibougou	189
Macina	Monimpebougou	Kokogo	203
Macina	Monimpebougou	Santiguibougou	287
Macina	Monimpebougou	Tangana	311
Macina	Monimpebougou	Kationa	496
Macina	Monimpebougou	Sougouba	599
Macina	Monimpebougou	Tougouma	604
Macina	Monimpebougou	Markala	4073
Macina	Saloba	M'Pimperebougou	20
Macina	Saloba	Tiebala	527
Macina	Saloba	Kondo	547
Macina	Saloba	Korona Wadie	737
Macina	Saloba	Ouana mama	1053
Macina	Saloba	N'golokouna	1238
Macina	Souleye	Tiantie	837
Niono	Diabaly	Bassitomo	55
Niono	Diabaly	Rounde Mody*****	251
Niono	Diabaly	N'Gounando	435
Niono	Diabaly	Mabrouck Kebe	488
Niono	Diabaly	Kalan-Coura	540
Niono	Diabaly	Kogoni Station	577
Niono	Diabaly	Segou Coura	664

Niono	Diabaly	Kourama Coura	672
Niono	Dogofry	Bamako coura	950
Niono	Dogofry	Massabougou****	235
Niono	Kalasiguida	N'Godila	204
Niono	Kalasiguida	Missira 7D	499
Niono	Kalasiguida	Niafassi Bambara	609
Niono	Kalasiguida	Molodocentre	3129
Niono	Mariko	Faba coro	576
Niono	Mariko	Konokassy	782
Niono	Mariko	Pamdo Camp	
Niono	Niono	N'Galamadian	449
Niono	Niono	Kolodougou Koura	1278
Niono	Niono	Kanyan N'golobala	1350
Niono	Niono	Moussa were	1397
Niono	Pogo	Tiongoba	35
Niono	Pogo	Kanto	229
Niono	Pogo	Marakabougou	640
Niono	Pogo	Pogo	1068
Niono	Seribala	M'Pewala	311
Niono	Seribala	Nadani	857
Niono	Seribala	Boh	1288
Niono	Sirifila Boundy	Madina KM39	2016
Niono	Sirifila Boundy	Medina Coura B3	2143
Niono	Sokolo	Nemabougou	267
Niono	Sokolo	Hamdalaye	276
Niono	Sokolo	Famanbougou	482
Niono	Sokolo	Medina Coura	895
Niono	Toridoga-ko	Bolibang B6	1184
Niono	Toridoga-ko	Kanassoko	1267
Niono	Toridoga-ko	Daba Camp ND16	1367
Niono	Toridoga-ko	Boi boi ND8	1458
Niono	Toridoga-ko	Abdoulaye Camp B8	
Niono	Yeredon Saniona	N'Djella	309
Niono	Yeredon Saniona	Siraouma	577
Niono	Yeredon Saniona	Tigabougou N7	1080
Niono	Yeredon Saniona	Werekela N8	1950
Segou	Baguindadougou	Baguindo	166
Segou	Baguindadougou	Sotlobougou	252
Segou	Baguindadougou	Dlaba	337
Segou	Baguindadougou	Djibougou	902
Segou	Boussin	Samabougou	615

Segou	Diganibougou	Kola were	263
Segou	Diganibougou	Sogobia	284
Segou	Diganibougou	Kalabougouni	284
Segou	Diganibougou	Zantiebougou	324
Segou	Diganibougou	Zangou were	449
Segou	Diganibougou	Magna	482
Segou	Diganibougou	N'Tobougou	888
Segou	Dioro	Bolitomo Dougounikoro	153
Segou	Dioro	Midian were	196
Segou	Dioro	Boumboukoro	285
Segou	Dioro	Songolon	307
Segou	Dioro	Kolomi	335
Segou	Dioro	Touba	338
Segou	Dioro	Tibi were	464
Segou	Dioro	Senekou	1672
Segou	Dougabougou	Bandougou	614
Segou	Dougabougou	Dougabougou Koroni	977
Segou	Farako	Djelibougou	184
Segou	Farako	Mimana	593
Segou	Farakou Massa	N'Goumba were coura	341
Segou	Farakou Massa	Konou	2021
Segou	Markala	M'Pebougou sokala	362
Segou	Markala	Koke	2044
Segou	Markala	Diamarabougou	12116
Segou	N'Koumandougou	Kango	550
Segou	N'Koumandougou	Doura	1552
Segou	Pelengana	Ouessebougou	219
Segou	Pelengana	Koukoun	1250
Segou	Pelengana	Banakounou	2934
Segou	Sandsanding	Diado	808
Segou	Sandsanding	Zanfina	
Segou	Sibila	Kathiona	299
Segou	Sibila	Banga	386
Segou	Sibila	Nierila	663
Segou	Sibila	Sosse bamanan	1019
	Zone Alatona	N’Doukala	1570
	Zone Alatona	Beldenadji	710
	Zone Alatona	Welingara	634
	Zone Alatona	Saber Noda	495
	Zone Alatona	Dar Salam	422
	Zone Alatona	Doungel	369

	Zone Alatona	Tomoni	352
	Zone Alatona	Dagabouri	315
	Zone Alatona	Danguere Kadji	303
	Zone Alatona	Feto	215
	Zone Alatona	Ouro Daye	178
	Zone Alatona	Toule A	152
	Zone Alatona	Ouro Moussa	145
	Zone Alatona (Diabaly)	Massabougou	134
	Zone Alatona	Fedji 2	128
	Zone Alatona	Fedji 1	118
	Zone Alatona	Danguere Baba	101
	Zone Alatona	Nantiela	99
	Zone Alatona	Motoni	93
	Zone Alatona	Yiriwa Were	91
	Zone Alatona	Tchili	88
	Zone Alatona	Tchili Coura	85
	Zone Alatona	Toule B	83
	Zone Alatona	Tende	82
	Zone Alatona	Fedji 3	78
	Zone Alatona	Wotoro Dankan	71
	Zone Alatona	Maraba Were	63
	Zone Alatona	Djodjiri Were	62
	Zone Alatona	Madina	62
	Zone Alatona	Samba Were	45
	Zone Alatona	Yaladji Were	43
	Zone Alatona	Siaka Daye	41
	Zone Alatona	Baba Nega	6

Appendix C: Replacement Criteria

There are two types of replacement criteria that should guide the administration of the questionnaire: one for respondents who are absent from the household but are part of the household, and one for households that have moved out of the village since the listing. These instructions were provided to ESDCO in November 2008.

Difficulty finding the correct respondent

After introducing the survey and making sure people in the household understand its importance, identify the respondents for the male and female questionnaire. If these people are not currently in the household, ask when they will be return and be available to be interviewed. Set up a time that is convenient for the household and return at that time. If the person you wish to interview is still not around, ask again about the person and try to figure out whether they are really in the household or just temporarily absent. Make another appointment to see the person, if possible. If on your third attempt to interview the person, they are still not there, interview the other males or females in the household who are the most knowledgeable about the household's activities. If there are no other males or females in the household, or the household is a female headed household with no other men, the respondent responds for both genders. If the household has only male adults, it is not necessary to complete the female questionnaire.

Households no longer in the village

If a household no longer exists in the village, then we will have a list of randomly selected replacement households that can be used for each village. This should not occur frequently as listing just occurred a month ago. If it is difficult to find, a supervisor should go to the village head and ask about the person and the people listed in the household. Ask about the person's neighbors who were listed before and after the household. You need to find out why this household is missing and document each household that is missing and why. A list of these households and their replacements needs to be included in the survey documentation at the end of the survey.

Appendix D: Propensity Score Matching Technical Appendix

A large literature has emerged that explores nonexperimental estimators, including propensity score matching and difference-in-differences matching estimators. Propensity score matching and difference-in-differences matching estimators require additional assumptions that require verification when using nonexperimental data. An important body of literature has tested these nonexperimental estimators against experimental benchmarks and against each other (see, for example, Heckman, Ichimura, and Todd 1997; Dehejia and Wahba 2002; Bertrand, Duflo, and Mullainathan 2004; Smith and Todd 2005; Dehejia 2005; and Diaz and Handa 2006). Nonexperimental estimators can perform well if the set of observable characteristics is rich enough to create valid treatment and comparison groups. This provided the motivation for collecting an extensive baseline survey, in order to maximize our ability to generate a valid estimate of the impact of the AIP on the well-being of its beneficiaries given that random assignment among the PAPs was impossible. High quality data on as many measurable characteristics of PAP households and potential comparison households are needed for the technique to produce believable estimates. We highlight that combining propensity score matching with baseline and follow-up data (facilitating a difference-in-differences strategy) further strengthens the design, although the caveat still applies that it is more likely that there are unobservable characteristics that differ across beneficiary and comparison groups than in the case of randomization.

To estimate the effects of irrigation, propensity scores are used to match households with similar observable characteristics, varying only the treatment, which is access to irrigation. The propensity score is simply the probability that a household has access to the treatment, $P(T = 1|X, V)$. Propensity scores are estimated using a probit model where a vector of household characteristics, *X*, and village characteristics, *V*, are regressed on P, a household's access to irrigation, to obtain predictions of household propensity scores, where

$$P^*_{v,h} = \beta X_{v,h} + \gamma V_{v,h} + \varepsilon_{v,h}. \qquad (1)$$

To estimate equation (1), household variables are used as controls, including household size, household assets such as household durables and total livestock units, the age of the household head, an education indicator for the household head and his or her spouse, an ethnicity indicator variable, and landholdings in 2008. Village characteristics include indicators for distance to the nearest road, distance to the Niger River, and the log price for transporting a sack of rice to

Mopti, a regional center. These characteristics control for village development; access to water, which is a necessary precondition for pump agriculture given the dearth of rainfall; and market integration. When the propensity score matching estimates are generated, the sample is also restricted to matches within villages, so that village fixed effects do not bias the estimates. Table 4 displays the descriptive statistics for the household and village characteristics.

The household and village variables used in the specification to generate the propensity scores satisfy the balancing property, following Dehejia and Wahba (2002). That is, the treatment and comparison observations are tested to ensure equality of observables across different propensity score groupings, so that there is an appropriate distribution of characteristics in each grouping of propensity scores. The assumption that $0 < P(T=1 \mid X,V) < 1$ is satisfied in our sample and the top and bottom 5 percent of the sample have been trimmed, following Smith and Todd (2005).

Our primary econometric strategy for PAP households to evaluate the impact of irrigation is a difference-in-differences matching estimator that exploits both baseline and follow-up survey data. The outcome variable of interest (agricultural production, consumption, livestock holdings) is represented by Y_{ht} for household $h=1,\ldots, N$ at time $t=1, 2$. Then variation in Y_{ht} is explained by covariates X_{ht} for household h at time t. The treatment variable, T indicates the household's access to irrigation. P is the propensity score estimated as in the above section using the probit model. Because selection bias due to the correlation of program placement with household characteristics (assets, education, location, etc.) is probable, the inclusion of the propensity score controls for the selection bias of the observable characteristics when the impact of irrigation is estimated on the outcome variables. Using the predicted propensity scores and taking first differences with the panel sample yields the difference-in-differences matching estimator, γ^m.

$$Y_{h2} - Y_{h1} = \beta X_{h1} + \gamma^m T + \gamma P + (\varepsilon_{h2} - \varepsilon_{h1}). \qquad (2)$$

Appendix E: ELIM 2006 Summary Statistics

	2001			2006		
	% population	Incidence pauvreté Méthode 1	Incidence pauvreté Méthode 2	% population	Incidence pauvreté Méthode 1	Incidence pauvreté Méthode 2
National	100	68.3	55.6	100	64.4	47.4
Type of Community						
Urban	26.2	37.4	24.1	31.7	31.8	25.5
Rural	73.8	79.2	66.8	68.3	79.5	57.6
Regions						
Kayes-Koulikoro	30.2	76.2	65.1	29.4	61.5	44.7
Sikasso	18.4	81.8	80.1	18.0	81.7	80.8
Mopti-Ségou	31.9	71.4	51.9	33.9	75.2	48.7
Tombouctou-Gao-Kidal	8.8	51.3	30.8	8.5	57.9	29.0
Bamako	10.7	27.5	17.6	10.2	11.0	7.9
Socio-economic group						
Salaried, public service	5.0	15.2	7.1	6.1	17.3	12.2
Salaried, private sector	4.0	30.8	26.0	4.7	39	29.5
Employer	0.6	39.7	17.0	1.4	29.5	16.1
Independent agriculture	63.0	83.4	70.1	54.8	80.4	59.2
Independent non-agriculture	18.5	43.2	27.8	15.1	33.7	22.7
Other employment	3.1	72.2	61.7	1.8	78.2	70.2
Unemployed	5.9	55.9	48.4	16.1	65.4	49.4

Source: **ENQUETE LEGERE INTEGREE AUPRES DES MENAGES (ELIM) 2006, Vol. 2, "Tendances et déterminants de la pauvreté au Mali (2001-2006)."**