E. Adjustments to the design for the final evaluation

After completing the interim evaluation report, which assessed the effects of the IWRM project on water use, agricultural production, household income, land security, and land conflicts three years after the close of the Senegal Compact, MCC and Mathematica reassessed the proposed approach for the final evaluation based on the interim findings. The interim evaluation identified that the project met or exceeded all output targets for building and refurbishing irrigation infrastructure, and also significantly expanded rice production in the main growing season. However, the project did not achieve key outcomes as intended in the project logic, such as increasing cropping intensity to 150 percent and increasing the cultivation of tomatoes and onions in the rainy and cold seasons. The evaluation also identified risks to the sustainability of project outcomes. While the project increased land formalization in the targeted communes, limited resources post-Compact constrained local institutions from being able to effectively record and process land title applications. It was also unclear the extent to which Senegalese government agencies would be able to maintain the project's primary and secondary irrigation infrastructure.

As a result, MCC and Mathematica agreed to reorient the final evaluation to explore why intended outcomes were not achieved during the interim evaluation and whether the initial outcomes were sustained. The final evaluation will also mainly focus on the Delta Activity area, which was a much larger investment for the IWRM Project relative to the Podor Activity area. The final evaluation will address the following research questions:

1. Has the primary irrigation infrastructure in the Delta Activity area and Podor Activity area been maintained? Why or why not?
2. Have farmers increased their cropping intensity as expected by the project logic in the Delta Activity area? Why or why not?
3. Are farmers growing tomatoes and onions as expected by the project logic in the Delta Activity area? Why or why not?
4. Which stakeholders were more likely to demand a land title and change land use behaviors?
5. Is there continued demand for land titles in the Delta Activity area and are they being processed? Why or why not?

To answer these research questions, Mathematica will carry out a mixed-methods evaluation that combines qualitative data collection and analysis, and an analysis of quantitative administrative data, with the aim of supplementing the impact and performance evaluation findings from the interim report. Specifically, we will conduct key informant interviews with stakeholders such as leaders of farmer cooperatives, land managers, WUAs, and SAED, the state entity that overseas irrigation and agricultural production in the Senegal River Valley; an engineering assessment of the irrigation infrastructure; and an analysis of farming and crop production data collected by Senegalese authorities. In addition, we will use the baseline and interim survey data to investigate which types of stakeholders demanded land titles and to calculate the ex-post economic rate of return (ERR) of the project.

The rest of this appendix describes our evaluation design, data sources and sampling strategy, analytical approach, evaluation timeline, and risks and mitigation strategies. We also provide more details on our ERR analysis.

A. Evaluation design

Table E.1 lists the analytical methods and data sources we will use to answer each research question.

Table E.1. Overview of evaluation design for final report

Research question	Analytical methods	Data sources
1. Has the primary irrigation infrastructure in the Delta Activity area and Podor Activity area been maintained? Why or why not?	In-depth qualitative analysis and engineering assessment	KIIs with cooperative leaders, WUAs, SAED extension agents, and other stakeholders in Delta and Podor; engineer's assessment of irrigation infrastructure; document review of maintenance plans
2. Have farmers increased their cropping intensity as expected by the project logic in the Delta Activity area? Why or why not?	Descriptive analysis of agriculture production data and in-depth qualitative analysis	KIIs with cooperative leaders, WUAs, and SAED extension agents; group interviews with farmers; SAED administrative data
3. Are farmers growing tomatoes and onions as expected by the project logic in the Delta Activity area? Why or why not?	Descriptive analysis of agriculture production data and in-depth qualitative analysis	KIIs with cooperative leaders, WUAs, and SAED extension agents; group interviews with farmers; SAED administrative data
4. Which stakeholders were more likely to demand a land title and change land use behaviors?	Descriptive analysis of quantitative data	Household survey data collected for the interim evaluation
5. Is there continued demand for land titles in the Delta Activity area and are they being processed? Why or why not?	In-depth qualitative analysis	KIIs with land managers and cooperative leaders; group interviews with farmers; review of land application records in Delta Activity area communes.

To answer these research questions, we intend to employ three main analytical methods:

In-depth qualitative analysis. Our primary analytical method will be in-depth qualitative analysis of data collected through key informant interviews and group interviews. Qualitative research allows us to probe on why or why not an outcome occurred, allowing us to understand what has changed since we last collected data for the interim evaluation report and provide insights into the interim results. We will interview a similar group of stakeholders to answer research questions 1, 2, and 3. Specifically, we will interview leaders of farmer cooperatives, heads of WUAs, and SAED agriculture extension agents to understand how the irrigation infrastructure is being maintained or why it is degrading, and to investigate why farmers are or are not using their plots in multiple seasons and cultivating onions and tomatoes. We will also conduct group interviews of farmers to provide further insights into agriculture production decisions. We will triangulate findings between different types of stakeholders and identify

common themes that emerge in the data. We will also ensure our sample includes both male and female stakeholders as well as stakeholders across three communes in the Delta to examine if farmer behavior was different depending on the gender of the farmers or location. For instance, women may be choosing to plant different crops or in different seasons than in men, or may have access to different types of plots that are more conducive to market vegetable crops. Our qualitative approach will unpack these nuances.

To investigate the level of demand for land titles (research question 5), we will visit commune land offices in Gandon, Ronkh, and Diama to interview the land managers in each office and to view land application records, if accessible. The interviews will provide information on land managers' perceptions of demand for titles and on what factors are driving or inhibiting demand for land titles. We will also ask to examine the land records in their offices, to the extent possible, to understand demand and processing of applications. At interim, the quality in land records varied greatly by commune. Gandon was the only commune with a functioning electronic land database; other communes where we conducted interviews used a paper system. We will capture photos of the paper summary records, if accessible. We hope that the records data can help us assess the level of demand for land titles, the number of land titles processed or approved by the land office, and trends over time. We will triangulate this information with interview data from leaders of cooperatives, members of the "domains communales," and WUAs to understand how and why title demand has changed, or why not.

Descriptive quantitative analysis. To address research questions 2 and 3 on the cultivation of tomatoes and onions and cropping intensity, we will use administrative data from SAED to examine trends on crop cultivation and farming plots in multiple seasons. SAED reports aggregated agriculture production data for the Delta Activity area by agriculture season, such as the amount of land under production and the amount of rice cultivated in each growing season. We will compare these trends to the targeted outcomes in the project logic to assess whether farmer behavior has changed in the Delta Activity area since the interim report. We will complement this analysis with the in-depth qualitative analysis to understand why or why not farmers are cultivating market vegetable crops and farming in the cold and rainy seasons (described above).

To answer which households and farmers were more likely to obtain land titles and change their land use behavior in the Delta Activity area (research question 4), we will analyze the baseline and interim household survey data. We will analyze the data two ways to answer this question. First, we will conduct a repeated cross-section analysis at the plot level.[1] We will examine the percent of plots that were reported to have a formal land title at baseline and interim, overall and by key characteristics, including gender of the plot manager, economic status of the household according to the Progress out of Poverty Index (PPI), size of parcel and household land holdings, types of crops being grown on the plots, and commune where the household is located. This will provide descriptive information as to whether certain groups of individuals increased their share of titled plots between baseline and interim and the agricultural characteristics of titled plots. For

[1] The baseline data provided to Mathematica does not have unique plot identifiers so it was not possible to track plots across survey rounds.

instance, we will be able to report on the share of female plot managers that had titled plots at baseline and at interim.

Second, we will conduct a household-level descriptive analysis to investigate the characteristics of households that increased their number of land titles between baseline and interim *and* changed their land use behaviors, including an increase in the amount of land under production or an increase in agricultural investment costs. We will provide descriptive statistics on the households including household size, age and gender of household head, land holdings, poverty likelihood, commune, and whether the household head received some formal education. This analysis will provide insights into the types of households that both increased their number of land titles and either increased their land under production or agricultural investments. To examine how common this type of behavior change is, we will also calculate the percent of households from the survey sample that changed or did not changed from baseline among each combination of the three main factors: number of land titles, amount of land under production, and amount of agriculture investment. For instance, we will report on the share of households that increased their land titles but did not increase their land under production (and vice versa), increased their land titles but did not increase their agriculture investment (and vice versa), increased all three factors, and did not increase on any factor.

Engineering assessment. To answer research question 1 on maintenance of the irrigation infrastructure, we will conduct, along with an engineering consultant, a detailed assessment of the primary irrigation infrastructure in both Delta and Podor, including physically inspecting the canals, sluice gates, and drainage systems. We will document the infrastructure's usage, quality, and maintenance, and what needs to occur to correct any observed infrastructure defects. As part of this assessment and the in-depth qualitative analysis described above, we will meet with staff at SAED, leaders of WUAs and agriculture extension agents to understand their experiences using the infrastructure. We will also review available infrastructure maintenance plans and identify if the plans are sufficient to maintain the equipment and if proposed maintenance has been carried out.

Table E.2 summarizes the data sources we will be using for the final evaluation.

Table E.2. Final evaluation data sources

Data source	Data collection method	Number	Sample
Farmer cooperative leaders	KII	9	Male and female leaders of farmer cooperatives in Diama, Ronkh, and Gandon (3 per commune)
Farmers	Group interviews (5-10 individuals per interview)	3	Farmers who cultivate land connected to the project infrastructure and who are involved in decision making around what and when to plant crops. Farmers will be selected based on a convenience sample through interactions at commune headquarters in the Delta Activity Area (Diama, Ronkh and Gandon).
Heads of WUAs	KII	6-9	Male and female heads of WUAs in each of the 3 targeted communes (2-3 per commune)

Data source	Data collection method	Number	Sample
SAED staff	KII	2-4	Key SAED staff at St. Louis headquarters who collect data on agriculture production, irrigation infrastructure and land titling
Land managers	KII	3	Land managers in three communes in the Delta Activity area: Diama, Ronkh, and Gandon
Infrastructure site visits	Engineer's assessment	2	Primary irrigation infrastructure in Delta and the Ngalenka perimeter in Podor
Land application records	In-person review	3	In-office review of land records in Diama, Ronkh, and Gandon
Infrastructure maintenance plans	Document review	2	Review of maintenance plans for irrigation infrastructure in Delta and Podor
SAED administrative data	Data transfer	1	Data on land under production and main crops cultivated by agriculture season; annual measure of cropping intensity
Other donors	KII	2-3	Lead program officers supporting programs in the Senegal River Valley who can provide information on trends in agriculture production and land tenure security, including how MCC investments have been sustained. Such donors may include Feed the Future/USAID, Agence Française de Développement (AFD), Japan International Cooperation Agency (JICA), and the International Food Policy Research Institute (IFPRI)

B. Data collection plan

Our primary qualitative data collection will involve a two-week mission to the Delta and Podor Activity areas by a four-member data collection team. Project Director Sarah Hughes will lead the data collection team and be supported by Dakar-based Research Coordinator Ahmadou Kandji. For part of the trip, the team will be joined by an expert engineering consultant to examine the irrigation infrastructure. The team will also include a research assistant with background in agriculture and ability to interpret Pulaar and Wolof to French. The research assistant will take notes and record interviews and provide interpretation, as needed. Both Dr. Hughes and Mr. Kandji were extensively involved with data collection for the interim report and bring a deep understanding of the IWRM Project, the evaluation, and agriculture and land tenure in the Senegal River Valley.

The team intends to visit three communes in the Delta—Diama, Ronkh, and Gandon—to interview key stakeholders and farmers, conduct observations of the irrigation infrastructure, and site visits to land offices to interview staff and review land records. The team will also visit the Podor area to conduct observations of the irrigation infrastructure and interview key stakeholders.

The team will work closely with MCC to collect agriculture production data for the Delta and Podor departments from SAED or other Senegalese agencies.

C. Economic Rate of Return analysis

MCC's investment in the IWRM Project was expected to benefit farmers by improving their access to irrigation and securing their land rights in order to increase investment, reduce land conflicts, improve crop production, and increase farmer incomes. To assess the potential benefits of the project against its costs, MCC calculated the project's ERR prior to compact implementation. Conceptually, the ERR is the discount rate at which the benefits of an intervention are exactly equal to its costs. MCC's ex-ante ERR analysis relied on assumptions to estimate both the economic benefits that would accrue to project beneficiaries over the next 20 years and what would have happened in absence of the project (the counterfactual).

We will recalculate the project's ERR separately for the Delta and Podor Activity areas. For the IWRM Project, financial benefits to farmers are the change in household income, inclusive of agriculture income and income from off-farm sources. Monetary costs include changes in costs to farmers, including the amount spent on agriculture inputs such as fertilizer, equipment, and labor, as well as the cost of the IWRM Project. We will use our interim survey estimates on net income to capture the combined financial benefits and costs at the farmer-level. Some of the inputs used and outputs from households' agricultural production may be subject to economy-wide distortions (e.g. fertilizer subsidies, tariffs on agricultural production). To adequately calculate the ERR, we must, therefore convert financial costs (benefits) to economic costs (benefits). As part of the qualitative data collection, we will assess the importance of these economy-wide distortions and, if possible, gather data from SAED staff that would allow us to construct[2] conversion factors for key inputs and outputs that will be used to convert financial costs and benefits to net economic benefits. We will also include project costs as reported by MCC as additional monetary costs. We will then calculate the ex-post ERR, which amounts to determining the discount rate at which net income equals project costs. Table E.3 summarizes the parameters we will estimate and data we will use for the ERR analyses for Delta and Podor.

Table E.3. Parameters and data sources for the ERR analysis

Model parameter	Model stream	Data source	Counterfactual
Delta Activity area			
Net household income	Farmer-level financial benefits and costs from agricultural production Farmer-level off farm income	• Impact estimate from interim evaluation survey data	• Part of impact estimate from matched-comparison group analysis
Activity costs	Economic costs	• MCC data on activity costs	• $0 (no costs without the activity)

[2] We will also explore whether existing estimates of conversion factors can be used to adjust our financial data. For example, Miklyaev and co-authors estimate conversion factors for rice seed (input) of 1.06, for DAP and Urea (inputs) of 2.03 and rice output of 0.95. (Cost Benefit Analysis of Senegal's Rice Value Chains, 2017) https://cri-world.com/publications/qed_dp_301.pdf)

Model parameter	Model stream	Data source	Counterfactual
Number of household beneficiaries	Project beneficiaries	• MCC compact close-out report; engineer's report on number of households that have access to irrigation infrastructure	• Not applicable
Podor Activity area			
Net household income	Farmer-level financial benefits and costs from agricultural production Farmer-level off farm income	• Pre-post estimate from interim evaluation survey data	• Will estimate counterfactual based on survey data in non-intervention areas of Podor and secondary data sources
Activity costs	Economic costs	• MCC data on activity costs	• $0 (no costs without the activity)
Number of household beneficiaries	Project beneficiaries	• MCC compact close-out report; land allocation database; engineer's report on number of households that have access to irrigation infrastructure	• Not applicable

Our key parameter for the ERR analysis is net household income among farmer beneficiaries, which, if conversion factors are available, will be broken into component parts and converted from financial benefits to economic benefits. For the Delta Activity area, we will use the income impact estimates from the matched-comparison group analysis.[3] For the Podor Activity area, we were unable to estimate a counterfactual and so do not have causal survey estimates to calculate the ERR. Since we only have survey results from two points in time, we also do not have a trend line to estimate a counterfactual. We will use interim survey data from non-intervention areas of Podor as well as other possible data sources to identify a trend line that will inform our assumptions of the counterfactual. Other data sources may include aggregated agriculture production data from SAED, including perimeter-level data from the Nianga perimeter in Podor. We will complement the ERR analysis with a discussion of potential economy-wide distortions and, if they have not been accounted for explicitly through our cost estimates, provide additional qualitative analysis on how the ERRs might change if these distortions were accounted for.

Another key model parameter is the number of beneficiary households in the Delta and Podor Activity areas. While we have survey data on average net income, we will need to estimate the number of beneficiary households in order to calculate total net income for the ERRs. In the Delta Activity area, we will use reported beneficiaries from MCC compact close-out documents. We will leverage other data collected for the interim evaluation, including qualitative surveys, to support our estimate of project beneficiaries. We will conduct a similar process for the Podor

[3] The interim evaluation found no significant change in net household income in the Delta Activity area. We therefore have no evidence that the project resulted in a net positive economic benefit to the targeted beneficiaries. While this impact estimate is from a snapshot in time, it provides our best evidence of the causal relationship between the IWRM project and its economic benefits. Thus, without being able to collect further primary data, the ERR for the Delta Activity area will be negative when factoring in program costs.

Activity area but also use the number of households from the land allocation database that received access to newly irrigated land to inform our assumptions.

Since we are relying on a snapshot in time to calculate net household income at the farmer-level, it will be important to explore different assumptions regarding how the trend in net income changes over time. As part of sensitivity analyses, we will provide a range of possible ERRs for the Delta and Podor Activity areas based on confidence intervals for model parameters like net household income and the number of beneficiaries. We will then assess why the ex-post ERR is different from the ex-ante ERR by identifying the key assumptions in the ex-ante ERR that failed to materialize based on our interim survey data and agriculture production data provided by SAED.

D. Evaluation risk and mitigation plan

Any evaluation approach involves risks and challenges to it successful completion. In Table E.4, we identify the most pressing evaluation risks as well as our plans to mitigate those risks to ensure the evaluation is completed on-time, within budget, and provides important learning for MCC.

Table E.4. Evaluation risks and mitigation strategies

Evaluation risks	Mitigation strategies
SAED does not provide crop production data or information on subsidies and other economic distortions to MCC	Mathematica will work closely with MCC and its contacts in Senegal to try to access SAED-collected crop production data and information on input and out subsidies, price supports, protective tariffs, etc. If SAED is unable to share such data, Mathematica will also examine alternative administrative data sources collected by other donors or Senegalese government agencies. If unable to acquire administrative data, Mathematica will focus on a qualitative analysis to understand why changes in production decisions did or did not occur.
Land officers are not willing to share land tenure application data with Mathematica	Mathematica will work closely with its contacts at the commune-level land offices to see if evaluation team members and review their land application logs during data collection. If land officers are unable to do so, our evaluation of the demand for land titles will use solely qualitative data collected among other stakeholders, such as mayors, cooperative leaders or members of the “domains communales”.

E. Administration

In this section, we describe our workplan for the final evaluation, including the specific tasks and deliverables we will complete. We also detail our staffing plan for data collection and analysis.

1. Final evaluation workplan

Figure E.1 displays our workplan to complete the final evaluation in 2020. Finalizing the redesign memo by January includes updating the Nesstar file for the evaluation design report, completing 508 compliance for the report, and translating this appendix into French. Finalizing the qualitative interview instruments by February includes addressing feedback from MCC and Senegalese stakeholders on the draft instruments. Final questionnaires will also need to be

translated into French. The data collection task, to be completed by April, includes an approved trip scope of work prior to travel and data collection trip report after travel. Data delivery will be for the survey data collected for the interim evaluation report. We will submit a draft of the final evaluation report by June. The final version of the report will also address MCC and stakeholder feedback and be translated into French and include a 508 compliant document. Mathematica will prepare a PowerPoint slide deck for its final presentations at MCC and in Senegal in October.

Figure E.1. Final evaluation workplan for 2020

Task	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov
Approved redesign memo	X										
Draft qualitative interview instruments	X										
Finalize qualitative interview instruments	X	X									
IRB approval		X									
Data collection			X	X							
Data analysis				X	X						
ERR analysis				X	X						
Draft final evaluation report					X	X					
Finalize evaluation report								X	X		
Data delivery									X	X	
Evaluation brief									X		
MCC presentation										X	
In-country presentation										X	
End of evaluation contract											X

2. Evaluation team: roles and responsibilities

Our evaluation team brings extensive experience conducting agriculture evaluation in Senegal. **Dr. Sarah Hughes** leads the team as project director, overseeing design and implementation of all evaluation activities. She will travel to Senegal to conduct qualitative data collection. **Dr. Anthony Harris,** an agricultural and land-focused economist at Mathematica and **Dr. Esteban Quiñones**, a researcher at Mathematica, will conduct the quantitative data analysis and the economic rate of return analysis. **Mr. Ahmadou Kandji**, a Dakar-based research coordinator and consultant, will work closely with Mathematica and local stakeholders to facilitate logistics for data collection and work with Dr. Hughes to conduct qualitative data collection. In addition to Dr. Hughes and Mr. Kandji, the data collection team will include an experienced engineer to assess the irrigation infrastructure and a research assistant with Pulaar-language skills to transcribe interview notes and provide interpretation where needed. **Ms. Sarah Leser** manages the project internally for Mathematica and supports research tasks and invoicing. **Dr. Evan Borkum** provides quality assurance review of all deliverables.