Note to readers, from MCC: Since the completion of this report, it has been decided that the Social Safeguard Measures activity, which the authors reference in the report, will no longer be implemented. Thus, this will similarly be removed from the evaluation, given that no activity components were ever implemented.

Impact Evaluation of Millennium Challenge Corporation's Irrigation and Water Resource Management Project in Senegal

Baseline Report

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All of the above organizations and individuals have contributed tremendously to this report and to the project more generally. Any remaining errors are the authors' responsibility.

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TABLE OF EXHIBITS

ACRONYM LIST

ANSD	Agence Nationale de la Statistique et de la Démographie
CVD	Comité Villageois de Développement
GoS	Government of Senegal
IRIS	Institutional Reform and the Informal Sector
IWRM	Irrigation and Water Resources Management Project
LTSA	Land Tenure Security Activity
MCC	Millennium Challenge Corporation
MCA-S	Millennium Challenge Account-Senegal
M&E	Monitoring and Evaluation
RCT	Randomized Control Trial
CR	Rural Communities
SAED	Société Nationale d'Aménagement et d'Exploitation des Terres du Delta du fleuve Sénégal et des Vallées du fleuve Sénégal et de Falémé
SRV	Senegal River Valley
WUA	Water User Association

1. BACKGROUND

1.1 Introduction

On September 16, 2009, the Millennium Challenge Corporation entered into a USD 540 million Compact Agreement with the Republic of Senegal. The Republic of Senegal established an autonomous body, the Millennium Challenge Account in Senegal (MCA-S), to effectively manage the work of this compact. The compact in Senegal entered into force in September 2010, initiating the 5-year timeline for project implementation. Compact funds have been strategically invested in two projects:

- Roads Rehabilitation Project
- Irrigation and Water Resources Management (IWRM) Project

This report presents findings from the baseline data collected for the IWRM project, which serves as the primary data source for evaluating the activities of the IWRM project. We describe household characteristics as well as baseline values of measures that will be used to assess the impacts of the IWRM interventions. An understanding of baseline characteristics provides a basis for comparison with household well-being following the IWRM activities. This report provides an overview of the current irrigation and agricultural situation in the Senegal River Valley. Additionally, the report provides a comparison of treatment and comparison households to check for systematic differences between groups at the time of the baseline survey.

The remainder of this chapter presents a general overview of the IWRM project and its sub-activities, as well as a literature review. Chapter 2 describes the impact evaluation design and data collection activities. Chapter 3 presents findings from the baseline data. Chapter 4 presents differences in means between the treatment and comparison groups. Chapter 5 presents several conclusions.

1.2 The Irrigation and Water Resources Management (IWRM)

MCC is investing USD 170 million to help improve agricultural sector productivity in the Senegal River Valley (SRV). The SRV is located in the northern part of Senegal, in the delta of the Senegal River and in Podor District. This region has the potential to benefit from intensive irrigation interventions because of:

- Extensive history of irrigation schemes in the SRV;
- Strong support from the Government of Senegal and the Société Nationale d'Aménagement et d'Exploitation des Terres du Delta du fleuve Sénégal et des Vallées du fleuve Sénégal et de Falémé (SAED); and
- Capability of farmers' associations to manage large irrigation schemes.

The agricultural potential of the SRV has been constrained by the poor quality and limited capacity of existing irrigation and a lack of appropriate drainage systems that increase soil salinity. To overcome these constraints and increase the agricultural yields in the region, the IWRM project is investing in order to:

- Improve the quality and capacity of the irrigation system;
- Reduce the risk of abandonment of land;
- Enhance land tenure regulations to secure the land rights of farmers;
- Mitigate land conflicts that arise from ambiguities about property rights; and
- Enhance the capacity of local institutions responsible for allocating and managing land rights.

The IWRM project consists of the following four activities:

1. Delta Activity
2. Podor Activity
3. Land Tenure Security Activity
4. Social Safeguard Measures

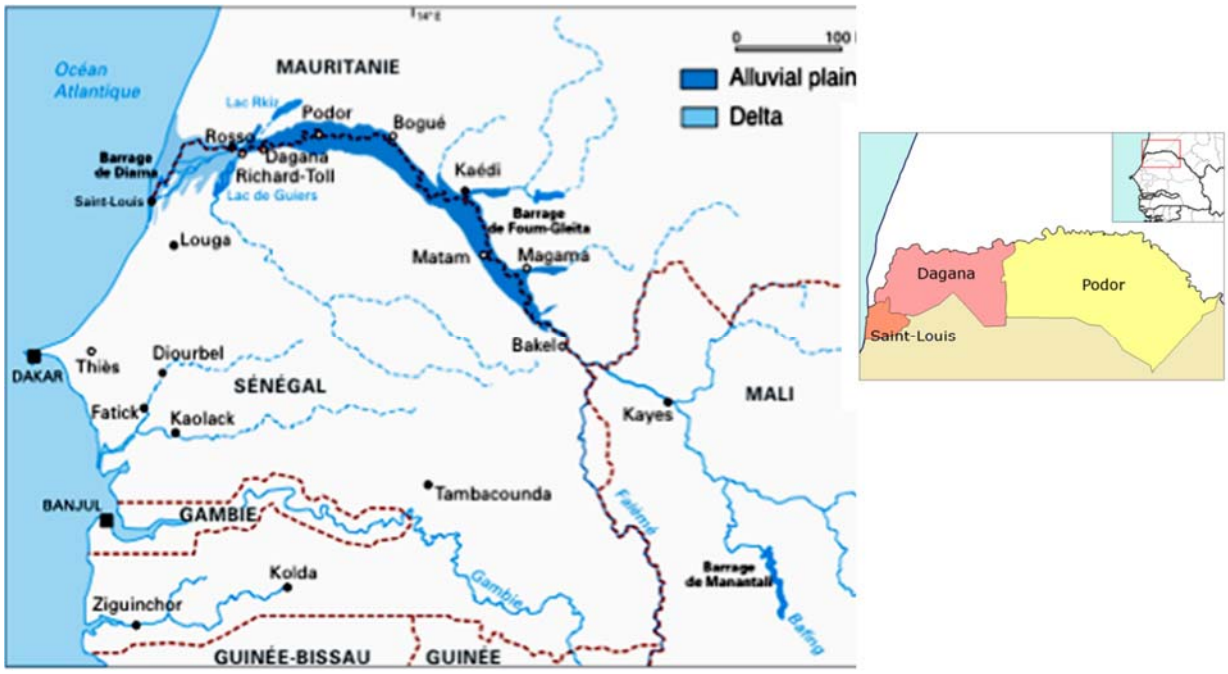
Below, we describe the four activities.

1.2.1 Delta Activity

The Delta area spans the departments of Saint Louis and part of Dagana in northwestern Senegal. Diama Dam, situated at the mouth of the Senegal River (see Exhibit 1), regulates its hydraulic levels. Approximately 30 percent of the 31,000 hectares (ha) of potentially irrigable land in the Delta are cultivated at any time during the year. The low proportion of irrigable land cultivated is primarily due to insufficient water delivery and poor drainage. MCC is investing approximately USD 154 million in the Delta to improve the conveyance capacity of primary irrigation channels (mainly along the hydraulic axes of Gorom-Lampsar and Kassack North), and to ensure appropriate drainage capacity to the area's middle and southern perimeters. The Delta Activity interventions consist of weed removal, dredging, profiling of berms, increasing levee heights, and rehabilitating or replacing structures and pumping stations along eight irrigation sections. The drainage activity consists of constructing a new drainage channel, pump station, bridge, siphon, elevation of the levees, as well as the construction of compensatory channels.

The goal of this activity is to restore or improve the quality, volume and reliability of water for agriculture that is delivered in existing irrigated perimeters, thus reducing the risk of abandonment of approximately 26,000 ha of land. In addition, this activity has the potential to encourage the creation of new irrigated perimeters (via other donor projects) thanks to the infrastructure improvements that will increase the availability of water.

Exhibit 1. Senegal River Valley and St. Louis Region Departments



1.2.2 Podor Activity

In Podor, north-central Senegal, the project is developing primary and secondary irrigation and drainage channels and associated structures at the N'Gallenka site (tertiary system financed by GoS). This activity created about 440 ha of new irrigated land for a total MCC investment of approximately USD 6.5 million, including construction supervision. The N'Gallenka site was chosen because of its high potential for rice production, abundance of water resources, cost of dikes per hectare and the existing irrigation facilities. In addition, MCC is also funding improvements in project management to support the Delta and Podor activities (approximately USD 3 million) through a project management unit at SAED.

1.2.3 Land Tenure Security Activity

MCC is investing approximately USD 3.8 million in the Land Tenure Security Activity (LTSA) to improve the investment climate in the IWRM project area and to mitigate the potential for land conflict due to increased demand for irrigated land as a result of the project. The LTSA supports development and implementation of transparent, fair, and efficient processes for land allocation and formalization of property rights to ensure equitable and secure access to land in the irrigated perimeters. The LTSA will also equip local authorities with tools such as manuals of procedures and land registries to improve land management. The LTSA will thus reinforce capacity through communication and training on the newly provided tools, as well as existing land management tools. In addition, the LTSA is being implemented in seven Rural Communities and two Communes in Dagana and Podor Departments, and therefore fully covers the IWRM intervention zones.[1]

The first phase of the LTSA entailed an exhaustive inventory of existing occupation patterns and property rights in the irrigation project and surrounding areas. The LTSA completed the documentation of property rights and use patterns for more than 55,000 ha and 15,000 parcels. In the second phase of the LTSA, the land in the new irrigated perimeter at N'Gallenka that is being built with Compact funds will be allocated based on criteria developed during the first phase, with participation of all local stakeholders. The allocation criteria are specific to each community,[2] and MCA-S has ensured that these criteria are transparent and supported by local communities.

1.2.4 Social Safeguard Measure Activity

MCC is funding and implementing up to eight daycare centers within the irrigation project treatment areas. The daycare centers are intended to complement the economic development resulting from the rest of the IWRM investments by allowing women to dedicate less time to child care and more time to economic activities (both agricultural and non-agricultural). It is also anticipated that enrolling young children in qualified daycare centers will augment early childhood development. It is hoped that such participation will lead to a higher rate of on-time enrollment of children in primary school (though the official age of entry into primary school in Senegal is 7 years of age, many children either do not attend at all or start attending school at later ages).

[1] The LTSA intervention zone is larger than the IWRM intervention zone. The LTSA targets capacity building of the local government council and thus extends throughout the government districts (see *Elbow et al., 2012*).

[2] A detailed list of community-specific criteria can be found here: *Activité de sécurisation foncière dans le cadre du projet irrigation et de gestion des resources en eau de MCA Senegal (August 2011).*

With the support of Compact funding and technical support, each of the constructed daycare centers will be locally managed by a management committee made up of local community members. This committee will be responsible for the ongoing operations and management of the daycare centers and for assuring ongoing sustainability. Once the daycare centers are operational, their ongoing operations and maintenance will be funded by a combination of user fees, community contributions and support funds from the GoS.

The daycare centers are expected to open in early 2015 and are expected to have a capacity of 90 children per center. Each center will be staffed by trained personnel using an established curriculum for early childhood development.

1.3 Literature Review

The objective of the IWRM is to improve agricultural productivity and water supply. This objective will be achieved through the installation of drainage channels for the recovery of old irrigated lands. The IWRM has been designed to expand the productive use of land in order to increase the volume and value of agricultural production in the project zones. Development of the agricultural sector has been shown to play an important role in reducing poverty (Christiaensen et al., 2011).[3] In this section, we present a brief review of the literature on the impact of irrigation improvements and enhancement of land security. While this review is not exhaustive, it presents key features of previous research that are relevant to an assessment of the impact of irrigation investments and land security.

Prior studies have attempted to measure the impact of agricultural infrastructure improvements on agricultural growth and poverty reduction. The results of these studies, however, have provided mixed results and, as a result, there is no consensus in the literature on the impact of irrigation investments. This is partly because irrigation is often only a sub-component of a much larger agricultural program, making it complicated to disentangle the contribution of irrigation investments to agricultural growth (Saleth et al., 2003).

Fan et al. (2000) analyzed the differential impacts of six different types of public investments on growth and poverty reduction in rural China. The results of this study showed that government investment in the rehabilitation and expansion of irrigation systems had only a modest impact on agricultural production growth and even less of an impact on the reduction of rural poverty and inequality. In contrast, spending on rural education and agricultural research and development (R&D) had larger impacts on agricultural growth and poverty reduction. The study also found large regional variations in the returns to different types of government investments.

[3] Refer to Dethier and Effenberger (2011) on a review of the literature linking agricultural development to poverty reduction.

Pender et al. (2002) investigated changes in agriculture and land management practices between 1991 and 1998 in the highlands of Tigray in Ethiopia. The authors found that irrigation was an important factor underlying different livelihood strategies, favoring production of perishable cash crops. Furthermore, the authors found that irrigation contributed to intensified land use and changes in crop choice. Nonetheless, they found that irrigation investments resulted in less improvement in yields than expected. To improve the returns to irrigation investment in Tigray, the authors recommend increasing the priority of extension activities in irrigated areas and increasing the emphasis on promotion of high-value crops in such areas. Complementary investments in roads or other infrastructure may also be important in some areas.

Dillon (2010) investigated if differences in the scale of irrigation projects are related to different impacts on poverty and production in Mali. In this study, Dillon used propensity score matching to identify a counterfactual comparison group. However, while this approach can improve the measurement of program impacts, the author acknowledges that the results may be biased due to unobservable household or individual characteristics. Nonetheless, the results of the study showed that small-scale irrigation schemes had larger effects on agricultural production and agricultural income than large-scale irrigation schemes.

Studies conducted in Sub-Saharan Africa found positive effects of irrigation on poverty alleviation. Minten & Barrett (2006), for example, used a unique, spatially explicit dataset to study the link between agricultural performance and rural poverty in Madagascar. Results showed that communes with higher rates of adoption of improved agricultural technologies and broader access to improved irrigation infrastructure enjoyed lower real food prices, higher real wages for unskilled workers, and greater profitability for farmers and better welfare indicators. The authors noted that while access to improved irrigation infrastructure leads to a higher uptake of improved technologies, the coefficient estimates were small, indicating that irrigation alone would not stimulate rapid uptake of improved technologies.

Results from studies on land tenure security and agricultural investment have also provided mixed results. Fenske (2011) found that these studies vary depending on research methods, local contexts and sample sizes. For example, Brasselle et al. (2002) investigated the relationship between land security and land investments in Burkina Faso and found that small-scale land investments were influenced by land tenure security. However, once the authors controlled for endogeneity bias,[4] the relationship between increased land rights and land investments no longer existed. Abdulai et al. (2011) analyzed land tenure arrangements and household investments in the Brong Ahafo region of Ghana and found that secured land rights tended to facilitate investment in agricultural activities. Additionally, the positive impact of secured land rights on investment remained unchanged when the authors controlled for household specific factors.

[4] Endogeneity in this article refers to the fact that tenure security may depend on investments made to the land. By not controlling for this, researchers may mistakenly attribute tenure security to causally increasing investments, when in fact the opposite is true (reverse causality).

Deininger and Jin (2006) used a large data set from Ethiopia that differentiated between tenure security and transferable land rights to examine the relationship between different types of land-related investments and productivity. The authors found that the impact of land rights on investment incentives varied depending on the type of investment. The authors also found that although land tenure security and transferability are important in stimulating investment, transferability had a larger impact on investment than tenure security.

While these studies have contributed to our understanding of investments in irrigation and land tenure security, they do not provide definitive conclusions about the impacts of such investments in developing countries. Thus, the results of this study will add to our knowledge and understanding the impacts of investments in irrigation and improved land rights.

2. EVALUATION DESIGN AND DATA

In this chapter, we provide a brief discussion of the design and data sources for the evaluation of the irrigation and water resource management project. A more detailed discussion of these topics is available in the evaluation design report (IMPAQ, 2014). The evaluation will focus on how the IWRM project interventions affect households in Senegal.

In this report, we analyze the baseline household and agricultural survey data. Before presenting this analysis, we present the conceptual framework and the key research questions that the evaluation will address. We also review the impact identification strategy, estimation methods, and the sampling and statistical power of the analysis.

2.1 Conceptual Framework and Key Research Questions

The IWRM project interventions have the potential to unlock agricultural (and non-agricultural) economic capacities and resources, thereby contributing to reducing poverty in Senegal. The impact evaluation of the interventions will estimate the effectiveness of the interventions in achieving the project goals.

Land productivity is significantly higher for irrigated land when compared to rain-fed land (World Bank, 2008a).[5] Thus, MCC's investment in water management and irrigation should provide more reliable irrigation sources to farmers and the potential for improving agricultural productivity and agricultural incomes. As a result of the IWRM activities, we may observe an expansion in irrigable land, more land area placed under production, improved agricultural productivity and increased incomes.

We also expect the land tenure activity to formalize land tenure rights and improve the efficiency of local land institutions. Because lack of formal land tenure rights is a major component of land insecurity, formalizing land tenure rights should increase farmers' feelings of security, which in turn should lead to greater investments in land. Formal land tenure rights, coupled with better and more efficient institutions and land management tools, should help reduce the incidence of land conflicts.

As immediate outcomes of irrigation and LTSA activities materialize, farmers will have incentives to invest in land and agricultural production activities. In particular, as farmers feel more secure on their land, adapt their agricultural practices to greater availability of water and gain flexibility to respond to market conditions because of more reliable access to water (off-season), we should expect a change in the amount of agricultural production, increases in productivity, and/or a shift to higher value agriculture (HVA).

[5] FAO (1996) reviews the irrigation literature for Asia and reports elasticities of crop yields with respect to irrigation in the range of 1 to 4. http://www.fao.org/docrep/x0262e/x0262e01.htm#a.

Based on this conceptual framework, the research will address the following broad research questions:

- Has there been a change in the main source of water/type of irrigation used?
- Has there been an increase in the amount of land that is irrigated and the intensity with which it is irrigated?
- Has there been a change in the total costs to provide adequate irrigation to the land?
- Has there been an increase in the volume of agricultural production, yields and agricultural income?
- Has there been an increase in the volume of high value crops (vegetables, for example) or crops that are very intensive in water use (rice)?
- Has there been an effect on land markets and/or on contractual arrangements (e.g. fewer sharecropping contracts?)
- Has there been an increase in total income?

2.2 Impact Evaluation Design

Although a random assignment design is considered the most rigorous evaluation approach, in the context of the IWRM project such a design is not feasible for an infrastructure project. In the IWRM, the selection of areas to receive the project interventions was not random. Rather, it was based on a variety of factors, including political, social and environmental. In the absence of random assignment, we use a Difference-in-Differences (DID) methodology combined with propensity score matching (DID-PSM) to estimate the impact of the IWRM activities.

In the DID-PSM approach, once the treatment group is identified and selected, each treatment group member is matched with one or more persons from a pool of individuals who did not receive the treatment. This matching process creates a comparison group that is similar to the treatment group in many observable characteristics. The effect of the program is then measured by the difference in outcomes before and after the program intervention for (a) the group that benefited from the intervention, or a treatment group, and (b) a similar group that did not benefit from the intervention, or a comparison group. The ex-ante matching increases the likelihood that the parallel trend assumption (which is central for DID identification) is not violated.

Because the selection of treatment areas was non-random, researchers and program administrators made an effort to identify and select comparison areas that are as similar as possible to the treatment areas. For the Delta, the treatment area comprises the Saint Louis and Dagana departments, in the northwest St. Louis region, and in particular the villages of Diama, Ronk, Ross-Bethio (Dagana department) and Gandon (St. Louis department). The comparison area was chosen from Communauté Rurale (CR) in Dagana department similar to those located in the treatment area and yet sufficiently distant from the project intervention zones. The comparison areas include the villages of Gaé, part of Rosso and Bokhol. In Podor, the treatment area comprises the N'Gallenka site (which occupies part of the CR of Ndiane Pendao). The comparison area is located in Podor department as well, but outside the N'Gallenka site (another part of CR Ndiane Pendao and CR Niandane). Judging from the documentation provided by MCA-S, the selection of comparison areas was based on a combination of objective criteria, including similarity of geographic location and of irrigation and drainage conditions. However, IMPAQ has not been able to access the details of this selection process. This report will assess the comparability of the two groups, particularly in terms of the groups' irrigation situation at baseline.

The impact evaluation of the LTSA program is more complex, given the structure of the LTSA program itself and that the sampling strategy is designed primarily for the evaluation of the irrigation intervention. First, the LTSA intervention does not overlap with the irrigation intervention. For understandable administrative reasons, the former was conducted at the Communauté Rurale level, which does not always match the irrigation systems, nor the water management intervention. The second issue is that the LTSA intervention was not uniform, but comprised of two phases, as described above in section 1.2.3.

For the Delta area, the entire treatment sample received both the LTSA and the irrigation intervention. In our comparison sample, both areas in the Bokhol CR received neither intervention and, as such, can function as comparison groups for evaluating the LTSA intervention. For Rosso Senegal, however, half of the subsample received the LTSA intervention. Depending on which variables are critical to the impact evaluation, the identification strategy will need to take into account these changes in sample size, as well as a possible issue with spill-overs within the Rosso Senegal treatment and comparison groups.

In the Podor area, the LTSA intervention varied in intensity across our samples. The Niandiane CR is a "pure" comparison group, as it received neither intervention. However, the remainder of our comparison group for the irrigation evaluation, in the Ndiane Pendao CR, did receive a LTSA intervention, like that of the Delta (as in the phase 1 described in section 1.2.3 above.) As for the treatment group in N'Gallenca, our sample received both phase 1 and the land allocation described as phase2. The resulting sample sizes might or might not be appropriate to detect an impact of the LTSA program in Podor, depending on which phase is being evaluated, which impact variable is selected and what is the desired Minimum Detectable Effect. Furthermore, the phase 1 program in the comparison areas should be controlled for when evaluating the irrigation intervention.

2.3 Sampling

2.3.1 Sample Requirements

To implement the DID analysis, we needed to draw the sample of households for the study from both the treatment and comparison areas. The previous evaluation contractor[6] determined that the sample size needed to estimate the combined impact of the irrigation and land intervention in the Delta was 2,612 households: 1,306 from the treatment area and 1,306 from the comparison area. Power computations showed that a sample size of 2,612 households could identify a 10 percent change in agricultural income, with 80 percent power and 5 percent significance level.[7]

For Podor, the sample size was initially constrained by the amount of land available for distribution, i.e. approximately 400 ha. MCA-S expected to distribute approximately 1 ha per household, meaning that the household sample size is approximately equivalent to the number of hectares available for distribution. The final sample size for Podor is 440 households in the treatment area and 440 households in the comparison area. Power computations show that with a sample of approximately 880 households we can expect to detect a change in agricultural income of approximately 19 percent, with 80 percent power and 5 percent significance level.[8]

2.3.2 Sampling for the Baseline Household Survey – Delta

To estimate the impact of the IWRM project in the Delta area, we will use DID with *ex-ante* matching. Matching *ex-ante* means matching prior to the full survey based on the variables collected at the *enumeration* stage,[9] as opposed to matching after the baseline survey data collection, i.e. *ex-post*. This method offers a higher probability of finding a match for each treated household based on the large pool of comparison households obtained at the enumeration stage. It thus reduces the sample size requirements.

[6] IMPAQ International was selected by MCC to replace the Institutional Reform and the Informal Sector center (IRIS) at the University of Maryland in the implementation of a rigorous impact evaluation of the IWRM Project.

[7] Without reliable data of agricultural income for Senegal, the data on agricultural income per capita used to perform power computations was sourced from the PNGT2 rural household survey conducted in Burkina Faso in 2005. According to the data, the average agricultural income per capita (net income: harvest value minus input costs) is FCFA 39,627, and the standard deviation of agricultural income per capita is FCFA 57,143. Computations assumed a baseline-end line auto-correlation in outcome of 0.75, a 0.05 statistical significance and 0.80 power. These computations were performed using STATA.

[8] The same data on agricultural income used to perform power computations for the Delta have been used for Podor.

[9] An *enumeration* is a listing (census) of households carried out in the areas covered by the project (both treatment and comparison areas). This census is necessary to construct the sampling frame (universe) from which a given number of households will be sampled and included in the survey.

To implement DID with ex-ante matching, households should be matched *before the survey*. This requires a detailed enumeration in the treatment and comparison areas to collect a set of variables that can match treatment and comparison households. In the spring of 2012, the Agence Nationale de la Statistique et de la Démographie (ANSD) conducted extensive enumeration in the Delta area, including the Saint Louis and Dagana departments, for a total of about 11,600 households. IMPAQ used the enumeration files to sample and match households. The target sample sizes for the Delta were 1,306 treatment households and 1,306 matched comparison households. To achieve this sample size, IMPAQ provided slightly larger samples to ANSD to allow for some non-response because the survey effort may not have reached 100 percent of the sample.[10] Specifically, we selected 1,637 treatment and 1,637 comparison households (about 25 percent more than the proposed sample sizes).

From the enumeration file, we randomly sampled 1,637 treatment households. We then matched each treatment household with a comparison household identified as the most similar in relevant pre-treatment characteristics. The basic idea of matching is to find a sample of comparison households that are on average similar to the treatment sample.

To identify similar comparison households, we employed a commonly used method of matching: *the propensity score method*. A propensity score is an estimate of the probability of being selected into the treatment group based on observable characteristics. Specifically, we derived a propensity score for each household based on the following logit model:

$$P(y_{ht} = 1) = \frac{\exp(\beta X_{ht})}{1 + \exp(\beta X_{ht})}$$

The dependent variable y_{ht} is an indicator equal to one (1) if the household *h* is in the treatment group at time *t* (baseline) and zero (0) otherwise. The probability *P* of being in the treatment group is modeled as a *logistic* function of the observable household characteristics (X_{ht}) obtained from the enumeration. The coefficients ($\boldsymbol{\beta}$) of the logit model capture the effect of the observable household characteristics on the probability of being selected.
We used the following variables from the enumeration as independent variables in the logit regression model:

- Age
- Household size
- Number of male workers
- Number of female workers
- Number of male workers in agriculture
- Ethnicity
- Literacy
- Socio-administrative status
- Status of land of household head
- Participation in an OP (*Organisation Paysanne*)
- Roof material

[10] Our goal is to achieve at least an 80 percent response rate.

- Number of female workers in agriculture
- Gender
- Floor material
- Wall material

After we derived a propensity score for each household, we matched each treated household to a comparison household whose propensity score was closest to the treated household's propensity score. When multiple households had the same propensity score, we randomly selected one of these households as the best match. After completing the sampling and matching process, IMPAQ provided the final sample to be surveyed by MCA-S and ANSD. The final sample included a list of treatment households and their associated (matched) comparison household.

2.3.3 Sampling for the Baseline Household Survey – Podor

In the spring of 2012, ANSD completed an extensive enumeration in the Podor area. Specifically, 1,617 households were enumerated in the treatment area and 585 were enumerated in the comparison area. For the impact evaluation, it is important that the treatment group include *households that will actually get the treatment (irrigation and land)*. However, at the time of sampling, we could not find a clear way to identify which households would receive irrigated land in Podor. Because the enumeration data includes 1,617 households in the treatment area and we needed to identify the 440 households that would receive land, a random sample would not ensure that we select enough households that actually receive land.

To identify land recipients, we considered using the information available on the land allocation criteria that was supposed to be used when the plots become available. However, we concluded that we could not find a clear way to plausibly identify households that would obtain land. We discussed this issue with MCC/MCA-S land team during a meeting in spring 2012 and concluded that it was not possible to obtain a list of households that would obtain land. This list will probably become available only in spring 2014. Furthermore, even trying to oversample from enumeration data according to the proposed selection criteria would be very risky because many land allocation decisions have not yet been made. The MCA-S land team agreed that it was not possible to know, with a sufficient degree of certainty, which households would receive land.

Given the urgency of selecting the samples and proceeding with the survey, MCA-S and IMPAQ agreed to survey all households (1,617) in the enumerated treatment area. This approach ensured that our survey sample would capture the households that would receive land (treatment group). In addition, we agreed to survey a random sample of 440 households in the Podor comparison area (out of a total of 585 households in the enumeration). Moving forward quickly was very important to avoid wasting time and resources. Furthermore, waiting until spring 2014 (when land decisions are expected to be finalized) could have jeopardized our ability to have useful baseline data because the intervention may take place before the baseline data collection.

2.3.4 IWRM Household and Agriculture Survey

The primary data source for the impact evaluation of the IWRM is a household and community survey in the *treatment* and *comparison* areas. MCA-S contracted with ANSD to collect the relevant data on households/communities living in the project intervention and comparison areas for the IWRM project. The key outcomes of interest include crops cultivated, crop production, agricultural income and household income. The survey also asked questions about satisfaction with the availability and effectiveness of irrigation systems, land conflicts and land rights.

The Senegal River Valley is dominated by three seasons: The dry and hot season from February to May, the rainy season from June to September, and the dry and cold season from October to January. Because most of the key outcome variables relate to agricultural production, they are season-dependent. To obtain reliable farm production/yield estimates, the baseline survey was administered in three waves to cover the three different agricultural seasons. Exhibit 2 summarizes the reference and baseline data collection periods for each wave.

Exhibit 2: IWRM Baseline Data Collection

Season	Reference Period	Data Collection Period
First Season (Cold season)	December 1, 2011–March 31, 2012	May 12, 2012–June 08, 2012
Second Season (Hot season)	April 1, 2012–July 31, 2012	October 1, 2012–November 20, 2012
Third Season (Rainy season)	August 1, 2012–November 31, 2012	January 29, 2013–end of March 2013

The impact evaluation requires two rounds of surveys: a baseline and a follow-up survey. Thus, to implement the impact evaluation, we will need a follow-up survey with the same households in the future.

Exhibit 3 summarizes the key data elements in the baseline household survey. As indicated in the Exhibit, the survey incorporates a household questionnaire and an agricultural questionnaire. A community questionnaire will also be administered to community leaders to gather information about community infrastructures, the incidence of land conflicts and other community characteristics.[11]

[11] The community includes some information on the existence of some organizations in the village, such as produce organizations and WUAs. However, it does not include information on how they function. The questionnaire is administered in the same communities occupied by the households. However, community data are collected only during the first season.

Exhibit 3: Main Variables for IWRM Questionnaires

Questionnaire/Description of Variables
HOUSEHOLD QUESTIONNAIRE
Household members' relationships to household head, age, gender, education, marital status
Activities of the various household members
Household assets, participation in farmer organizations
Non-agricultural revenues
Consumption and expenditures
AGRICULTURAL QUESTIONNAIRE
Plot size, agricultural production on the plots by crop
Land conflicts and perception of land security
Irrigation techniques
Labor inputs and other agricultural inputs and equipment
Amount obtained by commercialization of crops, amount of production lost
Livestock type, number of animals and their value
Production and commercialization of animal products
Household involvement in fishing and revenues
COMMUNITY QUESTIONNAIRE
Health and education
Community projects
Agriculture and livestock
Coping strategies
Land conflicts
Prices

3. RESULTS

This section presents the findings from the baseline survey. The data is summarized separately for the Delta and Podor samples. We first summarize the characteristics of the sampled households, and then summarize the information on irrigation practices and expenditures on farming practices. We also provide information on the types of crops produced and sold, as well as non-agricultural income sources. Finally, we provide descriptive information on land rights and land security.[12]

Delta

A total of 2,959 households were interviewed during wave 1 of the baseline survey. The response rate was 96.89 percent (2,867 households). Of the 92 households that did not complete a survey, 23 households did not have a family member available to complete the survey and 69 households were not interviewed either because the household refused (10 households), the household no longer existed (12) or for another reason (47). For wave 2, 2,732 of the 2,867 households that completed the survey in wave 1, also completed the survey in wave 2. Additionally, 38 households that did not complete the survey in wave 1 completed the survey in wave 2 for a total of 2,770 households. For wave 3, 2,715 of the 2,770 households that completed the survey in wave 2, also completed the survey in wave 3. There were an additional 18 households that did not complete the survey in wave 2 but completed the survey in wave 3. A total of 2,677 households completed the household survey in all three waves. The coverage rate across the three waves was thus 93.4 percent.

Podor

For the Podor sample, a total of 1,853 households were interviewed during wave 1 of the baseline survey. The response rate was slightly lower than the Delta sample, 90.93 percent (1,685 households). Of the 168 households that did not complete a survey, 38 households did not have a family member available to complete the survey and 130 households were not interviewed either because the household refused (3 households), the household no longer existed (2) or for another reason (125). For wave 2, 1,595 of the 1,685 households that completed the survey in wave 1, also completed the survey in wave 2. Additionally, 150 households that did not complete the survey in wave 1 completed the survey in wave 2 for a total of 1,745 households. For wave 3, 1,660 of the 1,745 households that completed the survey in wave 2, also completed the survey in wave 3. There were an additional 39 households that did not complete the survey in wave 2 but completed the survey in wave 3. A total of 1,552 households completed the household survey in all three waves. The coverage rate across the three waves was thus 93.4 percent.

Exhibit 4 lists the Rural Communities surveyed, along with the number of households surveyed in all three waves. Column 4 lists the number of households that completed all three waves of interviews (balanced panel).

[12] MCA-S contracted ANSD to administer all baseline surveys. ANSD developed the survey instruments, with input from MCC, MCA-S and IMPAQ.

Exhibit 4: Sample Size by Commune

Commune	Cold Season	Hot Season	Rainy Season	Balanced Panel
Delta				
GAE	400	396	394	387
ROSS BETHIO	162	158	154	151
ROSSO SENEGAL	706	645	631	616
BOKHOL	268	266	263	257
DIAMA	571	567	559	541
RONKH	363	347	343	338
GANDON	397	391	389	387
TOTAL	2,867	2,770	2,733	2,677
Podor				
NIANDANE	247	250	246	239
NDIANE PENDAO	1,439	1,495	1,453	1,313
TOTAL	1,686	1,745	1,699	1,552

Source: 2012 IWRM Survey

3.1 Household Characteristics at Baseline

Exhibit 5 presents the characteristics of the household heads for the Delta and Podor samples. The average age of the household head was 49 years of age. Approximately 13 percent of the heads of households in the sample were younger than age 35. One-third of heads of household were aged 55 or older. Over 80 percent of the heads of households were male. Because polygamy is practiced in parts of Senegal, Exhibit 5 also provides information on the marital status of the male heads of households. Over 90 percent of male heads of households were married and 20 percent of the male heads of households had two or more wives.

Educational attainment of heads of households was substantially low. Approximately 75 percent of heads of households did not have any formal education. The percentage of heads of households with no education differed between the Delta and Podor samples. About 90 percent of the Podor sample had no formal education compared to 70 percent for the Delta sample. Only 3 percent of the heads of households in the Podor sample had more than a primary education. This was also the case for 10 percent of the heads of households in the Delta sample.

Exhibit 5: Characteristics of the Household Head

Age groups	Podor	Delta	Total
Less than 35 years (%)	12.2	13.1	12.8
35–45 years (%)	24.4	25.2	24.9
45–55 years (%)	29.8	28.7	29.1
Older than 55 years (%)	33.7	33	33.3
Number of Observations (HHs)	**1,687**	**2,868**	**4,555**
Gender of Household Head			
Female (%)	17.7	18.3	18.1
Number of Observations (HHs)	**1,687**	**2,868**	**4,555**
Number of Spouses - Male Household Heads			
Not Married (%)	5	7.3	6.4
Married - 1 Wife (%)	74.2	72.8	73.3
Married - 2 or More Wives (%)	20.8	19.9	20.3
Number of Observations (HHs)	**1,389**	**2,342**	**3,731**
Educational Attainment			
None (%)	89.3	68.5	76.3
Primary School (%)	7.8	20.9	16
Middle School (%)	1.8	6.9	5
Secondary or more (%)	1.2	3.7	2.8
Number of Observations (HHs)	**1,650**	**2,746**	**4,396**

Source: 2012 IWRM Survey

Note: Data comes from wave 1 of the IWRM survey.

Exhibit 6 presents the characteristics of the households. On average, households had approximately nine household members. This is consistent with the average household size for the region based on the 2013 census. Households had on average three children under the age of 15.

Exhibit 6: Characteristics of the Household

Household Size (%)	Podor	Delta	Total
4 or fewer	20	17.4	18.3
5	10.6	9.3	9.8
6	11.7	10.5	10.9
7 or more	57.8	62.8	61
Number of children younger than 14 Years (%)			
0	9.8	10.7	10.4
1	14	11.9	12.7
2	18.4	18.3	18.4
3	16.4	18.9	18
4	15.6	14.5	14.9
5 or more	25.7	25.7	25.7
Number of Observations (HHs)	**1,687**	**2,868**	**4,555**

Source: 2012 IWRM Survey

Note: Data comes from wave 1 of the IWRM survey.

3.2 Farms and Irrigation Practices

This sub-section summarizes the characteristics of the households' farms, livestock ownership, irrigation practices and farmers' satisfaction with their irrigation practices. The sub-section also provides summary measures of farming expenditures. Descriptive information is provided for the three waves collected at baseline and separately for the Delta and Podor samples.

Farms in Senegal are owned and operated by individual members of the household. Exhibit 7 provides demographic information on the household members that report owning, leasing and/or sharecropping some land. The average age of farmers was 45 years of age. Female farmers represented 22 percent of the sample of farmers in the Podor sample while the Delta sample had a slightly higher proportion of female farmers, 24 percent. Educational attainment was low for the sample of farmers, 84 percent of farmers in the Podor sample had no education compared to only 64 percent of the Delta sample.

Exhibit 7: Farmer Characteristics

Age groups (%)	Podor	Delta	Total
Less than 35 years	21.7	27	25.3
35–45 years	26.1	25.4	25.6
45–55 years	26.8	23.9	24.8
Older than 55 years	25.4	23.8	24.3
Number of Observations (HHs)	**1,701**	**3,546**	**5,247**
Gender of Household Head (%)			
Female	21.8	24	23.3
Male	78.2	76	76.7
Number of Observations (HHs)	**1,701**	**3,546**	**5,247**
Number of Spouses - Male Household Heads (%)			
Not Married	5	7.3	6.4
Married - 1 Wife	74.2	72.8	73.3
Married - 2 or More Wives	20.8	19.9	20.3
Number of Observations (HHs)	**1,701**	**3,546**	**5,247**
Educational Attainment (%)			
None	86.4	64.1	71.4
Primary School	10	24.7	19.9
Middle School	2.5	7.9	6.2
Secondary or more	1.1	3.2	2.6
Number of Observations (HHs)	**1,701**	**3,546**	**5,247**

Source: 2012 IWRM Survey

Note: Data comes from wave 1 of the IWRM survey.

Exhibit 8 presents the distribution of land holdings by wave for the Delta sample.[13] The amount of land owned, leased and/or sharecropped was relatively small. Over 50 percent of the sampled households owned, leased and/or sharecropped less than 2 hectares of land. However, due to the small number of large farms, the average amount of land holdings was 3 hectares of land. The average number of plots owned, leased and/or sharecropped was approximately 3 plots of land. In per capita terms, the average amount of land holdings was .5 hectares.

During any given season, farmers cultivated on average 2 hectares of land, although the median size of land operated was only .5 hectares. Households operated between 1 and 2 plots of land. During the dry and cold season (wave 1), households operated on average 2.3 hectares of land and during the dry and hot season (wave 2), households operated on average 1.8 hectares of land. During the rainy season (wave 3), households operated on average 1.1 hectares of land.

[13] The survey asked each household member that owned, leased or sharecropped any parcels of land to provide information for each parcel. Land holdings for the household were obtained by summing the size of each household member's parcels of land.

Exhibit 8: Land Holdings - Delta

Delta			
Amount Owned, Leased, or Sharecropped	**Cold Season**	**Hot Season**	**Rainy Season**
Less than .5 ha (%)	11.1	12.1	12.3
.5–1 ha (%)	20.5	21.6	19.3
1–2 ha (%)	26.3	26.8	28.2
2 ha or more (%)	42.1	39.5	40.2
Land Owned, Leased or Sharecropped			
Average per hh (ha)	3.4	3.2	4.4
Median (ha)	1.5	1.4	1.5
Mean Number of Plots per hh (ha)	3	2.3	2.8
Land Owned Per Capita			
Mean (ha)	0.4	0.4	0.5
Median (ha)	0.2	0.2	0.2
Land Cultivated			
Average per hh (ha)	2.3	1.8	1.1
Median (ha)	1	0.7	0.2
Mean Number of Plots per hh (ha)	2.4	1.5	1.3
Land Cultivated Per Capita			
Mean (ha)	0.3	0.2	0.1
Median (ha)	0.1	0.1	0
Number of Observations (HHs)	**2,182**	**2,147**	**2,089**

Source: 2012 IWRM Survey
Notes: Results are reported only for households reporting owning, leasing, or sharecropping some land. Figures for land cultivated include only households reporting cultivating some land. The per capita land holdings is calculated by dividing the amount of land owned by the size of the household.

Exhibit 9 presents the distribution of land holdings by wave for the Podor sample. The amount of land owned, leased and/or sharecropped is substantially smaller than the Delta sample. Over 70 percent of the sampled households owned, leased and/or sharecropped less than 1 hectare of land and the median amount of land holdings was 0.5 hectares. The average amount of land holdings was 1 hectare of land and the average number of plots owned by the household was two plots. In per capita terms, the average amount of land holdings was .1 hectares.

During any given season, farmers cultivated on average 0.6 hectares of land and 1.5 plots. They reported that the main reasons for the relatively low land use, other than the plot being set aside without being sown, was due to a lack of resources.

Exhibit 9: Land Holdings - Podor

Podor			
Amount Owned, Leased, or Sharecropped	**Cold Season**	**Hot Season**	**Rainy Season**
Less than .5 ha (%)	37.6	41.5	35
.5–1 ha (%)	33.2	34.9	35.5
1–2 ha (%)	20.4	16.6	19.3
2 ha or more (%)	8.8	7	10.2
Land Owned, Leased or Sharecropped			
Average per hh (ha)	0.9	0.9	1
Median (ha)	0.5	0.5	0.6
Mean Number of Plots per hh (ha)	2	1.7	2.1
Land Owned Per Capita			
Mean (ha)	0.1	0.1	0.1
Median (ha)	0.1	0.1	0.1
Land Cultivated			
Average per hh (ha)	0.6	0.5	0.6
Median (ha)	0.4	0.4	0.4
Mean Number of Plots per hh (ha)	1.6	1.2	1.4
Land Cultivated Per Capita			
Mean (ha)	0.1	0.1	0.1
Median (ha)	0.1	0	0
Number of Observations (HHs)	**1,282**	**1,330**	**1,368**

Source: 2012 IWRM Survey
Notes: Results are reported only for households reporting owning, leasing, or sharecropping some land. Figures for land cultivated include only households reporting cultivating some land. The per capita land holdings is calculated by dividing the amount of land owned by the size of the household.

Exhibit 10 provides information on livestock ownership. In the Delta, 60 percent of households reported owning goats or sheep. In Podor, 70 percent of households reported owning goats and sheep. For both the Delta and Podor samples, approximately 30 percent of households owned cattle.

Exhibit 10 also converts livestock ownership into tropical livestock units (TLU). Converting the number of livestock into TLUs allows us to standardize the different types and quantities of livestock and allows for easier comparisons across households.[14] The average TLU for both the Delta and Podor sample was between 3 and 4 units.[15]

Exhibit 10: Livestock Ownership

Delta			
Type of Animal	Cold Season	Hot Season	Rainy Season
Tropical Livestock Unit	3.1	3.0	3.5
Donkeys/Horses/Camels (%)	21.0	22.0	26.0
Goats and Sheep (%)	62.0	64.0	64.0
Cattle (%)	31.0	29.0	30.0
Fowl (%)	21.0	20.0	24.0
Other (%)	1.0	1.0	1.0
Number of Observations (HHs)	**2,867**	**2,770**	**2,733**
Podor			
Tropical Livestock Unit	3.8	3.4	3.5
Donkeys/Horses/Camels (%)	29.0	29.0	35.0
Goats and Sheep (%)	72.0	75.0	81.0
Cattle (%)	27.0	26.0	28.0
Fowl (%)	11.0	6.0	13.0
Other (%)	0.0	0.0	0.0
Number of Observations (HHs)	**1,686**	**1,745**	**1,699**

Source: 2012 IWRM Survey

The objective of the water management and irrigation activity is to provide more reliable irrigation sources to farmers. The baseline survey asked a series of questions about irrigation practices at the plot level and the farmers' level of satisfaction with their irrigation methods. Responses from the survey showed that the share of land irrigated during the three seasons varied between 43 to 73 percent in the Delta and between 67 to 80 percent in Podor. The primary source of irrigation came from stream water and rainfall (Exhibit 11 and Exhibit 12), with rainfall providing the primary source of irrigation in the rainy season for 7 and 15 percent of all plots of land in Podor and the Delta, respectively.

[14] TLUs are commonly used to express the ownership of various livestock in order to have a common unit for comparison purposes. However, a different formula for estimating TLUs may be used in different parts of the world, depending on common livestock varieties. The standard used for one Tropical Livestock Unit is one cattle with a body weight of 250 kg (FAO, 1999). Refer to FAO (1999) for a more detailed discussion of TLUs.

[15] To calculate the TLU for each household, the number of each type of livestock owned was multiplied by its respective livestock coefficient and then summed across each livestock. The livestock coefficient units used are Cattle = 0.5, Sheep = 0.1, Goats = 0.1, Pigs = 0.2, Donkeys = 0.3, Horses = 0.5, Mules = 0.6, Camels = 0.7, Chickens = 0.01 (Chilonda and Otte, 2006).

Over 90 percent of parcels, whose main source or irrigation was not rain (stream water, wells, dams and drilling) used a gravity-fed irrigation system. For the Delta sample, 16 percent of plots in wave 1, 5 percent of plots in wave 2, and 42 percent of plots in wave 3 used a simple gravity-fed irrigation system (a simple elevated reservoir with a pipe that distributes water to the parcel). A substantial number of plots used an advanced gravity-fed irrigation system (water is pumped and distributed by canal to the parcel), 80 percent, 89 percent, and 55 percent of plots in waves 1, 2, and 3, respectively. For the Podor sample, between 10–15 percent of parcels were irrigated using a simple gravity-fed irrigation system and approximately 80 percent of parcels were irrigated using an advanced gravity-fed irrigation system.

The majority of farmers were satisfied with the availability of water used to irrigate their plots. Between 90 and 93 percent of farmers in the Delta sample were satisfied with the availability of water and between 86 and 97 percent of farmers in the Podor sample expressed some degree of satisfaction with the availability of water. A smaller share of farmers expressed satisfaction with the effectiveness of the irrigation system used on their plots. In the Delta sample, between 20 and 40 percent of farmers were not satisfied with the effectiveness of their irrigation systems. For the Podor sample, the range fell between 30 and 40 percent. The main reasons attributed to farmers' dissatisfaction were maintenance and costs.

Exhibit 11: Irrigation Practices (by Parcel) - Delta

Delta			
Main Source of Water (%)	Cold Season	Hot Season	Rainy Season
Stream Water (River, Lake, etc.)	97.2	95.4	84.3
Wells	1.2	1.8	0.6
Drilling	0.1	0.3	0.1
Dam, Withholding Water	1.2	0.3	0
Rain Water	0.1	1.8	14.9
Other	0.2	0.5	0
Number of Observations (Plots)	**5,305**	**3,295**	**2,707**
Type of Irrigation System (%)			
Simple Gravity-fed Irrigation	15.8	4.5	42.3
Gravity-fed Irrigation	78.3	88.3	54.7
Irrigation Sprinkler by Mobile Ramp	0.9	1.7	0.9
Spray (use of simple sprinkler) Irrigation	2.2	3.2	1.7
Drip Irrigation or Micro-Irrigation	0	0	0.1
Other	2.7	2.3	0.3
Number of Observations (Plots)	**5,291**	**3,235**	**2,318**
Satisfaction with the Availability of Water for Irrigation (%)			
Yes, a little	12.3	18.1	11.7
Yes, medium	24.9	20.4	7.7
Yes, quite	53.8	51.2	73.1
No	8.9	10.2	7.4
Number of Observations (Plots)	**5,295**	**3,232**	**2,315**
Satisfaction with the Effectiveness of Irrigation System (%)			
Yes	71.7	59.9	80.3
No	28.3	40.1	19.7
Number of Observations (Plots)	**3,950**	**3,126**	**2,125**
Reason for Not Being Satisfied with the Effectiveness of Irrigation System (%)			
Maintenance of the Irrigation Network is Hard	30.7	34.2	10.7
Water Theft (Piracy)	3.4	1.6	1.4
High Water Billing	13.8	11.3	12.1
Significant Water Losses	5.5	2.4	4.8
High Fuel Prices	16.6	10.7	18.1
Irrigation Equipment too Expensive	3.2	1	2.1
Other	26.8	38.8	50.7
Number of Observations (Plots)	**933**	**1,092**	**420**

Source: 2012 IWRM Survey

Note: Sample includes only plots operated by a member of the household.

Exhibit 12: Irrigation Practices (by Parcel) - Podor

Podor			
Main Source of Water (%)	Cold Season	Hot Season	Rainy Season
Stream Water (River, Lake etc.)	96.6	97	90.4
Wells	1.3	1.6	1.9
Drilling	1.5	0	0
Dam, Withholding Water	0.3	0	0
Rain Water	0	1.5	7.1
Other	0.2	0	0.4
Number of Observations (Plots)	**2,025**	**1,585**	**2,035**
Type of Irrigation System (%)			
Simple Gravity-fed Irrigation	9.9	14.8	12.8
Gravity-fed Irrigation	82.6	78	79.7
Irrigation Sprinkler by Mobile Ramp	0.6	0.1	0.7
Spray (use of simple sprinkler) Irrigation	0.5	0.6	1
Irrigation Pivot	0	0.1	0
Drip Irrigation or Micro-Irrigation	0.1	0	0
Other	6.2	6.3	5.8
Number of Observations (Plots)	**2,024**	**1,566**	**1,920**
Satisfaction with the Availability of Water for Irrigation (%)			
Yes, a little	26.4	24.1	14.7
Yes, medium	30.3	23	27.1
Yes, quite	29.3	49.2	55.3
No	13.9	3.7	3
Number of Observations (Plots)	**2,024**	**1,564**	**1,907**
Satisfaction with the Effectiveness of Irrigation System (%)			
Yes	58.3	71.1	65.5
No	41.7	28.9	34.5
Number of Observations (Plots)	**1,390**	**1,523**	**1,668**
Reason for Not Being Satisfied with the Effectiveness of Irrigation System (%)			
Maintenance of the Irrigation Network is Hard	26.2	10	10.8
Water Theft (Piracy)	1	3.5	0.9
High Water Billing	27.4	24.9	32.2
Significant Water Losses	4.6	1	3.8
High Fuel Prices	15	5.4	15.8
Irrigation Equipment too Expensive	0.9	0.4	0.5
Other	25	54.9	35.9
Number of Observations (Plots)	**581**	**519**	**546**

Source: 2012 IWRM Survey

Note: Sample includes only plots operated by a member of the household.

3.3 Farm Expenditures

The baseline survey collected information on farm expenditures incurred by the farmer for each plot. Exhibit 13 and

Exhibit 14 provide the average expenditure per hectare per plot for each of the reference periods for the Delta and Podor samples, respectively.

For the Delta sample (Exhibit 13), during the dry and cold season, the largest expenses for farmers were related to irrigation, which accounted for approximately 30 percent of total expenditures. During the dry and hot season, the largest expense for farmers were related to transportation and management costs, accounting for more than 30 percent of total expenditures. During the rainy season, the largest expenses for farmers were related to pesticides, fertilizers and irrigation, each accounting for approximately 30 percent of total expenditures.

For the Podor sample (

Exhibit 14), the largest expenses for farmers during the dry and cold season were related to mechanized work, accounting for 35 percent of total expenditures. During the dry and hot season, the largest expenses for farmers were related to transportation and management costs, accounting for more than 35 percent of total expenditures. Irrigation expenses accounted for 20 percent of total expenditures during the hot season. During the rainy season, the largest expenses were related to labor costs, mechanized work and transportation and management costs, each accounting for 20 percent of total expenditures.

Exhibit 13: Farm Expenditures Per Ha - Delta

Delta			
	Cold Season	Hot Season	Rainy Season
Type of Expenditure	Mean Per Hectare	Mean Per Hectare	Mean Per Hectare
Soil Preparation	124,500 (2,844,000)	194,000 (5,254,400)	63,300 (180,900)
Seed Purchase	370,200 (11,299,500)	203,300 (5,252,900)	78,200 (175,600)
Fertilizers and Pesticides	303,800 (6,384,900)	188,600 (4,084,500)	124,900 (381,500)
Irrigation Expenses	1,305,600 (27,794,300)	121,900 (3,530,200)	126,800 (2,695,000)
Labor	643,300 (12,277,100)	52,700 (202,800)	29,800 (190,600)
Other Mechanized Work (seeding, fertilization, etc.)	682,600 (15,803,200)	503,300 (15,223,300)	15,200 (44,700)
Other Charges (transportation, management, etc.)	831,600 (21,083,200)	511,100 (13,967,600)	9,800 (31,100)
Number of Observations (Plots)	**5,280**	**3,271**	**2,700**

Source: 2012 IWRM Survey

Note: Sample includes only plots operated by a member of the household. Standard deviations in parentheses.

Exhibit 14: Farm Expenditures Per Ha - Podor

Podor			
	Cold Season	Hot Season	Rainy Season
Type of Expenditure	Mean Per Hectare	Mean Per Hectare	Mean Per Hectare
Soil Preparation	192,300 (5,028,100)	286,700 (10,088,000)	298,500 (7,868,500)
Seed Purchase	139,400 (953,600)	40,600 (82,600)	353,900 (7,869,100)
Fertilizers and Pesticides	182,400 (652,900)	348,400 (10,103,300)	373,200 (7,861,200)
Irrigation Expenses	103,000 (257,600)	775,400 (15,757,400)	212,400 (5,554,900)
Labor	325,100 (9,531,600)	622,400 (14,799,900)	715,300 (16,811,100)
Other Mechanized Work (seeding, fertilization, etc.)	791,600 (16,667,100)	392,000 (10,862,800)	752,000 (16,951,800)
Other Charges (transportation, management, etc.)	540,500 (9,269,900)	1,568,000 (21,443,600)	725,500 (16,960,900)
Number of Observations (Plots)	**2,010**	**1,574**	**2,035**

Source: 2012 IWRM Survey
Note: Sample includes only plots operated by a member of the household. Standard deviations appear in parentheses.

3.4 Farm Production and Sales

The primary objective of the IWRM project is to increase agricultural productivity by improving access to water for irrigation. This sub-section presents baseline findings on the main intervention outcomes that the IWRM project aims to impact.

Exhibit 15 provides information on the share of sampled households producing and selling crops during the three seasons. Results are provided for the four main crops (rice, patates, onions and tomatoes) and for three categories of crops (main crops, horticulture and fruit arboriculture).[16] Rice is the most common crop grown in the Delta sample, approximately 45 percent of sampled

[16] The questionnaire allowed households to select up to 39 different crops grown. The questionnaire grouped the 39 crops into three categories, main crops, horticulture crops, and fruit arboriculture. For the purposes of this report, we group the crops/crop codes the same as the questionnaire. This is important to note because some crops are listed twice with a different code (okra and watermelon). Main crops includes millet, corn, jatropha (tabanani), rice, fonio, cotton, peanut, cowpea, forage, vouandzou (Gadianga), bissap, patate, cassava, sorghum, okra, beref, watermelon, other. Horticulture crops include ornamental plants, onion, bitter eggplant, eggplant, cabbage, pomme de terre, okra, chilli, strawberry, melon, watermelon, tomato, carrot, turnip, cucumber, lettuce/salad, other. Fruit arboriculture includes mango, bananas, citrus, other.

households produced rice during the dry and hot season. Between 7 and 10 percent of the Delta sample produced onions, tomatoes or patates. In the Podor sample, 43 percent of sampled households produced onions during the dry and cold season. Rice was produced by approximately 28 percent of the sampled households during the rainy season. Approximately 15 percent of households grew tomatoes.

Nearly every household that reported producing a crop also reported selling the crop (second panel of Exhibit 15). Thus, it appears that most households grew crops as a source of income.

Exhibit 15: Share of Households Producing and Selling Crops

	Cold Season	Hot Season	Rainy Season	Cold Season	Hot Season	Rainy Season
Type of Crop Produced (%)	**Delta**			**Podor**		
Rice	10.3	46.9	16.8	16.9	24.1	28.0
Patate (Sweet Potato/Yams)	8.2	4.7	0.4	0.8	0.3	0.0
Onion	7.1	5.3	0.1	43.8	3.0	0.7
Tomato	7.1	1.6	0.3	15.7	1.1	0
Main Crops	19.1	48.2	22.7	20.0	26.5	28.9
Horticulture	15.0	9.1	1.9	49.2	7.3	1.6
Fruit Arboriculture	0.7	0.7	0.3	3.3	5.7	4.6
Type of Crop Sold (As a percentage of HHs that reported producing the crop)						
Rice	89.2	93.2	97.2	66.0	65.1	85.7
Patate (Sweet Potato/Yams)	98.7	97.7	100.0	92.9	40.0	-
Onion	87.7	96.6	100.0	98.1	98.1	50.0
Tomato	98.5	100.0	87.5	98.9	100.0	-
Main Crops	93.4	93.4	89.0	65.6	65.2	84.7
Horticulture	93.7	96.8	98.0	98.1	93.7	81.5
Fruit Arboriculture	57.9	88.9	100.0	100.0	99.0	98.7
Number of Observations (HHs)	**2,977**	**2,134**	**1,731**	**1,698**	**1,310**	**1,728**

Source: 2012 IWRM Survey

Exhibit 16 provides the area allocated to the main crops grown. Rice and onions were allocated the largest share of land. In the Delta, on average 2 hectares of land were allocated to the production of rice. In Podor, approximately .5 and .4 hectares of land were allocated to the production of rice and onions, respectively.

Exhibit 16: Average Area per Household Allocated to Crops

Average Area Allocated to Crops (Mean Total Area in Hectares)			
Type of Crop	**Cold Season**	**Hot Season**	**Rainy Season**
Delta (Mean Total Area in Hectares)			
Rice	2.9	2.6	2.5
Patate (Sweet Potato/Yams)	0.3	0.4	0.8
Onion	1.1	0.8	0.5
Tomato	0.7	0.7	0.6
Main Crops	2.8	2.6	1.9
Horticulture	1.1	1.0	0.7
Fruit Arboriculture	0.7	0.6	0.7
Number of Observations (HHs)	**2,978**	**2,133**	**1,734**
Podor (Mean Total Area in Hectares)			
Rice	0.8	0.6	0.6
Patate (Sweet Potato/Yams)	0.3	0.5	0.1
Onion	0.6	0.7	0.6
Tomato	0.5	0.4	0.4
Main Crops	0.7	0.6	0.6
Horticulture	0.7	0.5	0.8
Fruit Arboriculture	0.2	0.2	0.2
Number of Observations (HHs)	**1,698**	**1,310**	**1,728**

Source: 2012 IWRM Survey
Notes: Values are conditional on the household reporting growing the crop.

Exhibit 17 provides the average amount produced in kilograms per hectare (kg/ha) of rice and the three categories of crops (main crops, horticulture and fruit arboriculture).[17] Rice-producing farmers in the Delta sample produced on average 1,400 kg/ha of rice during the dry and cold season, and on average 3,100 kg/ha during the rainy season. During the dry and hot season, average rice yields were 7,300 kg/ha for rice growers. Farmers reported producing approximately 35,000 kg/ha of horticultural crops during the dry and cold season, 15,000 kg/ha during the dry and hot season, and 2,800 kg/ha during the rainy season. During both dry seasons, farmers produced 1,400 kg/ha of fruit arboricultural crops and 3,200 kg/ha during the rainy season.

Rice-producing farmers in Podor reported production of 6,700 kg/ha of rice during the dry and cold season, 2,200 kg/ha during the dry and hot season, and 5,700 kg/ha during the rainy season. Farmers reported producing approximately 36,000 kg/ha of horticultural crops during the dry and cold season and 13,500 kg/ha during the dry and hot season. During both dry seasons,

[17] Due to the small number of households producing patates, onions, and tomatoes, the remaining exhibits only report statistics for rice separately.

farmers produced 12,000 kg/ha of fruit arboricultural crops and 9,200 kg/ha during the rainy season.[18]

Exhibit 17: Amount of Crops Produced (Kg/Ha)

	Cold Season	Hot Season	Rainy Season
Delta			
Rice	1,378	7,360	3,114
Main Crops	2,640	9,401	4,931
Horticulture	35,129	15,164	2,838
Fruit Arboriculture	1,482	1,401	3,198
Number of Observations (HHs)	**2,977**	**2,134**	**1,731**
Podor			
Rice	6,736	2,241	5,726
Main Crops	6,882	2,778	4,597
Horticulture	36,056	13,467	283
Fruit Arboriculture	12,135	11,829	9,252
Number of Observations (HHs)	**1,698**	**1,310**	**1,728**

Source: 2012 IWRM Survey

Note: Averages are conditional on the household producing the crop.

[18] The national average of rice yields reported in 2012 by FAOSTAT was 4,700Kg/Ha. The national average of onion, sweet potato, and tomato yields reported in 2012 by FAOSTAT was 24,000Kg/Ha, 25,000Kg/Ha, and 28,500Kg/Ha respectively (FAOSTAT 2014).

Exhibit 18 provides average income from crop sales for each growing season. For farmers in the Delta sample, 40 percent of crop sales during the dry and cold season came from horticultural crops and fruit arboricultural crops each. During the dry and hot season, 45 percent of crop sales came from main crops and 30 percent of crop sales came from horticultural crops.

For farmers in the Podor sample, during the dry and cold season, 50 percent of crop sales came from horticultural crops and 33 percent of crop sales came from fruit arboricultural crops. During the dry and hot season, 55 percent of crop sales came from fruit arboricultural crops and 35 percent of crop sales came from horticultural crops.

Exhibit 18: Average and Median Crop Sales per HH (FCFA)

Delta			
	Cold Season	Hot Season	Rainy Season
Crop	Mean (Median)	Mean (Median)	Mean (Median)
Rice	673,300 (222,500)	1,209,400 (450,000)	961,500 (360,000)
Main Crops	419,500 (109,300)	1,187,800 (450,000)	740,800 (240,000)
Horticulture	920,700 (428,700)	921,600 (419,000)	659,700 (215,000)
Fruit Arboriculture	1,109,500 (659,800)	710,100 (378,500)	884,100 (551,300)
Podor			
Rice	167,200 (39,500)	85,900 (45,500)	191,600 (120,000)
Main Crops	163,600 (30,600)	83,200 (36,000)	187,500 (120,000)
Horticulture	652,200 (350,000)	396,700 (120,800)	172,700 (58,800)
Fruit Arboriculture	427,500 (268,900)	650,800 (297,500)	- -

Source: 2012 IWRM Survey
Note: Medians appear in parentheses. Values are conditional on the household producing the crop.

3.5 Non-Farm Income

Exhibit 19 presents information on non-agricultural income sources. The Exhibit provides the number of households that reported receiving non-agricultural income and the average amount of income received. A substantial number of households reported receiving non-farm income, 2,400 households for the Delta sample and 1,200 for the Podor sample. A substantial number of households in the Delta sample also reported receiving remittances.

Exhibit 19: Income Sources

Source of Income	Cold Season	Hot Season	Rainy Season	Number of Observations
Delta - Source of Income (FCFA)				
Non-farm	550,400	510,300	544,100	**2,408**
Remittance	44,600	81,800	89,300	**1,346**
Rental	23,700	28,900	23,300	**223**
Pension	6,100	8,700	10,200	**419**
Aid	4,600	6,300	7,000	**330**
Podor - Source of Income (FCFA)				
Non-farm	285,800	294,400	301,500	**1,255**
Remittance	50,600	48,700	49,000	**535**
Rental	8,900	5,800	7,400	**114**
Pension	3,500	4,700	5,000	**40**
Aid	3,200	8,400	9,500	**286**

Source: 2012 IWRM Survey

Notes: Rental income includes income from the rental of buildings, equipment, receivables and the sale of capital. Aid includes income from family allowances, social assistance and aid from government or non-government sources.

3.6 Perception of Land Security and Land Conflicts

The LTSA aims to improve land security and land conflicts. The baseline survey collected data on land rights, perceptions about land security and land conflicts.

Exhibit 20 and Exhibit 21 provide information on farmers' title/guarantee to their plots of land and how secure farmers feel about their rights to the land.

For the Delta sample (

Exhibit 20), 70 percent of the surveyed plots did not have a document showing that the plot belonged to the farmer, while 20 percent of the surveyed plots had paper allocations to the OP.[19] Although farmers did not have documents on 70 percent of the surveyed plots, they only expressed concern about losing approximately 50 percent of the surveyed plots. However, farmers did not report that the concern of losing their plots decreased their likelihood of investing in their land. For about 30 percent of the surveyed plots, farmers expressed concern that they may lose the plot due to non-use.

For the Podor sample (

[19] Due to the relatively high share of plots that farmers reported having a title to during the cold season, we believe that there may have been some confusion on the part of the farmers when answering the question about the title to their land during the cold season. True land titles are very rare in rural Senegal (and generally throughout the region of West and Central Africa). We believe it is likely that some papers that actually fit the category of "paper allocation to the OP" (also known as "titre d'affectation") were mistakenly reported and registered as "land titles.

Exhibit 21), a smaller share of plots compared to the Delta sample did not have documents reporting the rights of the farmer. About 35–45 percent of the surveyed plots did not have a document showing that the plot belonged to the farmer. Another 33–43 percent of the surveyed plots had paper allocations to the OP.[20] Farmers expressed concerns about losing approximately 35 percent of the surveyed plots. Similar to the Delta sample, farmers did not suggest that the concern over losing their plots contributed to not investing in the plots. For about 40 percent of the surveyed plots, farmers expressed concern that they may lose the plot due to non-use.

[20] See footnote 20.

Exhibit 20: Land Security - Delta

Delta				
Title or Guarantee to the Parcel (%)	**Cold Season**	**Hot Season**	**Rainy Season**	**Total**
Title	2.6	0.5	0.5	1.3
Lease	0.5	0.3	0.2	0.4
Occupancy Permit	5.9	8.2	6.3	6.7
Paper Allocation to the OP	23.5	21	22	22.3
Other Document	2.4	0.5	0.2	1.1
No Document	65.2	69.4	70.7	68.3
Number of Observations (Plots)	**6,353**	**5,000**	**5,734**	**17,087**
Concerned about Losing the Plot (%)				
No	48.2	50.7	48.1	48.9
Yes, a little	9	10.8	12.7	10.7
Yes, medium	4.9	4.7	5.3	5
Yes, quite	37.9	33.8	33.9	35.4
Number of Observations (Plots)	**6,543**	**5,036**	**5,782**	**17,361**
If so, this Concern Prevents Investment on the Plot (%)				
No	77.5	90.7	93.8	86.5
Yes, a little	4.6	3.1	3	3.7
Yes, medium	4.7	1.7	1.3	2.8
Yes, quite	13.3	4.4	1.9	7.1
Number of Observations (Plots)	**3,821**	**2,708**	**3,091**	**9,620**
Concern about the Loss of the Parcel for Reason of Non-Use (%)				
No	49.9	56.9	61.3	55.7
Yes, a little	7.1	7	5.6	6.6
Yes, medium	5.2	3.1	2.1	3.6
Yes, quite	37.9	33	30.9	34.1
Number of Observations (Plots)	**6,491**	**5,021**	**5,769**	**17,281**

Source: 2012 IWRM Survey

Note: Sample includes all plots of land owned, operated, leased or crop-shared by a member of the household.

Exhibit 21: Land Security - Podor

Podor				
Title or Guarantee to the Parcel (%)	Cold Season	Hot Season	Rainy Season	Total
Title	11.6	1.7	1	4.8
Lease	0.2	0.3	0.1	0.2
Occupancy Permit	7.9	17.2	19.1	14.8
Paper Allocation to the OP	32.4	43.1	43.5	39.7
Other Document	3.8	2.8	2	2.9
No Document	44.1	34.8	34.2	37.7
Number of Observations (Plots)	**2,535**	**2,211**	**2,804**	**7,550**
Concerned about Losing the Plot (%)				
No	64	67.3	68.5	66.7
Yes, a little	15.2	11.8	8.9	11.9
Yes, medium	3.4	4.4	3	3.6
Yes, quite	17.3	16.5	19.6	17.9
Number of Observations (Plots)	**2,592**	**2,304**	**2,931**	**7,827**
If so, this Concern Prevents Investment on the Plot (%)				
No	64	75.2	64.4	67.9
Yes, a little	20.2	16.9	20.2	19.1
Yes, medium	3.3	2.6	3	3
Yes, quite	12.5	5.4	12.4	10.1
Number of Observations (Plots)	**1,196**	**1,133**	**1,065**	**3,394**
Concern about the Loss of the Parcel for Reason of Non-Use (%)				
No	59.8	60.5	66.2	62.4
Yes, a little	15	15.5	9.5	13.1
Yes, medium	3.6	4.8	2.7	3.6
Yes, quite	21.7	19.2	21.6	20.9
Number of Observations (Plots)	**2,585**	**2,292**	**2,908**	**7,785**

Source: 2012 IWRM Survey

Note: Sample includes all plots of land owned, operated, leased or crop-shared by a member of the household.

Exhibit 22 and Exhibit 23 present information on land rights and land conflicts. Fewer than 4 percent of the surveyed farmers reported having a conflict over land. This percent fell to 2 percent for the Podor sample. Few farmers had rights to sell their land, with farmers reporting that over 70 percent of the plots in the Delta sample could not be sold. For the Podor sample, 50 percent of the plots could not be sold. More farmers had rights to rent their land and hire labor to work the land. About 60 to 70 percent of plots could be rented or sharecropped.

Exhibit 22: Land Rights - Delta

Delta				
Land conflict (%)	**Cold Season**	**Hot Season**	**Rainy Season**	**Total**
No Land Conflict	96.3	98.8	99.4	98.4
1 or more Land Conflict	3.7	1.2	0.6	1.6
Number of Observations (Plots)	**3,552**	**5,055**	**5,793**	**14,400**
Can You Sell your Plots? (%)				
Yes, without Permission of a Person	19.5	19.8	17.1	18.6
With the Permission of the Household Steward of the Concession	7	3.6	3.8	4.5
With the Permission of the Community/Village	3.2	1.5	1.3	1.8
No	70.4	75.1	77.8	75
Number of Observations (Plots)	**3,538**	**5,046**	**5,794**	**14,378**
Can You Rent your Plots? (%)				
Yes, without Permission of a Person	51.1	62.5	62.5	59.7
With the Permission of the Household Steward of the Concession	9.8	5.5	6.6	7
With the Permission of the Community/Village	2.7	1.4	1.1	1.6
No	36.4	30.6	29.8	31.7
Number of Observations (Plots)	**3,543**	**5,052**	**5,794**	**14,389**
Can You Hire a Tenant (Sharecropping) on your Plots? (%)				
Yes, without Permission of a Person	60.4	71.7	70.4	68.4
With the Permission of the Household Steward of the Concession	9.5	5.2	5.9	6.5
With the Permission of the Community/Village	1.9	1.1	1	1.3
No	28.2	21.9	22.7	23.8
Number of Observations (Plots)	**3,541**	**5,049**	**5,793**	**14,383**

Source: 2012 IWRM Survey
Note: Sample includes all plots of land owned, operated, leased or crop-shared by a member of the household.

Exhibit 23: Land Rights - Podor

Podor				
Land conflict (%)	**Cold Season**	**Hot Season**	**Rainy Season**	**Total**
No Land Conflict	98.2	99.3	99.7	99.2
1 or more Land Conflict	1.8	0.7	0.3	0.8
Number of Observations (Plots)	**1,706**	**2,315**	**2,941**	**6,962**
Can You Sell your Plots? (%)				
Yes, without Permission of a Person	34.5	37.9	35	35.8
With the Permission of the Household Steward of the Concession	7.9	5.1	5.2	5.9
With the Permission of the Community/Village	4.8	16.3	12.7	12
No	52.8	40.7	47.1	46.4
Number of Observations (Plots)	**1,701**	**2,318**	**2,940**	**6,959**
Can You Rent your Plots? (%)				
Yes, without Permission of a Person	60.7	66.9	61.3	63
With the Permission of the Household Steward of the Concession	6	3.2	4.7	4.5
With the Permission of the Community/Village	2	8.8	7.6	6.6
No	31.3	21.1	26.4	25.9
Number of Observations (Plots)	**1,701**	**2,317**	**2,940**	**6,958**
Can You Hire a Tenant (Sharecropping) on your Plots? (%)				
Yes, without Permission of a Person	67.7	76.5	73.8	73.2
With the Permission of the Household Steward of the Concession	5.7	2.9	4.4	4.2
With the Permission of the Community/Village	0.8	3.9	5.1	3.7
No	25.7	16.8	16.6	18.9
Number of Observations (Plots)	**1,699**	**2,315**	**2,938**	**6,952**

Source: 2012 IWRM Survey
Note: Sample includes all plots of land owned, operated, leased or crop-shared by a member of the household.

4. DIFFERENCES BETWEEN TREATMENT AND COMPARISON GROUPS AT BASELINE

The baseline survey can verify whether households in the treatment group are similar to households in the comparison group prior to receiving the intervention. As mentioned earlier, comparison areas were selected based on characteristics that were believed to match the characteristics of the treatment areas, including similarity of geographic location and of irrigation and drainage conditions. Therefore, we expected differences between farmers in the treatment and comparison areas to be relatively small. Examining these differences for the key outcome measures is the subject of this chapter. In each table, we present the mean separately for the treatment and comparison sample, and the difference between the means of the treatment and comparison samples.

4.1 Baseline Differences in Household Characteristics

Exhibit 24 presents baseline differences in household characteristics. Comparing the baseline characteristics of households in the treatment and comparison areas indicates that households look very similar. For the Delta sample, the heads of households in treatment areas were slightly more likely to have no education. They were less likely to have had some secondary education and they had slightly fewer children under the age of 15 than heads of households in the comparison areas. However, the magnitude of the differences is not substantively meaningful. For the Podor sample, heads of households in the treatment areas were less likely to be male. The male heads of households had fewer wives and were more likely to have no education. They were also less likely to have attended primary school. Again, these differences are not substantively meaningful. However, the treatment households in the Podor sample were smaller than the households in the comparison areas (1.45 fewer members). This difference between the treatment and comparison samples may be relevant for the impact evaluation.

Exhibit 24: Differences is Household Characteristics

	Delta			Podor		
Household Characteristics	**Treatment Group Mean**	**Control Group Mean**	**Difference in Mean**	**Treatment Group Mean**	**Control Group Mean**	**Difference in Mean**
Head of Household's Age	48.86	49.52	-0.67	49.32	50.41	-1.09
Male Head of Household	0.82	0.82	0	0.81	0.87	-0.06**
Number of Wives (Male Heads)	0.96	0.95	0	0.95	1.12	-0.16***
Head of Household's Education						
None	0.71	0.65	0.06**	0.9	0.85	0.05**
Primary School	0.2	0.22	-0.03	0.07	0.12	-0.06**
Middle School	0.07	0.07	-0.01	0.02	0.02	0
Secondary or more	0.03	0.05	-0.02**	0.01	0.01	0
Household Size	8.81	9.23	-0.41	8.07	9.52	-1.45***
Number of Children	3.28	3.56	-0.28**	3.34	3.57	-0.23
Number of Observations (HHs)	**1,496**	**1,372**		**1,320**	**367**	

Source: 2012 IWRM Survey

Notes: These are proportions, unless otherwise indicated. For each variable, the means are presented along with the differences between the treatment and comparison group.

Statistically significant at 10 percent (*), 5 percent (**) and 1 percent (***).

Exhibit 25 presents differences in farmer characteristics. For the Delta sample, farmers in the treated and comparison villages appeared to be similar in terms of age and educational attainment. However, farmers in the treatment villages were more likely to be women. For the Podor sample, farmers in the treatment villages were less likely to be women. Farmers in the treatment villages on average also had fewer years of education.

Exhibit 25: Differences in Farmer Characteristics

	Delta			Podor		
Farmer Characteristics	**Treatment Group Mean**	**Control Group Mean**	**Difference in Mean**	**Treatment Group Mean**	**Control Group Mean**	**Difference in Mean**
Age	44.54	44.27	0.27	45.77	44.74	1.03
Male	0.82	0.7	0.13***	0.75	0.89	-0.14***
Farmer's Education						
None	0.65	0.63	0.02	0.88	0.81	0.07**
Primary School	0.24	0.26	-0.02	0.08	0.15	-0.07***
Middle School	0.08	0.08	0	0.02	0.02	0
Secondary or more	0.03	0.04	-0.01	0.01	0.01	0.01
Number of Observations (HHs)	**1,496**	**1,372**		**1,320**	**367**	

Source: 2012 IWRM Survey

Notes: These are proportions, unless otherwise indicated. For each variable, the means are presented along with the differences between the treatment and comparison group.

Statistically significant at 10 percent (*), 5 percent (**) and 1 percent (***).

4.2 Baseline Differences in Farms and Irrigation Practices

Error! Reference source not found. presents differences in land ownership for the Delta and Podor samples. Farmers in treatment areas of the Delta sample owned, leased and/or sharecropped more land during the two dry seasons than did farmers in comparison areas. As noted previously, it appears that there might be errors in the land ownership data. These variables are not necessarily important to the evaluation of the impact of the irrigation infrastructure itself. However, land titling is an important variable in the evaluation of the LTSA project.

Cultivated area is the important variable of interest in terms of impact of agricultural infrastructure. There were no differences between the samples in the average area of land under operation. For the Podor sample, however, the average cultivated area is significantly smaller in the treatment area, across all three seasons. This is not entirely surprising because we know from talking to local stakeholders that cultivation in the treatment area, the N'Gallenka basin, is notably underdeveloped, precisely because of the lack of appropriate water irrigation infrastructures. Because of the non-random character of the intervention and the difficulties in identifying control groups, these types of differences at baseline motivate the DID methodology.

Exhibit 26: Differences in Land Ownership

	Cold Season			Hot Season			Rainy Season		
Land Ownership	**Treatment Group Mean**	**Control Group Mean**	**Difference in Mean**	**Treatment Group Mean**	**Control Group Mean**	**Difference in Mean**	**Treatment Group Mean**	**Control Group Mean**	**Difference in Mean**
Delta									
Total Land Owned (ha)	3.92	2.79	1.13*	3.97	2.17	1.81***	4.37	4.44	-0.07
Total Land Cultivated (ha)	2.24	2.42	-0.18	1.93	1.56	0.37	1.02	1.1	-0.09
Num. of Obs. (HHs)	**1, 484**	**1,374**		**1,462**	**1,307**		**1,445**	**1,288**	
Podor									
Total Land Owned (ha)	0.87	1.13	-0.26***	0.94	0.82	0.12	0.99	1.15	-0.16
Total Land Cultivated (ha)	0.48	1.08	-0.60***	0.49	0.61	-0.12*	0.53	0.95	-0.42***
Num. of Obs. (HHs)	**1,318**	**363**		**1,383**	**360**		**1,342**	**357**	

Source: 2012 IWRM Survey

Notes: For each variable, the means are presented along with the differences between the treatment and comparison group.

Statistically significant at 10 percent (*), 5 percent (**) and 1 percent (***).

Exhibit 27 and Exhibit 28 present baseline differences in water sources used on plots and the types of irrigation systems used for the three crop seasons. For the Delta sample, there appeared to be substantive differences between treatment and comparison areas in water sources and in irrigation systems used. During the rainy season, farmers in the treatment areas were less likely to use stream water and more likely to use rainwater on their plots than farmers in comparison areas. Some of these differences, when they are small, could be due to variation in data collection between the seasons or errors from respondents.

Yet a persisting difference, which becomes quite important in the rainy season, is in the use of rain water. Almost 34% of the treatment group uses rainwater in the rainy season whereas almost no farmer does in the control group. This could be an indication that the water constraint is binding (lack of irrigation is a more serious problem) in the treatment group, or, alternatively, that it rains more (hence higher use of rainwater) in the treatment areas. Another statistic that also shows that the water management environment is substantially different in both areas during the rainy season is that farmers in the treatment area are more than twice more likely (almost 90%) to use pumps in their irrigation system than are farmers in the control area. One possible consequence of this for the impact analysis is the need to compare treatment and control groups in the seasons where they are comparable only (the cold and the hot season). A separate analysis for the rainy season might include collecting some qualitative data to better understand why their conditions are so different at that time of the year.

For the Podor sample, minor differences exist between the treatment areas and the comparison areas. During the rainy season, farmers in the treatment areas were less likely to use a simple gravity-fed irrigation system and more likely to use an advanced gravity-fed irrigation system compared to farmers in comparison areas.

Exhibit 27: Differences in Irrigation Practices - Delta

	Cold Season			Hot Season			Rainy Season		
	Treatment Group Mean	Control Group Mean	Difference in Mean	Treatment Group Mean	Control Group Mean	Difference in Mean	Treatment Group Mean	Control Group Mean	Difference in Mean
Delta									
Source									
Stream Water (river, lake)	0.976	0.97	0.006	0.931	0.98	-0.049***	0.638	0.994	-0.355***
Wells	0.019	0.007	0.012***	0.022	0.012	0.010*	0.012	0.002	0.010**
Drilling	0	0.001	-0.001	0.005	0.001	0.003	0.003	0.001	0.002
Dam (withholding water)	0.003	0.019	-0.016***	0.006	0.001	0.005**	0.001	0	0.001
Rainwater	0.002	0	0.002	0.033	0	0.033***	0.346	0.004	0.342***
Other	0	0.003	-0.003*	0.004	0.006	-0.002	0	0	0
Type of Irrigation System									
Simple Gravity Irrigation	0.085	0.214	-0.130***	0.045	0.044	0.002	0.06	0.601	-0.541***
Irrigation Gravity (pumping and distribution of the plot)	0.838	0.741	0.097***	0.864	0.903	-0.039***	0.878	0.384	0.495***
Irrigation Sprinkler by Mobile Ramp	0.011	0.008	0.003	0.019	0.014	0.005	0.018	0.005	0.013*
Spray (use of simple sprinkler) Irrigation	0.042	0.007	0.035***	0.054	0.008	0.045***	0.035	0.008	0.027***
Irrigation Pivot	0	0	0	0	0	0	0	0	0
Drip Irrigation or Micro-Irrigation	0	0	0	0.001	0	0.001	0.003	0	0.003
Other	0.025	0.029	-0.005	0.016	0.031	-0.014**	0.005	0.002	0.003
Number of Observations (Plots)	**1, 484**	**1,374**		**1,462**	**1,307**		**1,445**	**1,288.00**	

Source: 2012 IWRM Survey

Notes: These are proportions, unless otherwise indicated. For each variable, the means are presented along with differences between the treatment and comparison group. Statistically significant at 10 percent (*), 5 percent (**) and 1 percent (***).

Exhibit 28: Differences in Irrigation Practices - Podor

	Cold Season			Hot Season			Rainy Season		
	Treatment Group Mean	Control Group Mean	Difference in Mean	Treatment Group Mean	Control Group Mean	Difference in Mean	Treatment Group Mean	Control Group Mean	Difference in Mean
Podor									
Source									
Stream Water (river, lake)	0.978	0.95	0.028**	0.961	0.99	-0.029***	0.911	0.895	0.016
Wells	0.016	0.008	0.008	0.022	0.002	0.020***	0.024	0.013	0.012*
Drilling	0.001	0.035	-0.035***	0	0	0	0.001	0	0.001
Dam (withholding water)	0.001	0.006	-0.005	0	0	0	0.001	0	0.001
Rainwater	0.001	0	0.001	0.017	0.008	0.009	0.057	0.09	-0.033**
Other	0.003	0	0.003*	0	0	0	0.006	0.002	0.004
Type of Irrigation System									
Simple Gravity Irrigation	0.104	0.092	0.012	0.133	0.182	-0.049*	0.077	0.199	-0.122***
Irrigation Gravity (pumping and distribution of the plot)	0.814	0.843	-0.029	0.777	0.789	-0.012	0.815	0.772	0.043*
Irrigation Sprinkler by Mobile Ramp	0.008	0.005	0.003	0.002	0	0.002	0.01	0.002	0.007*
Spray (use of simple sprinkler) Irrigation	0.003	0.007	-0.004	0.006	0.008	-0.003	0.015	0.002	0.013**
Irrigation Pivot	0	0.001	-0.001	0.001	0	0.001	0	0	0
Drip Irrigation or Micro-Irrigation	0.002	0	0.002	0	0	0	0	0	0
Other	0.069	0.052	0.017	0.082	0.021	0.061***	0.082	0.024	0.059***
Number of Observations (Plots)	**1,318**	**363**		**1,383**	**360**		**1,342**	**357**	

Source: 2012 IWRM Survey

Notes: These are proportions, unless otherwise indicated. For each variable, the means are presented along with differences between the treatment and comparison group.

Statistically significant at 10 percent (*), 5 percent (**) and 1 percent (***).

4.3 Baseline Differences in Production

Exhibit 29 presents the differences in the share of farmers producing and selling crops. Significant differences in the types of crops grown exist between farmers in the treatment areas and farmers in the comparison areas for both the Delta sample and the Podor sample. In the Delta sample, farmers in the treatment areas were more likely than comparison area farmers to grow rice in the dry and cold season, and less likely to grow rice during the rainy season. Furthermore, the treatment groups produce more crops in the horticulture category, which includes high value crops. It will be important to control for such crop differences in the impact evaluation because not doing so might underestimate the impact of the project. For the Podor sample, significant differences existed in the types of crops grown between treatment and comparison area farmers. Additionally, treatment area farmers were less likely to sell rice than comparison area farmers.

Exhibit 30 and Exhibit 31 present the differences in the amount of crops produced in kilograms per hectare and differences in crop income, respectively, between treatment and comparison areas. The findings in Exhibit 30 and Exhibit 31 mimic the findings from Exhibit 29.

Exhibit 29: Differences in Crops Produced and Sold

	Cold Season			Hot Season			Rainy Season		
	Treatment Group Mean	Control Group Mean	Difference in Mean	Treatment Group Mean	Control Group Mean	Difference in Mean	Treatment Group Mean	Control Group Mean	Difference in Mean
Delta									
Type of Crop Produced									
Rice	0.152	0.05	0.101***	0.45	0.491	-0.041*	0.113	0.229	-0.116***
Main Crops[21]	0.16	0.224	-0.064***	0.456	0.512	-0.056**	0.215	0.24	-0.025
Horticulture	0.138	0.162	-0.024	0.122	0.056	0.067***	0.028	0.008	0.021***
Fruit Arboriculture	0.004	0.009	-0.005	0.003	0.01	-0.007*	0.004	0.001	0.003
Type of Crop Sold									
Rice	0.911	0.826	0.085	0.951	0.91	0.042**	0.963	0.973	-0.009
Main Crops	0.912	0.951	-0.04	0.951	0.918	0.033*	0.81	0.971	-0.161***
Horticulture	0.912	0.96	-0.047*	0.966	0.973	-0.006	0.976	1	-0.024
Fruit Arboriculture	0.5	0.667	-0.167	1	0.846	0.154	1	1	0
Number of Observations (HHs)	**1, 484**	**1,374**		**1,462**	**1,307**		**1,445**	**1,288.00**	
Podor									
Type of Crop Produced									
Rice	0.072	0.521	-0.449***	0.171	0.514	-0.343***	0.308	0.176	0.131***
Main Crops	0.104	0.548	-0.444***	0.198	0.525	-0.327***	0.319	0.176	0.142***
Horticulture	0.44	0.678	-0.238***	0.06	0.122	-0.062***	0.018	0.008	0.009
Fruit Arboriculture	0.002	0.149	-0.147***	0.008	0.244	-0.236***	0.002	0.21	-0.208***
Type of Crop Sold									
Rice	0.505	0.735	-0.230***	0.487	0.859	-0.372***	0.849	0.889	-0.04
Main Crops	0.511	0.754	-0.243***	0.511	0.857	-0.346***	0.841	0.889	-0.048
Horticulture	0.979	0.984	-0.004	0.94	0.932	0.008	0.792	1	-0.208*
Fruit Arboriculture	1	1	0	0.909	1	-0.091	1	0.987	0.013
Number of Observations (HHs)	**1,318**	**363**		**1,383**	**360**		**1,342**	**357**	

[21] See footnote 17 for detailed definitions.

Source: 2012 IWRM Survey
Notes: These are proportions, unless otherwise indicated. For each variable, means are presented along with differences between the treatment and comparison group.
Statistically significant at 10 percent (*), 5 percent (**) and 1 percent (***).

Exhibit 30: Differences in Crop Production (kg/ha)

	Cold Season			Hot Season			Rainy Season		
Type of Crop	Treatment Group Mean	Control Group Mean	Difference in Mean	Treatment Group Mean	Control Group Mean	Difference in Mean	Treatment Group Mean	Control Group Mean	Difference in Mean
Delta									
Rice	2,326.09	461.56	1864.53**	6,807.09	7,977.09	-1,170.00	1,736.06	4,875.17	-3139.11***
Main Crops	2,362.92	2,888.86	-525.94	6,638.35	12,429.20	-5,790.86	7,398.16	2,634.84	4763.32
Horticulture	25,055.77	84,693.72	-59,637.95	15,900.76	13,321.38	2579.38	4,475.69	1,334.84	3140.85**
Fruit Arboriculture	985.05	1,896.67	-911.61	96.93	3,597.60	-3500.67	6,082.71	25.00	6,057.71
Num. of Obs. (HHs)	**1, 484**	**1,374**		**1,462**	**1,307**		**1,445**	**1,288**	
Podor									
Rice	5,987.19	7,335.77	-1348.58	1,759.17	3,673.30	-1914.14***	6,149.61	3,049.62	3099.99**
Main Crops	4,939.72	8,832.85	-3893.12	2,264.46	4,362.15	-2097.69***	5,295.96	1,799.25	3496.71***
Horticulture	22,988.80	68,486.61	-45497.81*	11,223.26	17,691.58	-6,468.32	452.63	65.34	387.30*
Fruit Arboriculture	11,804.76	12,164.58	-359.82	15,556.81	11,455.81	4,101.01	3,933.15	9,758.96	-5,825.80
Num. of Obs. (HHs)	**1,318**	**363**		**1,383**	**360**		**1,342**	**357**	

Source: 2012 IWRM Survey
Note: For each variable, the means are presented along with differences between the treatment and comparison group.
Statistically significant at 10 percent (*), 5 percent (**) and 1 percent (***).

Exhibit 31: Differences in Average Crop Sales (FCFA)

	Cold Season			Hot Season			Rainy Season		
Type of Crop	Treatment Group Mean	Control Group Mean	Difference in Mean	Treatment Group Mean	Control Group Mean	Difference in Mean	Treatment Group Mean	Control Group Mean	Difference in Mean
Delta									
Rice	780,400	366,200	414,200*	1,499,900	895,400	604,500***	820,100	1,043,400	-223,300
Main Crops	753,200	161,000	592,200***	1,488,300	910,700	577,600***	490,200	1,001,200	-511,000*
Horticulture	744,100	1,071,200	-327,100	1,060,100	753,200	306,900	683,100	547,200	135,900
Num. of Obs. (HHs)	**1, 484**	**1,374**		**1,462**	**1,307**		**1,445**	**1,288**	
Podor									
Rice	116,100	402,700	-286,600	58,800	134,200	-75,400***	194,800	160,800	34,000
Main Crops	100,200	378,500	-278,300*	58,900	134,700	-75,800***	189,200	165,200	24,000
Horticulture	608,400	852,700	-244,300*	333,000	485,000	-151,900	204,200	118,500	85,700
Num. of Obs. (HHs)	**1,318**	**363**		**1,383**	**360**		**1,342**	**357**	

Source: 2012 IWRM Survey

Notes: For each variable, the means are presented along with differences between the treatment and comparison group.

Statistically significant at 10 percent (*), 5 percent (**) and 1 percent (***).

4.4 Baseline Differences in Non-Farm Incomes

Exhibit 32 provides the mean differences in non-agricultural income by source. In the Delta sample, during the dry and cold season, households in treatment areas received less income from non-farm income than households in comparison areas. During the dry and hot season, households in treatment areas received more income from the rental of equipment and buildings than comparison households, but received less income from pensions. During the rainy season, households in treatment areas received more remittances than households in comparison areas. For the Podor sample, treatment households received more remittances than comparison households in all three waves. During the dry and hot season, households in treatment areas received less non-farm income and more aid than households in comparison areas. Treatment households also received more aid than comparison households during the rainy season.

Exhibit 32: Differences in Non-Agricultural Income (FCFA)

	Cold Season			Hot Season			Rainy Season		
Source of Income	Treatment Group Mean	Control Group Mean	Difference in Mean	Treatment Group Mean	Control Group Mean	Difference in Mean	Treatment Group Mean	Control Group Mean	Difference in Mean
Delta									
Non-farm	510,000	591,200	-81,200*	498,000	523,600	-25,500	519,200	572,300	-53,100
Remittance	47,700	41,100	6,600	88,200	74,700	13,400	99,400	78,000	21,400**
Rental	25,100	22,200	2,900	35,900	21,000	14,900*	22,400	24,400	-2,000
Pension	5,800	6,400	-500	6,800	10,900	-4,100**	8,800	11,700	-2,800
Aid	5,400	3,700	1,700	6,100	6,500	-400	6,400	7,600	-1,100
Podor									
Non-farm	286,600	282,300	4,400	271,600	381,400	-109,800***	291,700	336,400	-44,800
Remittance	64,900	16,600	48,300***	55,500	22,600	32,900***	54,500	28,400	26,100***
Rental	7,600	12,700	-5,100	4,600	10,500	-5,800	8,100	4,900	3,200
Pension	4,300	1,400	3,000*	5,100	3,100	2,000	4,700	6,000	-1,300
Aid	3,200	3,100	200	10,100	2,100	8,000***	11,800	800	11,000***

Source: 2012 IWRM Survey

Notes: For each variable, the means are presented, along with differences between the treatment and comparison group. Rental income includes income from the rental of buildings, equipment, receivables and the sale of capital. Aid includes income from family allowances, social assistance and aid from government or non-government sources.

Statistically significant at 10 percent (*), 5 percent (**) and 1 percent (***).

4.5 Baseline Differences in Land Security

Finally, we examine baseline differences in land security (Exhibit 33). For both the Delta and Podor samples there were differences between the treatment areas and comparison areas in farmers' titles to land and their concerns about losing their land. Although most of the differences are minor, they are significant. For both the Delta and Podor samples, farmers in the treatment areas were more likely to have no documents supporting their rights to the land they farm. Interestingly, however, farmers in the treatment areas were less likely to be concerned about losing their land.

4.6 Summary

This section provided descriptive statistics on household and farmer characteristics, farming practices, farm production, and perceptions of land security in treatment and comparison sites. Additionally, tests were conducted to assess whether significant differences existed between households in treatment areas and households in comparison areas. The matching process employed to select the sampled households and described earlier ensured a comparison group that was similar to the treatment group in many observable characteristics, namely household characteristics. However, the findings from this section showed that substantial differences exist is some key variables that are most likely due to differences that exist between the treatment sites and comparison sites.

For the Delta sample, significant differences existed in irrigation practices, the share of households growing rice and the amount of land owned. Farmers in the treatment areas were less likely to use stream water and more likely to use rainwater on their plots than farmers in comparison areas. Additionally, farmers in the treatment areas were more likely to use advanced systems that rely on pumps than farmers in comparison areas. Farmers in the treatment areas were more likely than comparison area farmers to grow rice in the dry and cold season, and less likely to grow rice during the rainy season. Farmers in treatment areas owned, leased and/or sharecropped more land than farmers in comparison areas.

For the Podor sample, there were significant differences between treatment and comparison households in the share of households growing rice, the amount of land cultivated, titles to land and land security. Farmers in the treatment areas owned and operated less land than farmers in comparison areas. Farmers in the treatment areas were less likely than comparison area farmers to grow rice in the dry seasons and more likely to grow rice during the rainy season.

The evaluation design proposed relies on the assumption that treatment and comparison households are similar. However, results from this section indicate that there exist substantial differences in many observable characteristics. The benefits of having baseline data allow us to control for these baseline differences when conducting the impact evaluation.[22]

[22] Refer to the Evaluation Design Report (IMPAQ, 2014)

Exhibit 33: Differences in Land Security

	Cold Season			Hot Season			Rainy Season		
	Treatment Group Mean	Control Group Mean	Difference in Mean	Treatment Group Mean	Control Group Mean	Difference in Mean	Treatment Group Mean	Control Group Mean	Difference in Mean
Delta									
Title or Guarantee to Plot									
Title	0.033	0.019	0.013***	0.003	0.009	-0.006**	0.004	0.005	-0.001
Lease	0.008	0.001	0.007***	0.006	0	0.005***	0.005	0	0.005***
Occupancy Permit	0.086	0.033	0.053***	0.133	0.018	0.116***	0.108	0.015	0.093***
Paper Allocation to the OP	0.215	0.253	-0.038***	0.118	0.325	-0.208***	0.155	0.291	-0.136***
Other Document	0.032	0.017	0.015***	0.004	0.007	-0.003	0.002	0.003	-0.001
No Document	0.626	0.676	-0.051***	0.737	0.641	0.096***	0.726	0.686	0.040***
Concern About Losing Land									
No	0.507	0.457	0.050***	0.548	0.455	0.093***	0.489	0.473	0.016
Yes, a little	0.1	0.081	0.019**	0.109	0.106	0.004	0.126	0.128	-0.002
Yes, medium	0.051	0.047	0.003	0.021	0.08	-0.059***	0.026	0.083	-0.057***
Yes, quite	0.343	0.415	-0.072***	0.322	0.359	-0.037**	0.359	0.317	0.042***
Num. of Obs. (Plots)	**1, 484**	**1,374**		**1,462**	**1,307**		**1,445**	**1,288.00**	

Exhibit 34: Differences in Land Security (cont'd.)

	Cold Season			Hot Season			Rainy Season		
	Treatment Group Mean	Control Group Mean	Difference in Mean	Treatment Group Mean	Control Group Mean	Difference in Mean	Treatment Group Mean	Control Group Mean	Difference in Mean
Podor									
Title or Guarantee to Plot									
Title	0.079	0.187	-0.108***	0.022	0.004	0.018***	0.016	0	0.016***
Lease	0.001	0.003	-0.002	0.002	0.004	-0.001	0.002	0	0.002*
Occupancy Permit	0.094	0.049	0.045***	0.125	0.312	-0.188***	0.109	0.343	-0.234***
Paper Allocation to the OP	0.288	0.395	-0.107***	0.399	0.528	-0.129***	0.437	0.432	0.005
Other Document	0.048	0.02	0.028***	0.038	0	0.038***	0.031	0.001	0.030***
No Document	0.49	0.346	0.144***	0.414	0.153	0.262***	0.405	0.224	0.181***
Concern About Losing Land									
No	0.688	0.546	0.142***	0.688	0.625	0.063**	0.716	0.624	0.092***
Yes, a little	0.087	0.283	-0.196***	0.099	0.178	-0.079***	0.106	0.055	0.051***
Yes, medium	0.033	0.037	-0.004	0.047	0.036	0.011	0.03	0.03	0.001
Yes, quite	0.192	0.135	0.058***	0.166	0.162	0.004	0.148	0.291	-0.143***
Num. of Obs. (Plots)	**1,318**	**363**		**1,383**	**360**		**1,342**	**357**	

Source: 2012 IWRM Survey

Notes: These are proportions, unless otherwise indicated. For each variable, the means are presented along with differences between the treatment and comparison group.

Statistically significant at 10 percent (*), 5 percent (**) and 1 percent (***).

5. CONCLUSION

This report provided an overview of the characteristics and farming practices of households and farms at baseline for the Delta and Podor samples. The baseline assessment indicated that heads of household are older married males with little to no formal education. Households had on average nine household members with approximately 3 children under the age of 15. For the Delta sample, households owned on average 3 ha of land and operated between 1 and 2 ha during any given season. For the Podor sample, households owned on average 1 ha of land and operated 0.5 ha during any given season.

Irrigation practices varied by season in both areas, but on average, over 90 percent of plots relied on streams as their main source of water and over 75 percent of plots used advanced gravity-fed irrigation systems. However, a substantial number of farmers reported not being satisfied with the effectiveness of their main source of water for irrigation.

For the Delta sample, almost 70 percent of surveyed farmers had no document showing rights to their respective plots. For the Podor sample, only 40 percent reported having no documentation showing rights to their plots of land. Although few farmers reported being able to sell their land most farmers reported having rights to rent or hire a tenant to farm their land.

Although household and farmer characteristics were similar between treatment and comparison sites, there were substantial differences in some key variables. For the Delta sample, significant differences existed in irrigation practices, the share of households growing rice and the amount of land owned. Similarly, for the Podor sample, there were significant differences between treatment and comparison households in the share of households growing rice, the amount of land cultivated, titles to land and land security. Therefore, the baseline will be important for controlling for pre-existing differences between treatment and comparison households.

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