# Niger Irrigation and Market Access Project: Evaluation Design Report for Small-Scale Irrigation Activities and Complementary Investments in the Dosso-Gaya Area

**September 14, 2021**

Anthony D'Agostino, Christopher Ksoll, and Margo Berends

**Submitted to:**

Millennium Challenge Corporation
1099 Fourteenth Street, NW, Suite 700
Washington, DC 20005
Attention: Hamissou Samari, Project Officer
Contract Number: 95332418F0225

**Submitted by:**

Mathematica
1100 First Street, NE, 12th Floor
Washington, DC 20002-4221
Phone: (202) 484-9220
Fax: (202) 863-1763
Project Director: Christopher Ksoll
Reference Number: 50542.01.110.031.000

**This page has been left blank for double-sided copying.**

# ACKNOWLEDGEMENTS

This report was made possible through the contributions of many individuals.

We would like to thank the many individuals from MCC, MCA-N, and various members of government agencies in Niger who participated in the workshop to discuss the draft version of this report. Their thoughtful comments and feedback, which helped shape this final version, and our responses can be found in Appendixes F and G. Special thanks to Hamissou Samari and Sarah Lane (MCC), and Julien Tougouri (MCA-N) for their guidance and support throughout the design of this evaluation.

We also greatly appreciate the efforts of Mathematica staff who made helpful contributions to this report: Evan Borkum, Colleen Fitts, Cindy George, Matt Sloan, Samuel Studnitzer, and Poorva Upadhyaya. Finally, we are also grateful to our consultants Amadou Moussa Saidou, for his on the ground support in Niger, and to Moussa Diouf, who translated the French version of this report.

**This page has been left blank for double-sided copying.**

# Contents

ACKNOWLEDGEMENTS ..... iii

LIST OF ACRONYMS ..... vii

I. INTRODUCTION ..... 1

II. OVERVIEW OF THE COMPACT AND THE INTERVENTIONS TO EVALUATE ..... 3

A. Overview of IMAP investments ..... 3

B. Theory of change ..... 6

C. Economic rate of return and beneficiary analysis on the Dosso-Gaya project area ..... 9

III. LITERATURE REVIEW ..... 11

A. Effects of irrigation access ..... 11

B. Effects of land tenure strengthening and facilitating an active rental market ..... 13

1. Land tenure strengthening ..... 13

2. Facilitating an active rental market ..... 15

C. Effects of road improvements on farmers ..... 16

IV. OVERVIEW OF EVALUATION DESIGN ..... 19

V. IMPACT EVALUATION TO MEASURE *BASSE TERRASSE* OUTCOMES ..... 28

A. Evaluation overview ..... 28

B. Methods and data sources ..... 29

C. Evaluation risks, limitations and mitigation steps ..... 33

VI. PERFORMANCE EVALUATION ..... 36

A. Overarching: Implementation and sustainability analyses ..... 36

1. Evaluation overview ..... 36

2. Methods and data sources ..... 38

3. Analysis approach ..... 39

B. Irrigation Perimeter Development Activity ..... 40

1. Evaluation overview ..... 40

2. Methods and data sources ..... 42

3. Analysis approach ..... 43

C. Sustainable Irrigation Systems Management Sub-activity ..... 43

1. Evaluation overview ....43
2. Methods and data sources ....44

D. Land Tenure Security Sub-activity ....44

1. Evaluation overview ....44
2. Methods and data sources ....46

E. Agricultural Support Services Sub-activity ....47

1. Evaluation overview ....47
2. Methods and data sources ....49

F. Roads for Market Access outcomes for SSI beneficiaries ....50

1. Evaluation overview ....50
2. Methods and data sources ....51
3. Analytical approach ....52

VII. DATA COLLECTION ....53

A. Local data collection partners ....53

B. Data collection and reporting timeline ....53

C. COVID-19 mitigation protocols ....61

VIII. ADMINISTRATIVE ISSUES ....62

A. Summary of institutional review board requirements and clearances ....62

B. Data protection ....62

C. Preparing data files for access, privacy, and documentation ....62

D. Dissemination plan ....63

E. Evaluation team roles and responsibilities ....63

REFERENCES ....66

APPENDIX A. Evaluation questions and links to logic model ....A.1

APPENDIX B. Konni and Dosso-Gaya research questions ....B.1

APPENDIX C. Technical description of first stage matching process for the impact evaluation ....C.1

APPENDIX D. Input values for minimum detectible impact estimates ....D.1

APPENDIX E. List of key informant interviews and focus group discussions ....E.1

APPENDIX F. MCC comments on draft report ....F.1

APPENDIX G. Local stakeholder comments ....G.1

## Tables

II.1. IMAP targets by activity and geographic area ..... 9

IV.1. Evaluation design overview ..... 21

V.1. Evaluation methods, research questions, data sources, and key outcomes for the impact evaluation of *Basse Terrasse* SSI infrastructure ..... 28

V.2. Minimum detectable impacts for the impact analysis of SSI investments ..... 32

V.3. Decision points for switching from MCG to pre-post design ..... 35

VI.1. Evaluation methods, research questions, data sources, and key outcomes for overarching performance evaluation analyses ..... 37

VI.2. Evaluation methods, research questions, data sources, and key outcomes for the performance evaluation of the Irrigation Perimeter Development Activity ..... 41

VI.3. Evaluation methods, research questions, data sources, and key outcomes for evaluation of the SISM Sub-activity ..... 43

VI.4. Evaluation methods, research questions, data sources, and key outcomes for evaluation of the Land Tenure Security Sub-activity ..... 45

VI.5. Evaluation methods, research questions, data sources, and key outcomes for evaluation of the Agricultural Support Services Sub-activity ..... 48

VI.6. Evaluation methods, research questions, data sources, and key outcomes for evaluation of the Roads for Market Access Sub-activity ..... 50

VII.1. Timetable for planned implementation and data collection activities ..... 54

VII.2. Summary of quantitative data collection ..... 56

VII.3. Summary of qualitative data collection ..... 59

A.1. Evaluation questions and links to program logic ..... A.3

A.2. Evaluation methods, research questions, data sources, and key outcomes for implementation analysis of the Policy Reform Activity ..... A.8

B.1. Research questions for Konni and Dosso-Gaya ..... B.3

C.1. Variables used in matched comparison group selection and assessment processes ..... C.4

C.1. Covariate balance results for key variables of interest ..... C.7

D.1. Parameter values used in statistical power calculations ..... D.3

E.1. Qualitative data collection, by activity and source ..... E.3

F.1. EMC Comments ..... F.3

G.1. Local Stakeholder Comments ..... G.3

## Figures

II.1. Map of IMAP implementation areas in Niger ..... 3
II.2. *Basse Terrasse* project implementation area ..... 4
II.3. IMAP Logic Model ..... 7
IV.1. Thematic summary of research questions by evaluation methodology ..... 20
V.1. Overview of matched comparison group selection process ..... 31
C.1. Map of treatment and potential comparison areas ..... C.6

## LIST OF ACRONYMS

| | |
|---|---|
| BT | *Basse Terrasse* |
| CAIMA | *Centrale d'Approvisionnement en Intrants et Matériels Agricoles* (Supply Center for Agricultural Inputs and Materials) |
| CAP | Computer-assisted personal interviewing |
| CHIRPS | Climate Hazards Group infrared precipitation with station |
| COFOCOM | *Commissions Foncières Communales* (Communal Land Commissions) |
| CRC | Climate-Resilient Communities |
| DAC/SOR | *Direction des Actions de Coopération et de Soutien aux Organisations Rurales* (Directorate of Cooperative Actions and Support to Rural Organizations) |
| ERR | Economic rate of return |
| FFS | Farmer field school |
| FGD | Focus group discussion |
| GDP | Gross domestic product |
| GoN | Government of Niger |
| IMAP | Irrigation and Market Access Project |
| IPD | Irrigation Perimeter Development Activity |
| IRB | Institutional review board |
| IRI | International roughness index |
| IRR | Internal rate of return |
| IWUA | Irrigation water user association |
| KII | Key informant interview |
| LTS | Land Tenure Security Sub-activity |
| M&E | Monitoring and evaluation |
| MCA-N | Millennium Challenge Account-Niger |
| MCC | Millennium Challenge Corporation |
| MCG | Matched comparison group |
| MDI | Minimum detectable impacts |
| MOJEDEC | *Mouvement des Jeunes pour le Développement et l'Éducation Citoyenne* (Youth Movement for the Citizenship Development and Education) |
| MSMF | Management Services and Market Facilitation Activity |
| NASA | National Aeronautics and Space Administration |
| NASADEM | NASA digital elevation model |

| | |
|---|---|
| NDVI | Normalized difference vegetation index |
| NPK | Nitrogen, phosphate, and potassium |
| O&M | Operations and Maintenance |
| ONAHA | *l'Office Nationale des Aménagements Hydro-agricoles* (National Office for Irrigation Schemes) |
| PAP | Project-affected person |
| PR | Policy Reform Activity |
| RMA | Roads for Market Access Activity |
| RN35 | Route Nationale 35 |
| RN7 | Route Nationale 7 |
| RSS | Sambera Rural Road |
| SDI | *Société de Developpement International* |
| SISM | Sustainable Irrigation System Management Sub-activity |
| SONED | *Société International d'Ingénierie et d'Etudes de Développement en Afrique* |
| SSA | Agricultural Support Services Sub-activity |
| SSI | Small-scale irrigation |
| TOA | Top of atmosphere |
| TBD | To be determined |
| T&V | Training and visit |
| UNOPS | United Nations Office for Project Services |
| WaPOR | Water productivity through open-access of remotely sensed derived data |

# I. INTRODUCTION

The agricultural sector in Niger is the source of the livelihoods of more than 80 percent of the population and contributes approximately one-fourth of the country's gross domestic product (CIA 2018). However, agricultural productivity in Niger is among the lowest in West Africa (FAO 2021a). The majority of Niger's agricultural production is rainfed; in 2011, irrigated farmland accounted for less than 1 percent of the total agricultural land in the country (FAO 2016). Without access to irrigation, crop production is vulnerable to droughts, which are frequent in Niger and can cause severe crop losses. Inadequate irrigation infrastructure also constrains production growth in the dry season (World Bank 2013). Productivity gains are further hampered by farmers' lack of market access to improved seeds, low adoption of new technologies, and inadequate extension services (World Bank 2017). There is also a substantial gender gap in yields; agricultural land managed by Nigerien women produces 19 percent less per hectare than land managed by men (Backiny-Yetna and McGee 2015). Low agricultural productivity has broader implications for human development in Niger. More than 1.5 million people in Niger experienced food insecurity in 2017, and nearly 20 percent of the Nigerien population is food insecure and unable to meet their food needs (WFP 2017). In 2019, Niger was ranked last globally on the United Nations Human Development Index (UN 2019).

To improve Niger's agricultural productivity and increase the incomes of rural farmers, the Millennium Challenge Corporation (MCC) is partnering with the Government of Niger through the $426 million Niger Sustainable Water and Agriculture Compact.[1] The compact, which is being implemented between 2018 and 2023, includes two projects. One is the Irrigation and Market Access Project (IMAP), which aims to increase rural incomes through improved agricultural productivity and increased agricultural sales resulting from modernized irrigated agriculture with sufficient trade and market access. IMAP's activities include constructing small-scale irrigation (SSI) infrastructure in the part of the Dosso-Gaya area known as the *Basse Terrasse* (BT), rehabilitating irrigation infrastructure in the Konni area, supporting institutions to increase land tenure security, training farmers and facilitating market access, promoting policy reform, implementing sustainable management of irrigation systems, and upgrading rural and national roads to connect the Dosso-Gaya area to the rest of the country and facilitate trade. The other project is the Climate-Resilient Communities (CRC) Project, which aims to improve agricultural and livestock productivity for livestock-dependent households, preserve natural resources, and improve market sales of targeted commodities. The compact is being implemented by the Millennium Challenge Account-Niger (MCA-N), and the United Nations Office for Project Services (UNOPS) is supporting MCA-N by providing technical services that support the compact's management.

In September 2017, MCC contracted with Mathematica to design and implement an evaluation to cover IMAP project activities. Although IMAP's policy reform measures, such as strengthening the country's national statistics system capabilities and reforming fertilizer markets, are national in scope, other activities are concentrated in two implementation areas: the Konni area and the Dosso-Gaya project area. Different implementation timelines for the project activities in these two regions necessitated separate evaluation design reports for the Konni area and the Dosso-Gaya project area. The evaluation for the Konni perimeter investments and national-level activities was previously developed and approved by

[1] Prior to this compact, Niger participated in MCC's threshold program from 2008 to 2013. The program's focus was on improving girls' education access and quality and increasing civil society engagement to strengthen local governance and reduce corruption.

MCC (D'Agostino et al. 2019).[2] In this report, we present the design for the evaluations of IMAP activities focused on activities in the Dosso-Gaya project area, which include the construction of SSI infrastructure and complementary capacity-building activities for strengthening land tenure security, and improved agricultural productivity and market access. The design also includes an assessment of the benefits of the roads activity for beneficiaries of the SSI activities.

We propose conducting **a quasi-experimental impact evaluation** complemented by **a mixed-methods performance evaluation** to evaluate the SSI investments in the Dosso-Gaya project area and complementary IMAP activities. To assess the impact on outcomes of SSI investments and complementary project activities, such as farmer trainings and land tenure strengthening, we propose a quasi-experimental matched comparison group design. We construct a comparison group using a two-stage process that leverages remotely sensed data and household surveys to identify households outside the BT treatment area who best approximate beneficiary households in the BT based on their landholdings, agricultural performance, and other household characteristics. To estimate impacts we will then compare agricultural and land tenure-related outcomes of treatment plots, and income and food security outcomes of treatment households, to their comparison group counterparts, at two points in time: the midline data collection will take place just after the compact ends in spring 2023, and endline data collection will take place in Q1 of 2026, about three to four years after construction of the SSI systems. We will complement our quantitative impact evaluation with a mixed-methods performance evaluation to (1) investigate the importance of the complementary IMAP activities—including the technical assistance in managing SSI systems, in improving agricultural productivity and value chains, strengthening land tenure, and rehabilitating roads for market access—for households in the BT, and (2) provide more in-depth perspectives on program outcomes by drawing on key informant interviews (KIIs) with stakeholders such as officials at the Ministry of Agriculture and members of land commissions, and focus group discussions (FGDs) with beneficiaries. To address questions related to the implementation and sustainability of IMAP activities, we propose conducting qualitative analyses through document review, targeted KIIs, and FGDs.

In upcoming chapters, we provide context for the evaluation and describe the planned evaluation design in greater detail. In Chapter II, we provide an overview of the Niger Compact and the IMAP activities we will evaluate in the Dosso-Gaya project area. In Chapter III, we summarize the existing evidence and contextualize this evaluation's potential contribution to the relevant literatures. In Chapter IV, we discuss the research questions that our evaluation seeks to answer and provide an overview of our evaluation design. In Chapter V, we describe the impact evaluation and data sources that we will use to conduct the analysis. We describe our mixed-methods performance evaluation in Chapter VI, which is organized according to each activity and sub-activity under evaluation. In Chapter VII, we summarize all data sources and describe our approach to data collection. We conclude in Chapter VIII with a discussion of administrative details related to the evaluation.

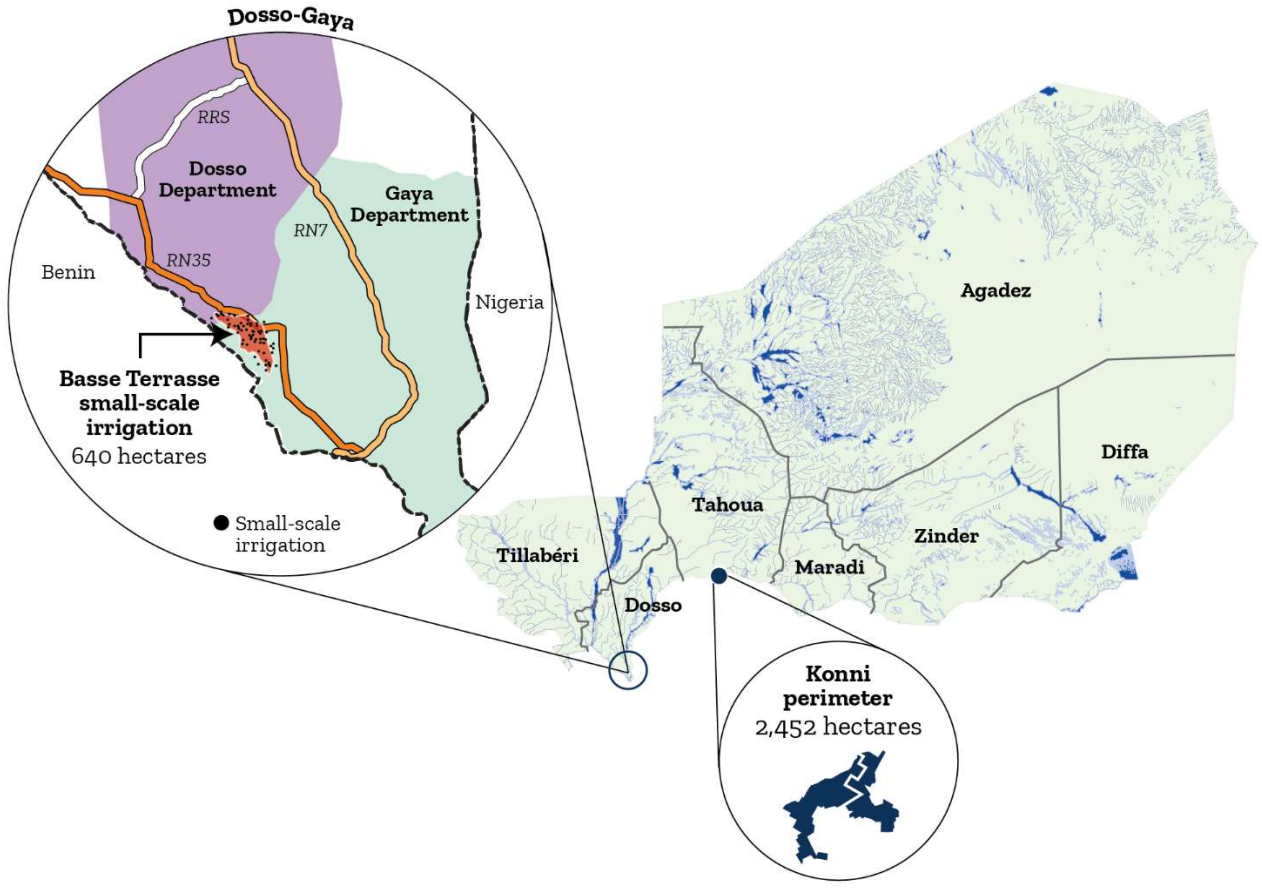
[2] MCC's evaluation catalog for the Niger IMAP houses all published materials associated with the evaluation and is available at https://data.mcc.gov/evaluations/index.php/catalog/265/related_materials.

# II. OVERVIEW OF THE COMPACT AND THE INTERVENTIONS TO EVALUATE

## A. Overview of IMAP investments

The $250 million IMAP comprises four overlapping activities: (1) the Irrigation Perimeter Development Activity (IPD), (2) the Management Services and Market Facilitation Activity (MSMF), (3) the Roads for Market Access Activity (RMA), and (4) the Policy Reform Activity (PR). The first two activities are being implemented in two areas of Niger: the Konni area and the Dosso-Gaya project area, shown in **Figure II.1**. The Roads for Market Access Activity is taking place only in the Dosso-Gaya project area, and the PR is national. Below, we describe each of the activities; the activities are still evolving, and we will update this project description as implementation plans are finalized.

**Figure II.1. Map of IMAP implementation areas in Niger**

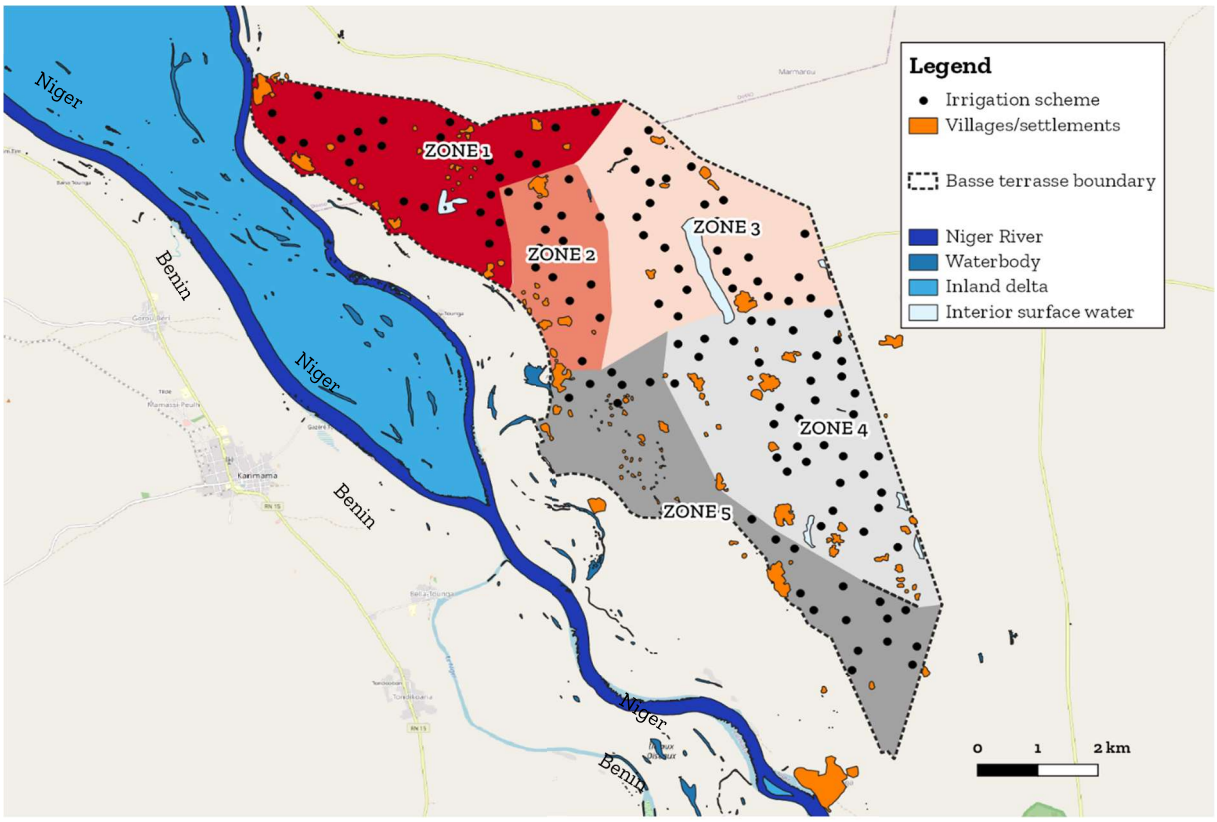



Source: MCC documents and private communications (various).

1. The **IPD** ($113.3 million) is rehabilitating the Konni irrigation system and constructing small-scale irrigation infrastructure in a part of the Dosso-Gaya project area called the *Basse Terrasse* (BT) located in the Tanda and Sambera communes. D'Agostino et al. (2019) describe the Konni perimeter activities in the Konni evaluation design report.

   Within the Dosso-Gaya project area, MCA-N is constructing approximately 640 hectares of SSI infrastructure in the BT, east of the Niger River and the border with Benin (**Figure II.2**). Unlike Konni, which had existing irrigation infrastructure in need of upgrading, this area will benefit from the first-time construction of irrigation infrastructure, which comprises small-scale systems that are likely to use drip irrigation technologies.[3] Under current plans, the SSI systems will be grouped together in networked clusters of five systems each. In these systems, MCA-N is installing pumping and water distribution networks for mixed-crop irrigated agriculture. The number and selection of areas that are ultimately irrigated will depend on the results of land tenure surveys and groundwater yields from test boreholes. Current implementation plans divide the BT into five geographic zones (Zone 1 through Zone 5) with the implementation scheduled to progress in three phases. The initial test phase encompasses 100 hectares in Zone 3 and part of Zone 4, followed by a supplemental 200 hectares in Zones 4 and 5, and a final 340 hectares in Zones 1 and 2, shown in **Figure II.2**.

**Figure II.2. *Basse Terrasse* project implementation area**




Source: MCC documents and private communications (various).

[3] Drip irrigation systems use perforated tubes, usually made of plastic, to distribute water to plants. Because perforations are placed close to plant roots and water is slowly released, this is more efficient than distributing water through surface canals or spraying water. A second variant of drip irrigation uses drip tape to distribute water from slits in tubes to plants. It is referred to as "Californian" irrigation technology in Niger.

2. The **MSMF** ($9.1 million) consists of three sub-activities: (1) the Sustainable Irrigation System Management Sub-activity (SISM), (2) the Land Tenure Security Sub-activity (LTS), and (3) the Agricultural Support Services Sub-activity (SSA). The SISM targets only irrigation infrastructure beneficiaries; the SSA and LTS will also include beneficiaries located outside the irrigation project areas. This evaluation focuses only on the group of investments made within the irrigated project area. This activity's implementation will be similar to that in Konni, albeit tailored to the production conditions faced by SSI users who will likely be more engaged in system operations and maintenance.
    a. The SISM envisions providing technical assistance and capacity building to producer organizations (small-scale cooperatives) to support the management and maintenance of the new SSI systems.
    b. The LTS includes steps to improve land tenure security through, on the Konni perimeter, the participatory development of local land allocation standards, and in both Konni and Dosso-Gaya, establishing transparent land governance processes. As part of the land governance investments, MCA-N will also build capacity for such local land governance entities as *Commissions Foncières Communales* (COFOCOMs) by incorporating integrated land use planning and training local officials in land tenure and conflict. In the Dosso-Gaya project area, the COFOCOMs will have a key role in adjudicating conflicts over land. For beneficiaries of SSI who are unable to provide sufficient family labor to cultivate their full acreage in the dry season, MCA-N will facilitate an active rental market to assist these landholders in renting out a portion of their land to groups who lack their own land and property rights to ensure cultivation of the entire acreage.
    c. The SSA will employ a community-based approach to provide services and training that address every step of the agricultural production chain, including the supply of agricultural inputs (for example, fertilizer and improved seed varieties), access to finance, efficient agricultural practices, product marketing, and sustainable natural resource use. This sub-activity will also include infrastructure investments for post-harvest value chain stages such as crop storage and agro-processing. To supplement the agricultural training, the SSA will build the capacity of beneficiaries in functional literacy and numeracy and will also support the creation of savings groups (*Association Villageoises d'Epargne et de Crédit* – AVEC) for women and youth.
3. The **RMA** ($113.4 million) aims to reduce trade barriers and increase market access through targeted improvements of the road networks that serve the Dosso-Gaya region and link these project areas to the rest of the country. Specifically, MCA-N will rehabilitate and upgrade 83 kilometers (km) of the RN7 main north-south international trunk road that links the cities of Gaya and Dosso. MCA-N will also rehabilitate 180 km of the RN35 road that connects Margou and Gaya, and 37 km of the Sambera Rural Road linking the Ouna-Kouanza and Sia irrigation project areas. **Figure II.1** displays the relative locations of the RMA relative to the SSI implementation area. This activity is part of our evaluation only to the extent that the improved roads affect the farmers benefiting from non-roads IMAP investments, because International Development Group Advisory Services (IDG) is serving as the independent evaluator for the RMA.[4]
4. The **PR** ($18.8 million) will develop and implement management plans for water, natural resources, and land use. It also involves reforming the fertilizer distribution market to increase the availability

[4] Evaluation materials associated with the RMA are available at https://data.mcc.gov/evaluations/index.php/catalog/254.

and affordability of fertilizer as part of an effort to ensure the success and sustainability of the project program. Specifically, the reform targets reducing the price of fertilizer by 30 percent. Another aspect of the activity is to build the capacities of the National Institute of Statistics, as well as relevant ministries (water and sanitation, agriculture and livestock, and environment) to generate more accurate agricultural data, analyze the impacts of policies, measure economic growth, and develop internal monitoring and evaluation skills. The Konni evaluation design report develops the design for the national-level policy reform activities (D'Agostino et al. 2019).

As of early 2021, the IMAP has begun preliminary implementation, and agriculture-related activities around the BT project area are scheduled to commence by fall 2021.

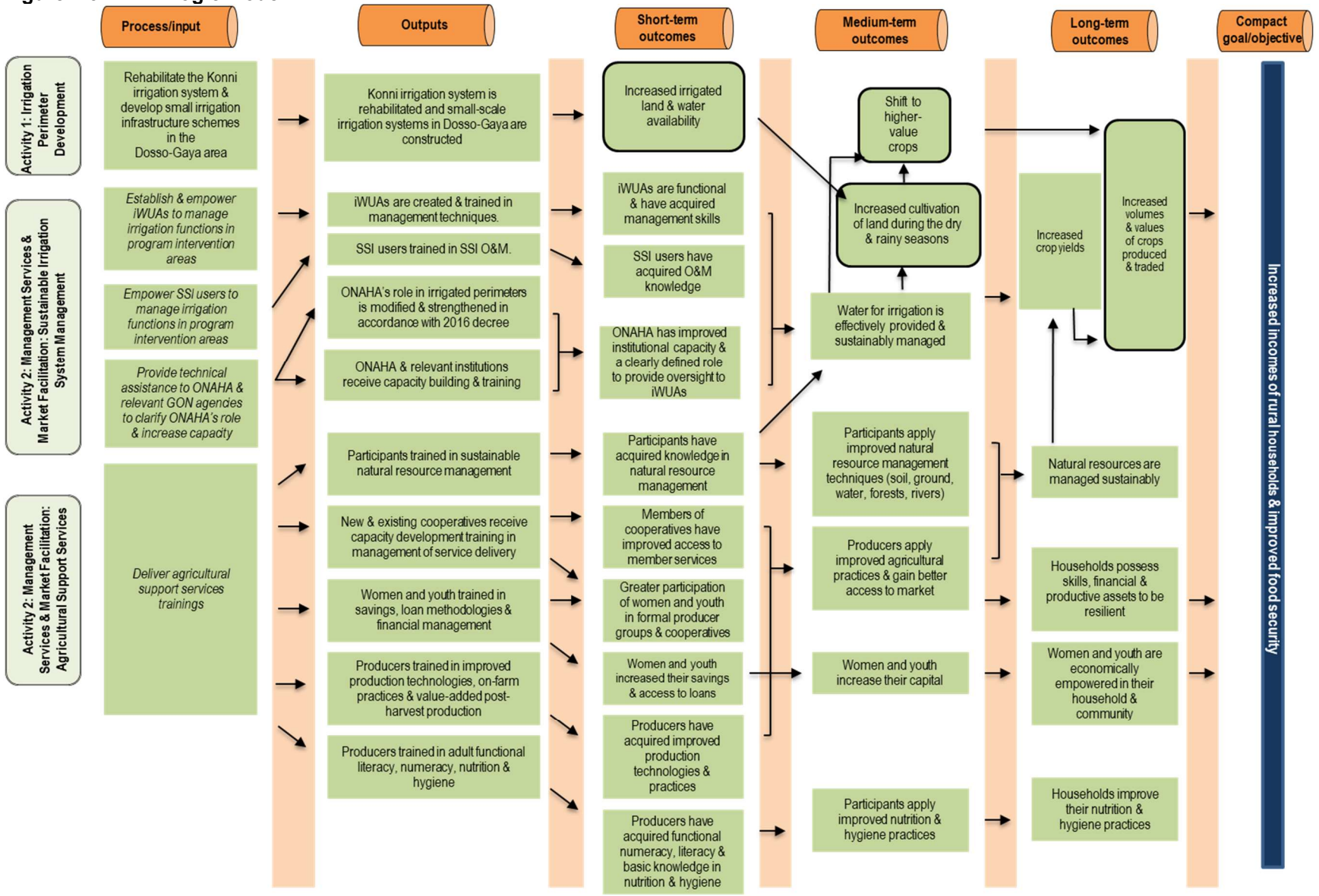
## B. Theory of change

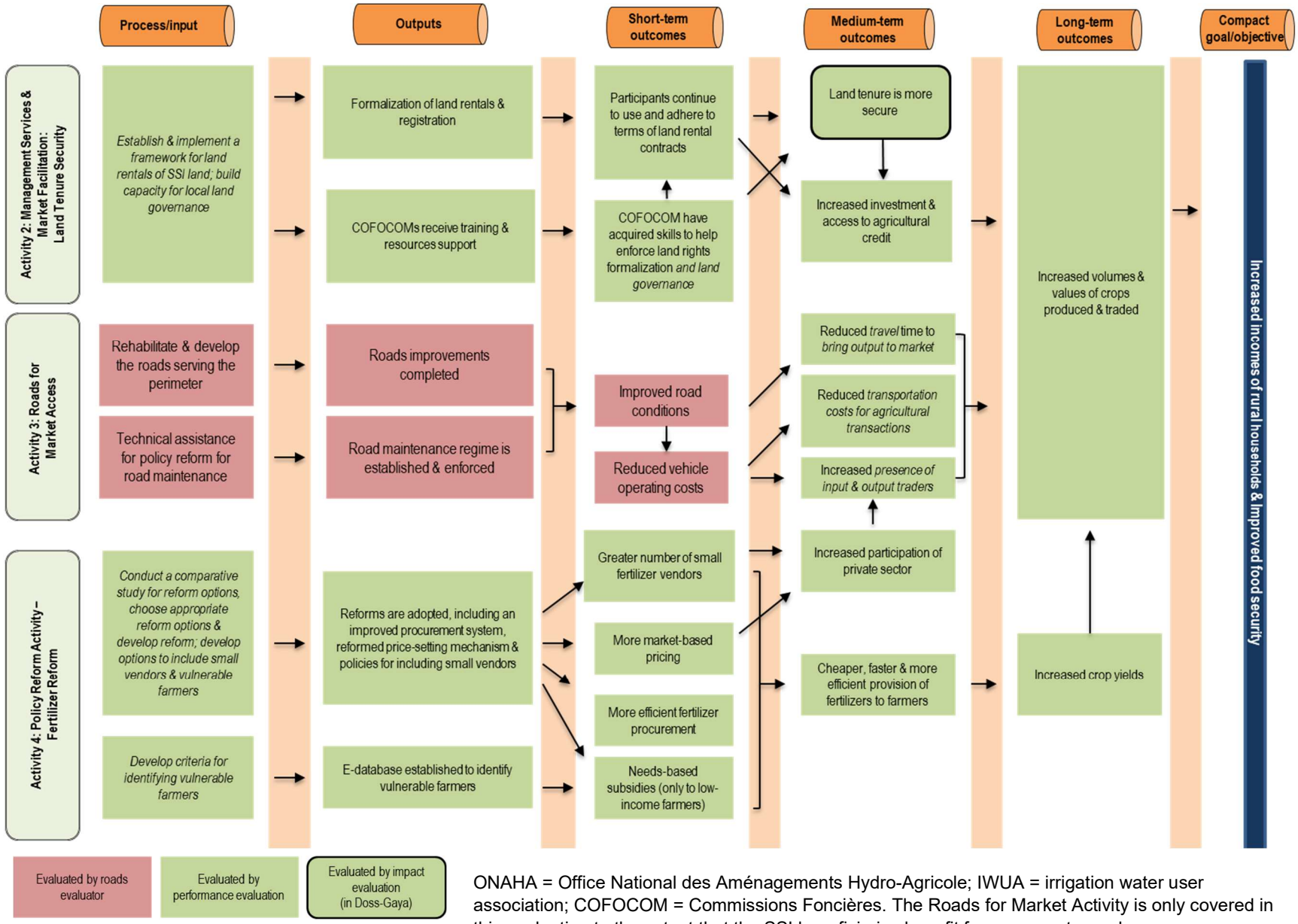
The IMAP's theory of change stipulates that investing in large- and small-scale irrigation infrastructure will result in increased water availability for project beneficiaries during the rainy and dry seasons (MCC 2016). The project logic model (**Figure II.3**) shows the pathway from anticipated activities to short-, medium-, and long-term outcomes. The outcomes in boxes with rounded corners and a black outline map onto indicators that will be measured through the impact evaluation in Dosso-Gaya, whereas the rest will be measured through the performance evaluation. Through complementary investments in capacity-building, program beneficiaries in the irrigated project area are expected to gain the skills to use irrigation water to increase productivity and efficiently produce higher-value crops and increase their total income. Land tenure security is expected to increase as a result of the provision of formal land use rights and a more robust land governance system, stimulating on-farm investments by land users who have greater assurance about the returns to their investments. In addition, to facilitate the transportation of agricultural products to markets, MCC will invest in roads that link to the irrigation project area. Through road upgrades, project beneficiaries will be able to access inputs, services, and markets more quickly and at lower cost, and sell their increased production. The combined investments in infrastructure, human capacity, land tenure strengthening, and market access will enable Niger's farmers to move from subsistence farming to higher-value commercial/cash crop agriculture, leading to growth in rural incomes as well as food security. Turiansky et al. (2018) provide an in-depth discussion of the assumptions underlying the project's theory of change.

Across both the project areas in Konni and in Dosso-Gaya region, MCC anticipates reaching 447,501 beneficiaries who will realize higher real incomes as a result of the project (MCC 2016). Beneficiaries of the RMA are all households in Dosso-Gaya residing within five kilometers of the road, which MCC estimates to be 447,501 individuals.[5] More than 37,500 people will directly benefit from the IPD and the MSMF in the BT. These beneficiaries are defined as individuals (and household members) who will gain access to irrigated land in the project area, stand to experience an increase in yields, sales, or profits as a result of having at least one member participating in trainings (in addition to receiving access to irrigation and land tenure documentation), or will experience an improvement in market access because of the roads investments. MCC has not yet identified the beneficiaries of the PR, but beneficiaries could be at the household or the enterprise level and could be located anywhere in the country.

[5] Mathematica's evaluation of the roads activity will only assess the effects of road improvements among the set of households who are also benefiting from MCC's SSI activities in Dosso-Gaya, whereas the roads evaluator will consider benefits to other beneficiaries along the roads.

**Figure II.3. IMAP Logic Model**






ONAHA = Office National des Aménagements Hydro-Agricole; IWUA = irrigation water user association; COFOCOM = Commissions Foncières. The Roads for Market Activity is only covered in this evaluation to the extent that the SSI beneficiaries benefit from access to roads.

The table below (**Table II.1**) summarizes some key targets for each of the activities. Most targets are depicted as published in the MCC Monitoring and Evaluation (M&E) Plan of the Niger Compact, with the exception of the hectares under improved irrigation that we updated to reflect the compact's revised plans for Dosso-Gaya. A revised M&E Plan with updated targets for Dosso-Gaya is forthcoming (personal communication with MCC, 2021).

**Table II.1. IMAP targets by activity and geographic area**

| Indicator name | Geographic area | Target |
|---|---|---|
| **Management Services and Market Facilitation Activity: Irrigation Perimeter Development Activity** | | |
| Hectares under improved irrigation | Konni | 2,452 |
| | Dosso-Gaya | 640 |
| | *Total* | *3,092* |
| **Management Services and Market Facilitation Activity Sub-activity: Sustainable Irrigation Systems Management Management** | | |
| IWUAs that self-finance with fees covering assigned operations, maintenance, and rehabilitation | Konni | 1 |
| | Dosso-Gaya | 0 |
| | *Total* | 5 |
| **Services and Market Facilitation Activity: Land Tenure Security Sub-activity** | | |
| Land rights formalized | Konni | 3,400 |
| | Dosso-Gaya | 1,920 |
| | *Total* | 3,400 |
| **Management Services and Market Facilitation Activity Sub-activity: Agricultural Support Services** | | |
| Farmers trained | Konni | 4,834 |
| | Dosso-Gaya | 6,000 |
| | *Total* | 10,834 |
| Farmers who have applied improved practices as a result of training | Konni | 1,450 |
| | Dosso-Gaya | 1,800 |
| | Total | 3,250 |

Source: M&E Plan of the Niger Compact, March 2018.

*The number of trained farmers in Dosso-Gaya includes farmers who do not receive SSI equipment but participate in IMAP training activities.

## C. Economic rate of return and beneficiary analysis on the Dosso-Gaya project area

Households in the BT who own or cultivate land on which SSI infrastructure is built are expected to benefit from MCC's IMAP investments in terms of increased household income, as shown in the project logic model (**Figure III.3**).

To determine whether these benefits exceed project costs, MCC conducts a cost-benefit analysis (CBA) and calculates the economic rate of return (ERR) of its projects. The ERR is a summary statistic that reflects the economic merits of an investment. Conceptually, the ERR represents the discount rate at which an intervention's benefits exactly offset costs. Larger ERR estimates imply a greater ratio of discounted benefits relative to discounted costs. The ERR is computed using the estimated economic value of the total costs and benefits of each project activity, with benefits aggregated across all beneficiaries. The timing of cost and benefit accrual is accounted for through discounting. To ensure that

estimated returns are due to MCC investments, ERR values are constructed using scenarios of with and without the project to establish a counterfactual.

MCC has noted it is developing a revised CBA model for the SSI investments, but it is not yet available. Similarly, the specific project beneficiaries for the SSI project and the complementary activities have not yet been fully defined, but according to initial project designs, project beneficiaries are expected to comprise owners of irrigated land and renters in the BT, and beneficiaries of capacity-building activities within the BT and some neighboring areas. Mathematica will discuss the CBA model and beneficiary identification in the interim report.

As part of the evaluation, we will compute the ex-post ERR of the SSI investments using updated estimates of benefits and costs across the IMAP's activities, drawing primarily on data collected for the impact evaluation described in Chapter V. This ex-post ERR estimate can be compared to economic returns of other investments and can also enable MCC and other stakeholders to determine the soundness of this project based on whether it surpasses MCC's hurdle rate of 10 percentage points.

# III. LITERATURE REVIEW

Most Nigeriens derive their livelihood from agriculture. They face significant income risks from the multiple threats associated with predominantly low-productivity, rain-fed agriculture, especially recurring droughts and pest outbreaks (World Bank 2013). Although yields for important crops such as cowpeas and sorghum have been steadily increasing over the past decade, they still lag those of neighboring Burkina Faso and Nigeria (according to authors' calculations using Food and Agriculture Organization of the United Nations [FAOSTAT] 2019 data). IMAP activities in irrigation development, farmer training, formalization of land use rights, and rehabilitation of roads for market access are designed to address many of the urgent constraints to rural productivity growth and to increase farmers' resilience to production risk. To situate the IMAP evaluation in a broader context of empirical and theoretical work related to the types of rural development activities that the project includes, this literature review summarizes the current state of knowledge about the effectiveness of such interventions and identifies key research gaps that the IMAP evaluation may be able to address.

## A. Effects of irrigation access

Irrigation is an important input to agriculture that enables farmers to increase crop yields; level out crop water consumption over the agricultural calendar; cultivate water-intensive, higher-value crops; engage in more intensive cropping; and reduce vulnerability to weather shocks (Hussain and Hanjra 2004; Burney et al. 2013). The large yield gains that accrued from the Green Revolution's introduction of high-yielding variety seeds in the 1960s was largely the result of irrigation, with yield performance highest in areas that were either irrigated or rainfed with adequate water-control measures (Evenson and Gollin 2003).

Despite several past efforts to increase irrigation availability in the country, Niger's water resources remain underutilized. The World Bank (2018) estimates that less than 30 percent of the country's potentially irrigable land is currently irrigated and only about 20 percent of an estimated 2.5 billion cubic meters of renewable groundwater (the source of water for small-scale irrigation schemes) is currently being exploited (Villholth 2013; Merrey and Sally 2014). Similarly, You et al. (2011) estimate that nearly 200,000 additional hectares could be irrigated through projects with positive internal rates of return (IRRs), with small-scale irrigation projects accounting for the majority of the hectarage (127,000) and yielding an IRR of 40 percent. Although there is considerable opportunity for tapping the available groundwater using small-scale irrigation, such irrigation schemes are not without their challenges. Disputes and conflicts over access to water and land have been documented throughout West Africa, and the relatively low cost of pumps has resulted in extensive pump-based irrigation, which can deplete groundwater reserves because withdrawal rates exceed aquifer recharge rates, necessitating close monitoring to ensure the sustainability of these resources (de Fraiture and Giordano 2014; Merrey and Sally 2014).

Given the importance of agriculture to developing countries' rural economies, such substantial increases in agricultural productivity from irrigation can generate widespread improvements in welfare through reduced poverty and conflict over natural resources. In their review of empirical studies, Hussain and Hanjra (2004) claim a relatively unambiguous relationship between irrigated areas and lower poverty rates. Duflo and Pande (2007) observed reductions in poverty rates for districts in Andhra Pradesh, India, that are downstream from dams. Using a fuzzy regression discontinuity design, Sekhri (2014) found lower poverty head counts and fewer water-related disputes in villages with comparatively more accessible groundwater.

The reported income and crop yield gains from irrigation in several studies are economically meaningful. Abric et al. (2011) find that households participating in a public-private partnership irrigation program that deployed tube wells, pumps, and low-pressure distribution systems in Niger had incomes 1.5 to 3 times the country's average. Aw and Diemer (2005) observe average paddy yield increases of more than 300 percent over 20 years after development of the Office du Niger, a major irrigation scheme located in the middle of Mali. Burney et al. (2010) estimate per capita consumption expenditure growth exceeding 80 percent among women's group members participating in a solar-powered drip irrigation randomized control trial in Benin. For some of those participating women, sales of surplus vegetables gave them their first-ever source of personal income (Burney and Naylor 2012). The effects found by Burney et al. (2010) and Burney and Naylor (2012) may be underestimates of the total impact: Dillon (2011) found in his evaluation of irrigation in northern Mali that households with irrigation are more likely to share food with non-irrigators, which means the consumption impacts from irrigation are likely to be underestimated if they only consider households that directly benefit from irrigation.

Several studies suggest that irrigation may positively contribute to improved food and nutritional security. In the Benin experiment mentioned earlier, women's group participants in treatment villages increased their household consumption of grown vegetables and were more able to meet their household food needs (Burney et al. 2010). Domenech's (2015) review of the literature on the linkages between irrigation, food security, and improved nutrition and health showed generally stronger food security levels and improved nutrition when irrigation is introduced. In many examples, irrigation led to growing fruits and vegetables that become important sources of income, though irrigation may also lead to monocropping (Hossain et al. 2005 cited in Domenech 2015).

Although the literature does not provide explicit guidance over the exposure period needed to observe effects, experimental and quasi-experimental papers reporting positive results have tended to span fewer than three years between baseline and endline survey rounds (e.g., Burney et al. 2010; Balana et al. 2020) or have lacked baseline data altogether (e.g., Mwangi and Crewett 2019; Zeweld et al. 2015). Dillon (2011) is a notable exception, and draws on endline data collected eight years after the baseline. However, the focus of such papers has not been in identifying the optimal exposure period.

This evaluation will make multiple contributions to the literature on the welfare impacts of irrigation access. First, much of the research examining the food security benefits of receiving irrigation examines only a small number of irrigated parcels. The evaluation of IMAP will be one of the few instances in which these outcomes are measured across an entire project area. Second, this evaluation will be able to generate new insights on the economic returns to small-scale irrigation, using data collected to revise the IMAP CBA, and to contrast the estimated ERR with the Konni perimeter ERR. This comparison will offer insight into the relative cost-effectiveness of providing small-scale irrigation investments relative to investments in large-scale irrigation perimeters, within the same country and therefore holding country-specific costs constant. Our results could inform donors' future strategies for investing in the irrigation sector. Lastly, our evaluation involves a lengthy exposure period that will enable us to estimate long-run irrigation impacts of irrigation. By examining household outcomes using both interim and endline data, we will be able to offer evidence on the role of learning and start-up costs as determinants in the timing of household benefits.

## B. Effects of land tenure strengthening and facilitating an active rental market

The IMAP seeks to formalize land rights as well as actively establish a land rental market—two separate but related objectives. Here we review the evidence for both land tenure strengthening and facilitating an active rental market.

### 1. Land tenure strengthening

Formalizing land tenure has widely been considered a precondition for farmers to make productivity-enhancing land investments. If they face a strong threat of land expropriation or confiscation without legal recourse, which formalized land rights would insulate against, farmers might not make such investments; instead, they might make less productive investments to safeguard their land. For example, fallowing can increase future yields, but under traditional tenure systems this could lead to land confiscation in areas where rights are exercised through visible demonstrations of labor, such as tree planting or fence building (Place and Otsuka 2002; Gottlieb and Grobovsek 2019). For similar reasons, perennial crops with longer maturation times may not be cultivated due to expropriation threats. Such tenure systems often reward farmers who make defensive investments, such as planting trees or building fences, to solidify their tenure claims in the face of uncertainty (Deininger and Jin 2006), even if such investments do not yield on-farm productivity gains.

Although contemporary land tenure strengthening programs have largely focused on issuing individual titles, several sub-Saharan African countries have enacted policies and programs that either formalize usage rights or provide certificates with limited transferability. A key difference between titling and certification programs lies in land ownership, with the latter typically provided under a state ownership rather than individual model. Delineating land boundaries has been an important component of these formalization and certification programs. A Benin-based randomized control trial of a program that demarcated parcel boundaries and involved publicly settling land disputes resulted in sharp increases in long-term investments of tree planting and growing perennial cash crops (Goldstein et al. 2015). The authors do not observe an immediate increase in crop yields or farm income, likely because their survey timing allowed for an exposure period of about one year.

Although Goldstein et al. (2015) represents one of the few instances of randomized certificate issuance, land reforms in Ethiopia were comprehensive and rapid and have provided much evidence of the effects of certification at scale. Deininger et al. (2008) use countrywide survey data following the registration of 20 million plots in 7 years, which adopted a public process in which neighbors could contest purported land claims. They find that households were 5 percent more likely to invest in their land if issued a certificate. Certificate holders also indicated higher perceptions of tenure security and were less likely to believe that redistribution or reallocation would affect their landholdings in the subsequent five years (Deininger et al. 2011).

Certification programs that stop short of individual titling may be temporary solutions, as land markets face fluxes from population growth and transfer restrictions may limit access for certain groups. The Certificate of Right instrument rolled out to Botswana's urban poor was seen as a starting point upon which titling programs might eventually be built (Nkwae and Dumba 2010). In Ethiopia, land registration was available in two stages. The first stage employed relatively rudimentary methods to demarcate boundaries, using ropes, tape, and recall from neighbors. This procedure was completed at an average cost of $1 per plot, and people were mostly satisfied with this approach (Bezu and Holden 2014). The authors find limited demand for the more expensive second-stage certification that would georeference

boundaries using GPS readings. Certification is often coupled with transfer restrictions on sales and leases, under the premise of promoting equality by preventing elites from buying large tracts of land (Ho and Spoor 2006; Crewett and Korf 2008). Such restrictions may have the perverse effect of locking youth out of land access and pushing them into off-farm employment (Yami and Snyder 2016).

Empirical work has examined the effect of tenure formalization (including programs with and without individual titling) on intermediate farm-level outcomes, such as access to credit, perceptions of tenure security, and incidents of social conflict, with land productivity and household consumption as final outcomes of interest (Lawry et al. 2017). Sitko et al. (2014) drew on a nationally representative household survey in Zambia, and found suggestive evidence of land titling increasing investment in irrigation equipment, inorganic fertilizer application, and erosion control management each by about two to four percentage points. A land regularization pilot program in Rwanda had no effect on increased credit access but did increase the use of improved seeds in some econometric specifications (Ali et al. 2014). Lawry et al. (2017) found that tenure recognition programs increase the monetary value of land productivity on average by 40 percent; however, there is significant regional heterogeneity, with much larger effects in Latin America and Asia and smaller effects in sub-Saharan Africa. They also observed no evidence that the connection between tenure recognition and productivity gains operates through a credit mechanism.

The absence of a clear link between land tenure strengthen and increased access to credit could reflect the limitations of rural credit markets and does not rule out the existence of a potential credit mechanism linking tenure and borrowing that could emerge if supply-side issues were alleviated. Lenders may simply opt out of markets when verifying a borrower's land rights is costly. Deininger and Goyal (2012) tested whether digitizing land title records sufficiently reduces banks' transaction costs to trigger credit expansion in Andhra Pradesh, India. They found that access to credit in urban and semi-urban districts rose more than 15 percent two years after digitization, but rural areas experienced no improvement in credit access. Lending may be unresponsive to changes in tenure status for unrelated reasons, such as the underdeveloped or undercapitalized status of local financial institutions (Migot-Adholla et al. 1991).

Recent interventions and research have focused on the effect of reforms on gender equity in access to and security of land. Although Niger's Rural Code stipulates that men and women have equal land access, women's access is through husbands and male relatives (Hughes 2014). Ali et al. (2014) found that legally married women's tenure security increased from a pilot of a land regularization program that issued claim receipts to all individuals, including women and minors, with a claim to the parcel. Land under ownership of a married woman was also more likely to have received soil conservation efforts. In some contexts, there may be a concern that demand for land titling might be depressed if women must be included on the title. Ali et al. (2016) examined this in an experiment in unplanned settlements in Dar es Salaam. They offered households a small discount toward the title application fee if a woman was included on the application and found this significantly increased women's inclusion on title documents with no adverse effects on title demand. The researchers concluded that even small financial nudges have the potential to increase women's economic empowerment.

A major limitation when synthesizing results across contexts is inconsistent definitions of tenure security. Researchers must proxy for the elusive concept of security, which consists of a bundle of rights that vary in their certainty and duration. In his interpretation of the evidence over the previous 15 years of studies on land tenure effects in sub-Saharan Africa, Place (2009) stated that mixed results may be driven by differences in proxies used for tenure security. He cautioned that although empirical research has acknowledged the heterogeneity of tenure systems, policy formulation has not yet been as attentive and often generates generic prescriptions that may be locally inappropriate. Arnot et al. (2011) raised similar

concerns and propose that tenure security emphasize the dimension of "assurance," which is often proxied by the probability of an event like eviction, or change in government policy, which would overturn rights claims. In their review of the literature, they found that in the absence of good data on rights assurance, researchers often rely on the length of time over which rights have been enjoyed, which may be a poor indication of future rights certainty.

Prindex (2019) compiles tenure security perceptions from random samples across multiple countries, and finds that 28 percent of Nigerians perceive their tenure to be insecure.[6] Nearly half of the Nigerien respondents report having no land documentation, but the authors find no significant difference in the perceived security levels between respondents with and without formal documentation. Among those claiming to be insecure, disagreement with family or relatives was the largest source of insecurity.

### 2. Facilitating an active rental market

We are not aware of evidence on interventions that attempt to directly intervene in rental markets by matching renters and borrowers. Most studies of rental markets are either observational studies or studies of projects in which more active rental markets are intermediate outcomes that arise from the strengthening of land tenure security. In the following, we survey the literature that links rental market functioning and outcomes, as well as the heterogeneity in outcomes.

A lack of land tenure security and/or the absence of an active rental market creates hurdles for landowners to rent out land and for landless individuals, as well as households with abundant labor supply, to gain access to cultivable land. In 2015, only 7 percent of households in Niger rented land and only 1.6 percent of households rented out land (Deininger et al. 2015).[7] The absence of an active rental market creates inefficiencies as land is left unproductive or not allocated to the most efficient producers (Deininger et al. 2015). In the absence of land tenure security or a rental market, landowners may still rent informally, but only to known entities such as family, friends, or neighbors, which significantly limits the size of the potential rental market and prohibits landowners from renting out as much land as they wish to, resulting in ongoing inefficiencies and lower productivity (Marcours et al. 2010; Muraoka et al. 2018).

Simulations based on land rental markets in the Dominican Republic conducted by Marcours et al. (2010), suggest that improving land tenure security alone would increase land rentals by 21 percent and increase the area of land rented to the poor by 63 percent. In a study of the land rental market in Ethiopia, Deininger et al. (2011) found that renting land transferred the land to more productive producers, but that inefficient contractual arrangements hindered efficient land rental arrangements.

Renting land often bestows benefits on landowners and renters, and redistributes land from relatively wealthier land-rich households to relatively poor labor-rich households who are either landless or have smaller landholdings. Tenant households gain access to productive assets, which has been shown to increase their income and food security. At the same time, renting out land also increases the income and food security of landowners and increases crop yields as land is transferred to more productive farmers (Deininger et al. 2015; Jin and Jayne 2013; Benin et al. 2005; Muraoka et al. 2018). In China, Deininger and Jin 2009 found that net revenue was 60 percent higher on rented plots compared to what landowners

[6] Although the Prindex sample includes both urban and rural residents, 84 percent of surveyed respondents in Niger reported living in rural areas.

[7] The authors state that urban landlords who are not included as survey respondents of the Living Standard Measurement Survey – Integrated Surveys on Agriculture may be one contributor for the discrepancy in these values.

had earned under self-cultivation. Rental rights and greater land tenure security also increase the probability of out-migration and off-farm employment for landowners (Mullan et al. 2011).

An active rental market is particularly beneficial for women and youth, whose participation in land transactions may be otherwise constrained. Using Living Standard Measurement Survey – Integrated Surveys data from Ethiopia, Malawi, Niger, Nigeria, Tanzania, and Uganda, Deininger et al. 2015 find that renting out land confers greater income gains to female landowners (who generally realize smaller yields and income than their male counterparts), but their participation in rental markets may be obstructed or more difficult relative to male landowners. Female landowners or managers could increase output by 11 to 37 percent by leasing their land to an average producer rather than self-cultivating. This suggests that the rental market component of IMAP in the BT has the opportunity to benefit female landowners in particular, especially if the implementation design considers the unique challenges female landowners may face in tenancy agreements and aims to alleviate these barriers. Rental markets also facilitate access to land for younger farmers; however, these youth often face higher transaction costs (Deininger et al. 2015; Ricker-Gilbert and Chamberlin 2018; Jin and Jayne 2013).

There is precedent for the type of shared SSI infrastructure and land rental market that MCA-N aims to establish in the BT arising organically without outside intervention. de Fraiture et al. (2014) document the spontaneous creation of a water pump and land rental market around the Korsimoro reservoir in Burkina Faso to facilitate dry season irrigation. Pumps, which siphon water from the reservoir without authorization, are privately owned and financed by individual farmers, either for individual or shared use. Most landowners cultivate land bordering the reservoir during the rainy season and rent it out during the dry season to pump owners. Because some pumps' capacity to irrigate land exceeds the amount of land some pump owners can cultivate, some of the pump owners then sublet portions of the land in conjunction with irrigation provision to other farmers. Contractually, the different constraints lead to a variety of arrangements for the renting of land and pumps. The Korsimoro reservoir provides a relevant example of SSI irrigation and land rental in practice.

This evaluation of the land tenure strengthening component of the IMAP will contribute to the growing body of evidence on the relationship between land tenure security and agricultural outcomes and increase understanding of drivers of land tenure insecurity in the Nigerien context. The evaluation will also contribute to evidence of the relationship between land tenure security and rental markets in an environment where other barriers to rental, such as high transaction costs, have been alleviated. The IMAP is unique in its approach of taking an active role to establish a rental market, in addition to formalizing land rights. This evaluation will help determine the extent to which MCA-N's active participation in facilitating an efficient land rental market enables farmers in the project area in the Dosso-Gaya region enter into efficient tenancy arrangements, resulting in productivity gains and increased access to land for groups such as youth that may have previously been excluded due to high transaction costs.

## C. Effects of road improvements on farmers

Rural roads connect farmers to markets where they purchase agricultural inputs and sell their crops. The presence and quality of the roads linking farmers to markets determines, among other things, travel time, transportation costs, and post-harvest losses, which in turn affect the quantity of output sold, selling price, and ultimately profit. The economic effect of roads investments on agricultural households is an empirical question, because there are numerous competing factors that govern benefit streams. New or rehabilitated roads can open access to new markets, which can bid up crop prices if farmers are growing novel crops

not produced elsewhere. Conversely, those same roads will increase local access to outside producers and would lead to price declines if they are more competitive than local producers. When roads strengthen foreign trade, as is likely to be the case between Niger and Nigeria and Benin with the RMA investments, affected households grow more integrated with foreign markets in addition to those domestic markets whose trade linkages were too costly before the investments. That further amplifies market exposure for both consumers and producers. Here we review the evidence of the impact of road infrastructure investments on the various determinants of agricultural profit as well as other channels through which roads improvements may affect farmers' livelihoods.

Infrastructure improvements to roads confer benefits to farmers by increasing access to inputs, decreasing trade costs, and ultimately increasing yields and profit. Further distance from local markets and longer travel times are correlated with lower use of fertilizer and other inputs, lower crop sales per hectare, and lower agricultural wages (Jacoby 1998). In a systematic review of more than 50 studies of rural road investments, Hine et al. (2016) found that improving rural roads decreased transportation costs, increased agricultural production, increased agricultural marketing, and increased non-farm employment. Improved access and connectivity through road infrastructure upgrades have also been found to increase land under cultivation, crop diversity, and use of inputs including fertilizer and hired labor (Berg et al. 2018; Shamdasani 2018). Higher input intensity, especially fertilizer application, results in higher crop yields, especially for cash crops, which increases farmer income and profit (Hine and Bradbury 2016 cited in Bradbury et al. 2017; Shamdasani 2018).

Another channel through which road improvements can benefit farmers is the reduction of post-harvest in-transit losses. Although this relationship is unambiguous, the magnitude of the impact depends on the quality of the roads before and after they are upgraded and the types of crops being transported, with fruits and some vegetables being most susceptible to damage in transit as a result of rough road conditions or prolonged storage and transportation times (Kuyu et al. 2019; Sibomana et al. 2016; Delgado et al. 2017). For example, Steyn et al. (2015) quantify the relationship between road roughness (as measured by the international roughness index (IRI) and damage to tomatoes. They find that a rise in the IRI from 1 to 6,[8] which represents the average change in roughness between a paved road in pristine conditions and a damaged paved road or unpaved road in relatively good condition, increased the percentage of tomatoes damaged by three percentage points and increased the percentage of tomatoes that could not be sold by one percentage point. On a road with an IRI of 6, about 29 percent of tomatoes were damaged in transit and 7 percent were damaged to the point of being unsellable. Improving road quality can reduce these post-harvest losses.

The evidence of the relationship between roads improvements and crop prices, another channel through which roads can impact agricultural profit, is more mixed. In an ex-post evaluation of a roads project in Kenya, Hine and Bradbury (2016) found that roads improvements resulted in higher farmgate prices due to increased competition from traders and improved market access. Using a regression discontinuity design in Sierra Leone, Casaburi et al. (2013) found that the rehabilitation of rural roads reduced prices of cassava and rice, which the authors hypothesize is a result of increased competition resulting from improved connectivity.

[8] The IRI scale ranges from 0 to 16. Superhighways and airport runways generally range from 1 to 2, newly paved roads range from 1 to 4, older or damaged paved roads range from 2 to 7, maintained unpaved roads range from 3 to 10, and rough unpaved roads range from 5 to 15 (Bradbury et al. 2017 citing Sayers et al. 1986).

Using a trade model that is parameterized with Peruvian data on land, agriculture, and prices, Sotelo (2019) shows that the sign and magnitude of household impacts are partly determined by the household's occupational status, the crops they produce at baseline, the relative productivity of their agricultural land, and their ability to shift cropping composition in response to dynamic market conditions. Farmers with comparative advantage because of innate skill or land quality gain income because of market expansion, especially if their comparative advantage makes them competitive in foreign markets. However, along the continuum of farmers, some experience real welfare losses because of competition from newly integrated domestic producers.

The pre-post outcomes analysis of the RMA in the Dosso-Gaya project area will provide additional evidence on the relationship between roads investments and crop prices. It will also provide insight into how the activity interacts with the other project activities to accrue benefits to farmers and enable us to understand the relationship between market access and agricultural activity and outcomes in the region.

# IV. OVERVIEW OF EVALUATION DESIGN

In this chapter, we introduce our design for the evaluation of the IMAP. Given the large number of research questions this evaluation will address, we first present a summary of the research questions in **Figure IV.1**, grouped by activity. The lettering (A–F) of the groupings in **Figure IV.1** corresponds to the section of **Chapter V** or **VI** in which they are covered. Research questions grouped in A are overarching research questions and groupings B–F correspond to the different activities or sub-activities. We have categorized the research questions into six groups corresponding to the activity to which each question relates: (1) overarching questions related to implementation, sustainability, and project impacts; (2) questions related to the IPD; (3) questions related to the SISM; (4) questions related to the LTS; (5) questions related to the SSA; and (6) questions related to the RMA.

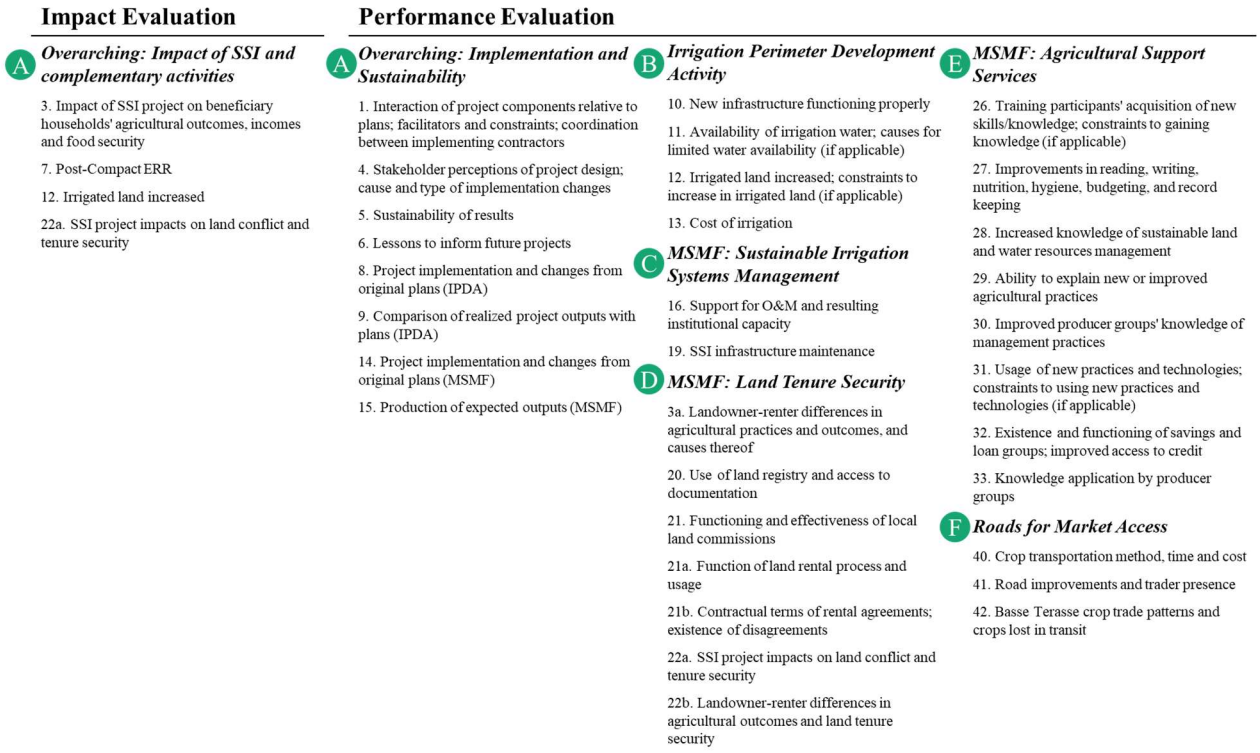
The full set of research questions, along with evaluation methods and data sources we propose to address them with, are presented in **Table IV.1**.[9] Additionally, **Table A.1** provides a link of evaluation questions and a link to the program logic model of each question. These research questions for the evaluation flow directly from the project's theory of change (**Figure II.3**). All research methods are defined and described in detail in subsequent chapter sections.

To answer these research questions, we have designed a comprehensive evaluation approach, comprising a quasi-experimental impact evaluation and a mixed-methods performance evaluation:

- We will use a quantitative quasi-experimental **impact evaluation approach**—a matched comparison group design—to estimate the impact of SSI investments on agricultural outcomes, income, and food security for SSI beneficiary households in the BT. Through the impact evaluation, we will use household survey and remotely sensed data to estimate the causal impact of the SSI investments and complementary activities on key outcomes, such as agricultural productivity, income, and food security. The comparison group, which will consist of households similar to those in the BT, provides a counterfactual for how outcomes of SSI beneficiary households would have evolved over time absent the IMAP investments, enabling us to isolate program-related changes from other time-varying factors such as weather shocks, inflation, or changes in trade policy. We will also use the impact evaluation estimates to quantify the IMAP benefit streams for the project's CBA model and estimate the post-compact ERR.

[9] Where possible, we have retained the original research question numbering that was used for the research questions in the evaluation design report for Konni (D'Agostino et al. 2019). Due to differences in project activities and the availability of a comparison group that supports causal attribution, we have reformulated research questions to be relevant to the Dosso-Gaya context. We have also added additional sub-questions as needed or omitted research questions that are not relevant for Dosso-Gaya. As a result, research questions are not sequential when Konni-specific questions are not applicable. Appendix Table B.1 lists RQ for the two project areas side by side.

**Figure IV.1. Thematic summary of research questions by evaluation methodology**




BT = *Basse Terrasse*; ERR = economic rate of return; IPDA = Irrigation Perimeter Development Activity; MSMF = Management Services and Market Facilitation; O&M = operations and maintenance; SSI = small-scale irrigation.

- We will complement the impact evaluation with a **mixed-methods performance evaluation** that (1) examines implementation, (2) helps explain the findings of the impact evaluation, (3) assesses the quality of the SSI infrastructure, (4) explores the role of complementary activities, and (5) assesses sustainability. The performance evaluation will use a tailored approach to address each of these components. We will use qualitative analysis of information from focus groups and KIIs to provide a more in-depth understanding of implementation issues that may have arisen, complementing our review of project documents, as well as monitoring data collected by the implementers. Our qualitative analysis will also serve to triangulate or complement the findings from the impact evaluation. To assess the quality of construction of the SSI infrastructure and its operation and durability, we will conduct an infrastructure assessment. To assess complementary activities—such as support for SSI infrastructure operations and maintenance, and the LTS, SSA, and RMA—we will use quantitative performance evaluation approaches, such as descriptive analysis and pre-post analyses, and qualitative analysis of information from focus groups and KIIs. To answer some of the questions around sustainability, we will conduct a sustainability analysis using qualitative information and an infrastructure assessment.

The impact evaluation will cover the BT and comparison areas, whereas the geographic coverage of the performance evaluation varies by activity based on the implementation area. Specifically, the IPD and SISM will cover the BT; the LTS and SSA will cover the Gaya, Tanda, and Tounouga communes in which portions of the BT exist but does not fully cover; and the RMA will cover the Dosso-Gaya project area.

**Table IV.1. Evaluation design overview**

| # | Research question | Evaluation method | Data source and type |
|---|---|---|---|
| **A. Overarching impact evaluation questions (Chapter V)** | | | |
| RQ3 | What is the impact of SSI investments on beneficiary households' incomes, volumes, and value of agricultural products sold and traded, food and nutritional security, and production of cash crops? | • Impact analysis | • Surveys of SSI beneficiary and comparison households<br>• Satellite imagery<br>• Crop cuts |
| RQ7 | What is the post-compact ERR of the project (except for the Roads for Market Access Activity)? | • Cost-benefit analyses | • Surveys of SSI beneficiary and comparison households<br>• Project financial data<br>• Satellite imagery<br>• KIIs with market actors<br>• Crop cuts |
| RQ12a | Did irrigated land increase as expected? | • Impact analysis | • Satellite imagery<br>• Surveys of SSI beneficiary households |
| RQ22a | What is the impact of SSI investments and land formalization on land tenure security and the level and risk of land conflict? | • Impact analysis | • Surveys of SSI beneficiary households<br>• COFOCOM administrative data |

Table IV.1 (*continued*)

| # | Research question | Evaluation method | Data source and type |
|---|---|---|---|
| **A. Overarching performance evaluation questions (Chapter VI.A)** | | | |
| RQ1 | Did the project components interact as envisioned during project design to reach a common objective? If yes, what facilitated the interaction, and if not, why not? Was there close coordination and planning among the different contractors designing and implementing the activity (land governance, infrastructure, training in infrastructure management, and agricultural services)? Did UNOPS in the role of project management consultant facilitate the rollout and coordination of activities? | • Implementation analysis | • Project documentation<br>• KIIs with MCA-N, UNOPS, and program implementers<br>• FGDs with beneficiaries |
| RQ4 | Do stakeholders believe the project was well designed to achieve the project objective? What changes to implementation occurred and why? | • Implementation analysis | • Project documentation<br>• KIIs with MCA-N, program implementers, GoN stakeholders |
| RQ5 | If the project produced results, are they expected to be sustained? | • Sustainability analysis<br>• Infrastructure assessment | • KIIs with MCA-N, program implementers, GoN stakeholders<br>• Site visits |
| RQ6 | What lessons can be drawn to inform future projects? | • Synthesis of evaluation analyses | • Mathematica evaluation analyses<br>• Compact closeout documents<br>• KIIs with MCA-N, program implementers, GoN stakeholders |
| RQ8 | Were IPD project activities implemented as planned? If not, what changes occurred? | • Implementation analysis | • Project documents<br>• KIIs with MCA-N, program implementers, Ministry of Water and Sanitation<br>• FGDs with beneficiaries |
| RQ9 | Were the expected outputs produced by the IPD activity? | • Infrastructure assessment<br>• Qualitative analysis | • Program monitoring data<br>• KIIs with MCA-N, program implementers, GoN stakeholders<br>• FGDs with beneficiaries<br>• Project area visits |
| RQ14 | Were MSMF project activities implemented as planned? If not, what changes occurred? | • Implementation analysis | • Project documentation<br>• KIIs with MCA-N, program implementers, Ministry of Agriculture<br>• FGDs with beneficiaries |

Table IV.1 (*continued*)

| # | Research question | Evaluation method | Data source and type |
|---|---|---|---|
| RQ15 | Were the expected outputs produced by the MSMF activity? | • Implementation analysis | • Program monitoring data<br>• KIIs with MCA-N, program implementers, GoN stakeholders<br>• FGDs with beneficiaries |
| **B. Irrigation Perimeter Development Activity evaluation questions (Chapter VI.B)** | | | |
| RQ10 | Is the new infrastructure operating and functioning properly? | • Infrastructure assessment<br>• Qualitative analysis | • Site visits and irrigation assessment<br>• KIIs with MCA-N, program implementers, GoN stakeholders<br>• FGDs with beneficiaries |
| RQ11 | Is water for irrigation in farmers' plots available as expected from the small-scale irrigation systems, including frequency, timing, and amount as planned? If not, why not? | • Quantitative descriptive analysis<br>• Qualitative analysis | • Surveys of SSI beneficiary households<br>• FGDs with beneficiaries<br>• Satellite imagery (e.g., Soil Moisture Active Passive)<br>• KIIs with GoN stakeholders<br>• FGDs with beneficiaries |
| RQ12b | If irrigated land did not increase as expected, then why not? | • Qualitative analysis | • Surveys of SSI beneficiary households<br>• KIIs with GoN stakeholders |
| RQ13 | What is the cost of irrigation, including any fuel costs for pumping water? If water was available before the SSI system was built, how did the cost of irrigation water change? | • Quantitative descriptive analysis | • Surveys of SSI beneficiary households |
| **C. Management Services and Market Facilitation Activity: Sustainable Irrigation Systems Management Sub-Activity evaluation questions (Chapter VI.C)** | | | |
| RQ16 | Did the project support the institutions or market actors responsible for O&M as planned? What is the capacity of these institutions or market actors, and the government oversight institutions? | • Qualitative analysis | • KIIs |
| RQ19 | Is the small-scale irrigation infrastructure being maintained properly? | • Infrastructure assessment<br>• Qualitative analysis | • KIIs with MCA-N, program implementers, GoN stakeholders<br>• FGDs with beneficiaries<br>• Site visits |
| **D. Management Services and Market Facilitation Activity: Land Tenure Security Sub-Activity evaluation questions (Chapter VI.D)** | | | |

Table IV.1 (*continued*)

| # | Research question | Evaluation method | Data source and type |
|---|---|---|---|
| RQ3a | Do agricultural input use, crop choice, agricultural techniques, and agricultural income, volumes and value of agricultural products differ between landowners and renters or renter groups? If so, why? | • Quantitative descriptive analysis<br>• Qualitative analysis | • Surveys of SSI beneficiary and comparison households<br>• Satellite imagery<br>• KIIs with GoN stakeholders<br>• FGDs with beneficiaries |
| RQ20 | Is the land registry used as a tool by local authorities to continually record changes in landholdings? Do landholders have access to the correct documentation according to the project plan? | • Qualitative analysis<br>• Quantitative descriptive analysis | • KIIs with MCA-N, program implementers, GoN stakeholders<br>• COFOCOM administrative data<br>• Program monitoring data<br>• FGDs with beneficiaries<br>• Surveys of SSI beneficiary households |
| RQ21 | Are the local land commissions in the project zone better equipped to ensure sustainable management of land rights in/around the BT project area? | • Sustainability analysis | • Project documentation<br>• Budget outlays<br>• KIIs with MCA-N, program implementers, GoN stakeholders |
| RQ21a | Is the formal land rental process used by landholders? How is it functioning? | • Qualitative analysis<br>• Quantitative descriptive analysis | • KIIs with MCA-N, program implementers, GoN stakeholders<br>• COFOCOM administrative data<br>• Program monitoring data<br>• FGDs with beneficiaries<br>• Surveys of SSI beneficiary households |
| RQ21b | What are the contractual terms between landowners and land renters or renter groups? How are input costs—including costs for the irrigation operation and maintenance— and agricultural outputs shared between owners and renters or renter groups? Have there been disagreements over land usage and contract terms? | • Quantitative descriptive analysis | • Surveys of SSI beneficiary households |
| RQ22a | What is the impact of SSI investments and land formalization on land tenure security, and the level and risk of land conflict? | • Qualitative analysis | • FGDs with beneficiaries |

Table IV.1 (*continued*)

| # | Research question | Evaluation method | Data source and type |
|---|---|---|---|
| RQ22b | How do perceptions of land tenure security, risk of land conflict, access to credit, and agricultural inputs, investments, and outputs compare between landholders and tenants, and vary among tenants with different contractual terms? | • Quantitative descriptive analysis | • Surveys of SSI beneficiary households |
| **E. Management Services and Market Facilitation Activity: Agricultural Support Services Sub-Activity evaluation questions (Chapter VI.E)** | | | |
| RQ26 | Did participants perceive that they learned new skills/knowledge? Did this vary by subgroup? If they didn't perceive learning/acquiring new knowledge, why not? | • Quantitative descriptive analysis<br>• Qualitative analysis | • Surveys of SSI beneficiary households<br>• Program monitoring data<br>• KIIs with MCA-N, program implementers, GoN stakeholders<br>• FGDs with beneficiaries<br>• Program implementer reports |
| RQ27 | What percentage of participants of adult functional literacy and numeracy report improvement in their skills (basic reading and writing) after the training? What percentage of them indicate improved knowledge of nutrition and hygiene, and budgeting and record keeping? | • Quantitative descriptive analysis | • Surveys of SSI beneficiary households<br>• Program monitoring data |
| RQ28 | What percentage of participants' self-report increased knowledge of sustainable land and water resources management? | • Quantitative descriptive analysis | • Surveys of SSI beneficiary households<br>• Program monitoring data |
| RQ29 | What percentage of participants show an active knowledge of improved agricultural practices that they did not know before the training? | • Quantitative descriptive analysis | • Surveys of SSI beneficiary households<br>• Program monitoring data |
| RQ30 | What percentage of members of *comites de gestion* within the producer groups indicate improved knowledge of producer group management? | • Quantitative descriptive analysis | • Surveys of SSI beneficiary households<br>• Program monitoring data |
| RQ31 | Have participants applied new practices and technologies? Was this different for women/men or youth/non-youth participants? If knowledge was not applied, why not? | • Quantitative descriptive analysis<br>• Qualitative analysis | • Surveys of SSI beneficiary households<br>• Program monitoring data<br>• KIIs with MCA-N, program implementers, GoN stakeholders<br>• FGDs with beneficiaries<br>• Program implementer reports |

Table IV.1 (*continued*)

| # | Research question | Evaluation method | Data source and type |
|---|---|---|---|
| RQ32 | Were savings and loans groups created and fostered by the project? Based on their participation, have group participants indicated they have improved access to credit? | • Quantitative descriptive analysis<br>• Qualitative analysis | • Program implementer reports<br>• Program monitoring data<br>• KIIs with MCA-N, program implementers, GoN stakeholders<br>• FGDs with beneficiaries<br>• Program implementer reports |
| RQ33 | How are producer groups applying knowledge? | • Qualitative analysis | • KIIs with MCA-N, program implementers, GoN stakeholders<br>• FGDs with beneficiaries and producer groups<br>• Program implementer reports |
| **F. Roads for Market Access Activity evaluation questions (Chapter VI.F)** | | | |
| RQ40 | To what extent did the activity lead to a change in transportation method, travel time, vehicle operating costs, and transportation costs for traders and farmers in the *Basse Terrasse* and surrounding areas? | • Pre-post analysis<br>• Quantitative descriptive analysis | • Surveys of SSI beneficiary and comparison households<br>• Surveys of traders<br>• Surveys with village leaders |
| RQ41 | Are more input and output traders present in the Dosso-Gaya region as a result of the roads improvements? | • Quantitative descriptive analysis | • Market records<br>• Surveys with village leaders |
| RQ42 | To what extent did the activity contribute to increased volumes and values of agricultural products traded from the *Basse Terrasse* area? How has the activity changed the quality of crops, in particular produce, brought to market and the quantity of crops lost in transportation post-harvest? | • Pre-post analysis<br>• Quantitative descriptive analysis<br>• Qualitative analysis | • Surveys of SSI beneficiary and comparison households<br>• Surveys of traders<br>• Surveys with village leaders<br>• KIIs with traders |

Note: Where possible, we have retained the original research question numbering that was used for the research questions in the Konni perimeter evaluation design report (D'Agostino et al. 2019). Due to differences in project activities and the availability of a comparison group that supports causal attribution, we have reformulated research questions to be relevant to the Dosso-Gaya context. We have also added additional sub-questions as needed or omitted research questions that are not relevant for Dosso-Gaya. As a result, research questions are not sequential when Konni-specific questions are not applicable.

[a] The Policy Reform Activity is national, and the evaluation of this activity is covered in the Konni perimeter evaluation design report (D'Agostino et al. 2019).

ERR = economic rate of return; FGD = focus group discussion; GoN = Government of Niger; KII = key informant interview; LTS = Land Tenure Security Sub-activity; MCA-N = Millennium Challenge Account-Niger; O&M = Operations and maintenance; ONAHA = *l'Office National des Aménagements Hydro-agricoles;* SSA = Agricultural Support Services Sub-activity; SSI = Small-scale Irrigation; SISM = Sustainable Irrigation System Management Sub-activity; UNOPS = United Nations Office for Project Services.

This evaluation design applies MCC's Gender Integration Guidelines and includes critical components that support a gender assessment of all project activities. For the impact evaluation we have calculated sample sizes with sufficient power to present sex- and age-disaggregated results, and we plan to conduct surveys with male and female household heads. Additionally, in our qualitative evaluation, we will interview and hold FGDs with women and younger beneficiaries to learn if they have benefited from improved access to irrigation, gained relevant knowledge from farmer training, benefited from new land parcels, and been affected by national policy reforms, such as those that affect fertilizer prices.

Our evaluation will integrate findings from the impact and performance evaluations, to present a comprehensive view of the effects of IMAP. We anticipate our conclusions will provide guidance to MCC, MCA-N, and other stakeholders about the impacts of the agricultural development activities included in IMAP. In the following chapters, we discuss our evaluation approach in more detail.

# V. IMPACT EVALUATION TO MEASURE *BASSE TERRASSE* OUTCOMES

In this chapter, we present the impact evaluation, which will be used to measure the causal effect of the IMAP's investments in SSI infrastructure and complementary investments on beneficiary outcomes. First, we provide an overview of the impact evaluation and summarize the key research questions, data sources, and key outcomes of interest. Next, we describe the matched comparison group methodology, the selection process for identifying comparison group units, and our estimation procedure. Last, we summarize the key evaluation risks and the mitigation steps we will undertake to minimize those risks.

## A. Evaluation overview

We will employ a quasi-experimental impact evaluation to assess the IPD. **Table V.1** outlines this evaluation approach, which will focus on the effect the SSI infrastructure and complementary investments in infrastructure operations and maintenance, land tenure security, and agricultural support services have had on beneficiaries' agricultural production and food security status. We next provide a more detailed description of our impact evaluation approach, outcomes of interest, and data sources.

**Table V.1. Evaluation methods, research questions, data sources, and key outcomes for the impact evaluation of *Basse Terrasse* SSI infrastructure**

| Evaluation method | Research questions | Data sources | Key outcomes |
|---|---|---|---|
| Impact analysis | RQ3. What is the impact of SSI investments on beneficiary households' incomes, volumes, and value of agricultural products sold and traded, food and nutritional security, and production of cash crops?<br>RQ12. Did irrigated land increase as expected? | • Surveys of SSI beneficiary and comparison households<br>• Satellite imagery | • Land under irrigation<br>• Cropping pattern<br>• Agricultural sales<br>• Agricultural and non-agricultural income<br>• Food and nutritional security |
| Impact analysis | RQ22a. What is the impact of SSI investments and land formalization on land tenure security, and the level and risk of land conflict? | • Surveys of SSI beneficiary and comparison households | • Perceptions of land tenure security<br>• Land conflicts |
| Cost-benefit analysis | RQ7. What is the post-compact ERR of the project (except for the Roads for Market Access Activity)? | • Surveys of SSI beneficiary and comparison households<br>• Project financial data<br>• Satellite imagery<br>• KIIs with market actors | • Construction costs<br>• Agricultural and non-agricultural incomes<br>• Irrigation access, costs, and usage<br>• Perceptions of market distortions of inputs and outputs |

ERR = economic rate of return; SSI = small-scale irrigation; KII = key informant interview.

## B. Methods and data sources

We will use a **matched comparison group design** to evaluate the impact of SSI investment on selected outcomes. With a credible comparison group, this design can support causal claims that the estimated effects are the result of IMAP activities. Specifically, the comparison group enables us to remove the effects of external shocks and isolate changes in beneficiaries' outcomes that are due solely to IMAP project activities. The ability to account for common shocks affecting both treatment and comparison households is especially valuable in contexts where livelihoods depend heavily on rainfed agriculture and thus outcomes fluctuate widely from year to year depending on rainfall. The counterfactual provided by the comparison group will also improve the accuracy of the investment's CBA, which will be based on changes driven by the program and not just changes over time, as would be the case in analyses lacking a comparison group.

The presence of a comparison group can also be helpful in clarifying mechanisms in a multi-pronged intervention like the IMAP. For example, the Niger IMAP aims to support nationwide reforms of the fertilizer sector, which should lead to increased availability and affordability of fertilizer. Project activities in the BT may also influence fertilizer demand by training farmers in appropriate input management and increasing agricultural income. The ability to assess fertilizer use in the comparison group—this group is affected by the same national policy changes and availability of fertilizer in the larger Dosso and Gaya markets—would allow us to attribute changes in the amount of fertilizer applied to fields to the IMAP's activities within the BT versus national policy reform activities that would have similar effects across all farmers in Niger. (Because the fertilizer reforms will be national in coverage, no meaningful comparison group will be available to measure only the effects of the reform, independent of the farmer training activities.)

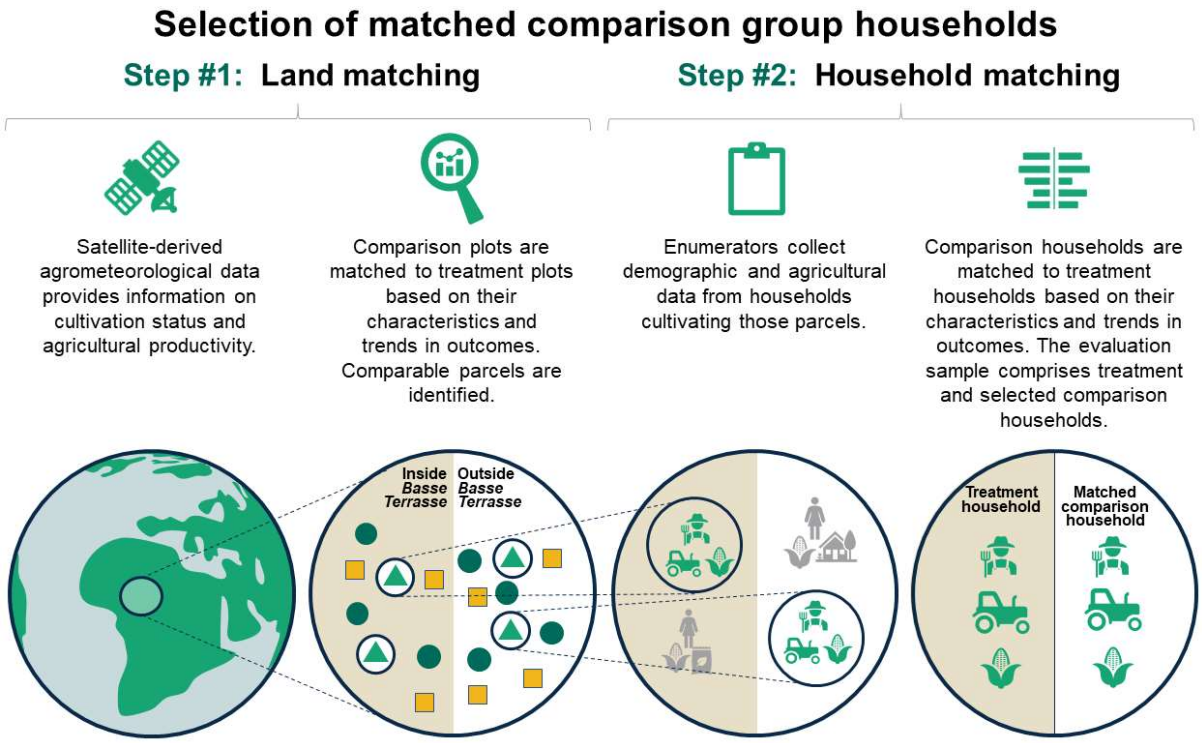
Executing this design requires assembling a comparison group of households who can provide a credible counterfactual for treatment households had they not received treatment. Central to that task is selecting plots and households with characteristics like those of the plots and households receiving SSI investments before the project is implemented, especially with respect to (1) access to groundwater (upon which BT irrigation is predicated) and (2) agricultural productivity. Although non-beneficiary households living in or owning land on the BT are likely to be comparable to beneficiaries with respect to these characteristics, they are anticipated to receive some project benefits and therefore are not an appropriate comparison group. Specifically, such households may benefit from the MSMF complementary activities and may have new income-generating opportunities as laborers or renters on the SSI treatment parcels. We therefore consider only households outside the BT but still in the southern part of Dosso Region, located between Benin and Nigeria, when considering potential members of the comparison group. However, because households located adjacent to the BT might also experience benefits, we do not consider areas immediately adjacent to the BT—from Koulou to Gaya—for inclusion in the comparison group.

Because project implementation details, such as which households will eventually benefit from SSI infrastructure on their land, continue to evolve, our research design has been developed based on the information available to date and will be responsive to new data that become available. For example, although information on the areas inside the BT that are targeted for SSI is available, the specific land parcels belonging to treatment households are not yet known except for a pilot group of parcels spread over about 100 hectares in Zones 3 and 4. As a result, we use preliminary data from MCA-N on potential areas within the BT where the 640 hectares of SSI might be targeted as the best available information of treatment assignment, and consider all parcels in these areas as treatment parcels for the purposes of identifying the comparison group.

We adopt the following two-stage matching process to select comparison group units, which is graphically depicted in **Figure V.1.**:

1. **First stage: land matching**. In the first stage of the matching process, which has been completed and is described in more detail in Appendix C, we have used remotely sensed land cover and groundwater data to shortlist potential comparison *land parcels* with hydrogeological conditions and cropping histories that are similar to those of parcels in the BT areas targeted to receive the SSI treatment. This process combines both longitudinal (e.g., time-series vegetation indices) and cross-sectional (e.g., access to groundwater aquifers) data to ensure that prospective matches are as similar as possible to treatment parcels in recent years and over a longer period. The potential comparison parcels were concentrated in three geographic clusters, to which we plan to restrict the comparison group in order to reduce data collection costs. We have used statistical tests to assess whether selected comparison parcels are similar to treatment parcels and find that they are sufficiently comparable to justify proceeding with this analysis approach.
2. **Second stage: household matching.** In the second stage of the matching process, which has not yet been conducted, we will match *households* cultivating the treatment parcels to households cultivating the selected comparison parcels. In both treatment and comparison areas, we will conduct a listing exercise to identify and survey farmers who are cultivating these parcels. The listing exercise is necessary for two key reasons. First, without a village cadaster, we have no information on who is responsible for the cultivation of any parcel of land, and we therefore must establish a link between a parcel of land and the household responsible for its cultivation. It is especially important to address this when a single household manages multiple parcels, because the first stage of our matching process contains no information about how distinct land parcels may be economically connected. Second, although similarity of cropping outcomes and landholdings is a necessary condition for comparison units to possess, it is not a sufficient condition. For example, two households may cultivate parcels that look similar in terms of hydrogeological conditions and cropping histories, but if one household also runs a thriving business while the other does not, then they are unlikely to be comparable along other dimensions such as total household income or food security status, which are important for the evaluation. The listing exercise will therefore include a brief survey on aspects like household size, asset ownership, total landholdings, and income that will serve as inputs to the second stage matching process of selecting comparison *household* units. To collect the listing data we will use POKET—an Android-based phone app—and local youth contributors from the selected comparison areas to collect information on the potential comparison households.

**Figure V.1. Overview of matched comparison group selection process**




To carry out the impact analysis, we will collect data from respondents using three rounds of household surveys: a baseline round (in October 2021, to collect data on agricultural outcomes before SSI construction), an interim round (anticipated in 2023, to assess medium-term impacts about one to two years after SSI construction), and an endline (anticipated in 2026, to assess long-term impacts about four to five years after SSI construction). We will implement the impact analysis in both our interim and endline evaluation reports. In our endline report, we will also be able to compare differences in key outcomes between baseline and interim, and between baseline and endline, to understand whether most of the impacts arise immediately following new investments or take several years to materialize. If available from our ongoing partnership with NASA and RTI International, we will use estimates derived from satellite imagery to complement household survey responses on agricultural outcomes, by enabling us to understand changes in agricultural practices and yields in non-survey years. To gather additional information on agricultural inputs and outputs between household survey years, we will use the POKET app for lean data collection of inputs, production, yields and sales prices in the BT and comparison areas.

We will use the household survey data to estimate the average impact on outcomes at interim and endline, applying the inverse-propensity-weighting-regression-adjustment technique proposed by Wooldridge (2007) that uses the propensity scores to weight observations in a usual least squares regression model in **Equation V.1**,

$$(V.1)\ y_i = \beta Treat_i + \gamma X_i + \varepsilon_i \ ,$$

where $i$ is an index denoting households 1…$N$. *Treat* is a binary value that takes the value of 1 if the household is part of the SSI treatment group, and 0 otherwise. Outcome $y$ is specific to a household at a given time and may be a continuous or binary variable. The vector of household characteristics, $X$, will consist of any baseline variables that should be controlled for because of imperfect matching at baseline, and may also include household $i$'s baseline value of $y$ and other characteristics that might affect the

outcome that are measured at baseline.[10] The key outcomes we will examine include total household income, agricultural production, cropping patterns between cash and non-cash crops, household food security levels, perceptions of land tenure security, and outcomes related to irrigation such as total irrigated area and irrigation costs. The estimate of interest is $\beta$ and measures the average difference in outcomes that can be attributed to program participation. To understand how outcomes differentially respond for members of a given subgroup, we will include an interaction of the treatment term with an indicator for subgroup membership. We will use estimates derived from the impact analysis to estimate the benefit streams the CBA model specifies and to calculate the ex-post ERR, as discussed in Section II.C.[11]

In **Table V.2**, we present our estimated minimum detectable impacts (MDIs) for various outcomes of interest for the impact analysis. MDIs represent the smallest impact that is statistically distinguishable from zero for a given sample size and set of assumptions about the data, such as mean and variance. We estimate MDIs using a sample size of 1,500 completed household surveys: 600 SSI treatment households and 900 comparison households outside the BT.[12]

**Table V.2. Minimum detectable impacts for the impact analysis of SSI investments**

| (1) | Outcome | | | |
|---|---|---|---|---|
| | Total annual household profits ('000 CFA) | Annual household agricultural expenditures ('000 CFA) | Household had no food to eat at least once in the previous month (%) | Plot-level fertilizer application (kilograms per hectare) |
| | (2) | (3) | (4) | (5) |
| **Minimum detectable impacts** | | | | |
| For SSI Treatment and Comparison | 16% | 15% | −6 pp | 19% |
| **Observed values for Konni baseline data** | | | | |
| Difference between households with and without irrigation access | 31% | 195% | −6 pp | 120% |
| **Inputs to MDI calculations** | | | | |
| Estimated mean | 2,682 | 337 | 19 | 441 |
| Estimated standard deviation | 2,920 | 328 | 39 | 540 |

Source: Mathematica calculations using Ksoll et al. (2021) baseline survey data collected for the Konni perimeter.

Notes: Reported means are based on responses to the Konni baseline survey. All input parameters into the MDI calculations are reported in Appendix D.

[10] The technique proposed by Wooldridge is "doubly robust" in the sense that the estimator is asymptotically unbiased if either the propensity score model is correct or the regression model is correct.

[11] We will describe this in further detail in the interim evaluation report after the CBA model is finalized by MCC and MCA-N.

[12] In a previous memo shared with MCC, we provided MDI estimates for different sample sizes. The sample size proposed here balances trade-offs between statistical power and data collection costs.

For all of the four outcomes listed in **Table V.2**, the MDI estimates are smaller than or equal to (in absolute value) the differences we observe between households with and without irrigation access on the Konni perimeter (Ksoll et al. 2021). Because irrigation is likely to be the key channel improving SSI beneficiaries' agricultural and household outcomes, these differences in Konni provide a plausible benchmark of the magnitude of outcomes differences that might be observed between treatment and comparison households for SSI activities at endline. Accordingly, we have a sufficiently large sample to detect statistical effects, although we might have limited power to detect the relatively small impacts that we might expect for the food security outcome (percentage of households that had no food to eat at least once in the month preceding the survey).

## C. Evaluation risks, limitations and mitigation steps

The matched comparison group design approach we propose will provide credible estimates for the impacts of the SSI investments under a defined set of assumptions. In this section, we describe the risks threatening the credibility of treatment effect estimates, and detail what steps we have or plan to undertake to minimize those risks.

- An important caveat is that we have not yet conducted the listing survey necessary to implement the second stage of matching. Therefore, despite the treatment-comparison balance shown in **Table C.2**, it is still unclear whether a truly comparable set of *households* along the dimensions that are important to the evaluation (such as household income, landholdings, and cropping practices) can be obtained using our matching process. If defensible household-level matches cannot be obtained through the household survey data, then we will transition the design to a pre-post analysis, as part of the performance evaluation.
- To conduct the matching, we need baseline data that are collected before the project is implemented. Because IMAP implementation details have not been finalized for all treatment areas, it is possible that some households that we sample in the initially identified treatment areas may ultimately not participate in the project.[13] If a large fraction of sampled households in the treatment group do not ultimately participate, then we will present both intent-to-treat and treatment-on-the-treated estimates. The former will represent project impacts among households initially assigned to treatment areas, and the latter will represent impacts among households that participated in the SSI project.

[13] Even if there is substantial noncompliance with treatment assignment, we will still be sufficiently powered to detect impacts for the full sample, but would not be able to reliably conduct subgroup analyses.

- Because our impact evaluation is based on two post-intervention rounds of household survey data collection, our estimated project impacts will be sensitive to aggregate shocks like drought or pest outbreaks that occur during any of the surveyed time periods. While such shocks would not negate our research design's *internal validity*, since the estimated project impacts would be correctly identified for the growing conditions households actually faced, the estimates might lack *external validity* and therefore serve as a poor guide to the impacts the project might have were it implemented elsewhere or at some other time (Rosenzweig and Udry 2020). To confidently elaborate the relationship that rainfall, for example, plays on project investment returns would require observing farmers' behavior across the range of realized rainfall levels. This is infeasible when data collection is limited to three rounds—the two post-intervention surveys as well as the baseline survey—and weather conditions within the treatment and control areas do not vary significantly. We are also unable to use economic theory to predict impacts in non-survey years because of possibly countervailing effects. For example, while a nationwide drought would negatively affect agricultural productivity it could raise crop prices due to lower supply. Because production of irrigated agriculture is less sensitive to weather conditions, treatment farmers could thus earn higher household incomes during drought years due to the price increases. However, whether the price for a crop would rise would depend on how price-sensitive and income-sensitive demand for that crop is—with price and income effects likely different for staple crops such as millet and higher-value crops such as tomatoes—and the extent to which the local area is integrated into national and international markets. We propose to mitigate this limitation of collecting extensive household survey data in only two post-intervention years by complementing this data with both remote sensing data and the POKET app-based data collection to provide some insight on project impacts in non-survey years. We will work with NASA and RTI International to assess whether crop identification and yield estimation techniques are sufficiently reliable in their cross-year and cross-region predictions to be able to use data collection from Konni to construct a more continuous picture of agricultural production in Dosso-Gaya than available through household surveys alone. Additionally, we will collect a subset of important outcomes, including crop production, yields, sales, and output prices, through our POKET-based data collection which will also occur in non-survey years. The lean data collection we propose has some limitations. Given that POKET data collection relies on local youth contributors to collect data from neighbors or other members of their own village, this data collection approach cannot be relied on for obtaining more sensitive outcomes like food insecurity—which respondents are likely to be reluctant to disclose in order to preserve dignity and social capital (Hampshire et al. 2009), or total household income.
- Between now and the endline data collection, other development agencies may roll out programs that might affect outcomes of either SSI beneficiaries or households in a comparison group. If such a program were to benefit comparison group households, the effects of IMAP could be underestimated, and any program that benefits SSI households could overestimate IMAP's effects. To minimize these concerns, we seek input from MCC and MCA-N on any information they have of other agencies operating in the region (such as LuxDev). If, however, the comparison group does receive access to irrigation between the baseline and the interim survey, we would propose to switch to a pre-post design and collect interim (and endline) survey data from BT households only.
- Given the lengthy time frame between baseline and endline, it is inevitable that some percentage of households will relocate out of the treatment and comparison areas. If levels of attrition are high

enough to threaten evaluability using households that were surveyed since the baseline, we will supplement our sample in the endline with surveys from new arrival households.[14]

In **Table V.** we summarize the decision points, the evaluation design threats that mark potential "exit ramps" from the matched comparison group design because new information reveals that the matched comparison group is no longer appropriate, and the timing of when information about those threats is expected to become available.

**Table V.3. Decision points for switching from MCG to pre-post design**

| Decision point | Threat | Course of action | Timing |
|---|---|---|---|
| Evaluation design | MCC could decide that comparison area will receive project benefits. | Switch from MCG to pre-post design. | June–Dec. 2021 |
| | Project areas cannot be suitably matched based on satellite and other available data. | Switch from MCG to pre-post design. | April/May 2021 |
| Baseline data analysis | Project households and/or plots cannot be suitably matched to households/plots in comparison areas. | Switch from MCG to pre-post design. | March 2022. |
| Interim data collection | Other development actors have created irrigation infrastructure in comparison areas between baseline and endline. | It may be possible to continue with the MCG under certain conditions that need to be verified. Depending on the scale of this intervention it may be possible to use an instrumental variables approach. It may also be possible to conduct the MCG using households in any comparison areas unaffected by other development actors. Otherwise switch from MCG to pre-post design. | February 2023 |
| Endline data collection | Similar to row above but applied to period between interim and endline data collection. | Similar to row above. | February 2026 |

MCG = matched comparison group.

[14] We note that the high-attrition scenario will affect how treatment effects are interpreted. Were there no attrition, then the treatment-comparison difference at interim could be compared to the treatment-comparison difference at endline with no concern of being driven by compositional effects. If there is high attrition, then endline effects could be due to differences in renter profiles over time. To mitigate those concerns, we can rematch our sample at endline. To the extent possible, we will follow both plots of land and households over the survey rounds so long as households continue residing inside the survey area.

# VI. PERFORMANCE EVALUATION

In this chapter, we present the mixed-methods performance evaluation. As described in Chapter IV, the performance evaluation seeks to (1) examine implementation, (2) help explain the findings of the impact evaluation, (3) assess the quality of the SSI infrastructure, (4) explore the role of complementary activities, and (5) assess sustainability. We begin by discussing the implementation and sustainability analyses, which we group together because they cover all the activities. Next, we discuss the performance evaluation of the Irrigation Perimeter Development Activity, which will complement the impact evaluation. Finally, we discuss the performance evaluation of the other complementary activities, specifically the Sustainable Irrigation Systems Management Sub-activity, the Land Tenure Security Sub-activity, the Agricultural Support Services Sub-activity, and the Roads for Market Access Activity. (The SSI infrastructure assessment is cross-cutting and is discussed as part of the sustainability analysis, the performance evaluation of the Irrigation Perimeter Development Activity, and the performance evaluation of the SISM Sub-activity.)

## A. Overarching: Implementation and sustainability analyses

### 1. Evaluation overview

We will conduct an **implementation analysis** to evaluate whether project activities were implemented as planned, and to document instances and reasons for deviations from the original design. We will also focus on identifying barriers and facilitators to implementation, and documenting lessons learned. Our implementation analysis will cover activities and sub-activities specific to the BT, and those that extend beyond the BT to elsewhere in the project area in the Dosso-Gaya region. Because IMAP encompasses these multiple activities and sub-activities, designed with the purpose of creating complementary benefits, our implementation analysis will also explore the extent to which activities interacted and coordinated. In addition to those questions, we will use the implementation analysis to support our analysis on why realized outcomes may have differed from targets specified during the project design phase.

After the end of the compact in 2023, we will analyze the project's prospects for the long term through a **sustainability analysis**. Because the most important investments in the BT and Dosso-Gaya region are the SSI infrastructure investments, this analysis will focus on the longevity of the irrigation infrastructure and the supporting institutions. To that end, it will draw in part on an **irrigation infrastructure assessment** that will assess the condition and functionality of the MCC-funded infrastructure several years after the end of the compact. We elaborate on the implementation analysis and sustainability analysis in the following section.

Throughout our analysis, one overarching research question that applies equally to the implementation-focused research questions and the other research questions is to draw out lessons learned for future projects, both those conducted by MCC and other funders. We will synthesize findings from the impact evaluation and all of the components of the performance evaluation to inform future projects.

**Table VI.1** lists the research questions our implementation analysis and sustainability analysis (and the related infrastructure assessment) will address in the project area in the Dosso-Gaya region, along with the data sources we will rely on and the key outcomes of interest.[15]

**Table VI.1. Evaluation methods, research questions, data sources, and key outcomes for overarching performance evaluation analyses**

| Activity | Evaluation methodology | Research question | Data sources | Key outcomes |
|---|---|---|---|---|
| **All** | Implementation analysis | RQ1. Did the project components interact as envisioned during project design to reach a common objective? If yes, what facilitated the interaction and if not, why not? Was there close coordination and planning among the different contractors designing and implementing the activity (land governance, infrastructure, training in infrastructure management and agricultural services)? Did UNOPS in the role of project management consultant facilitate the rollout and coordination of activities? | • Project documentation<br>• KIIs with MCA-N, UNOPS and program implementers<br>• FGDs with beneficiaries | • Implementation fidelity<br>• Implementation barriers and facilitators<br>• Lessons learned<br>• Implementation coordination and examples of cross-agency planning |
| **All** | Implementation analysis | RQ4. Do stakeholders believe the project was well designed to achieve the project objective? What changes to implementation occurred and why? | • Project documentation<br>• KIIs with MCA-N, program implementers, GoN stakeholders | • Project design and rollout<br>• Barriers and facilitators<br>• Lessons learned |
| **All** | Sustainability analysis; infrastructure assessment | RQ5. If the project produced results, are they expected to be sustained? | • KIIs with MCA-N, program implementers, GoN stakeholders<br>• Site visits | • Sustainability of achievements |
| **All** | Synthesis of evaluation analyses | RQ6. What lessons can be drawn to inform future projects? | • Mathematica evaluation analyses<br>• Compact closeout documents<br>• KIIs with MCA-N, program implementers, GoN stakeholders | • Design and rollout<br>• Barriers and facilitators<br>• Lessons learned |

[15] Research questions to evaluate the nationwide Policy Reform Activity, presented in the Konni evaluation design report (D'Agostino et al. 2019), are included in Table A.2.

Table VI.1 (*continued*)

| Activity | Evaluation methodology | Research question | Data sources | Key outcomes |
|---|---|---|---|---|
| **IPD** | Implementation analysis | RQ8. Were project activities implemented as planned? If not, what changes occurred? | • Project documentation<br>• KIIs with MCA-N, program implementers, Ministry of Water and Sanitation<br>• FGDs with beneficiaries | • Design and rollout of irrigation activities<br>• Barriers and facilitators for irrigation activity<br>• Lessons learned |
| **MSMF** | Implementation analysis | RQ14. Were project activities implemented as planned? If not, what changes occurred? | • Project documentation<br>• KIIs with MCA-N, program implementers, Ministry of Agriculture<br>• FGDs with beneficiaries | • Design and rollout of SSA activities<br>• Barriers and facilitators for SSA<br>• Coordination with beneficiaries<br>• Lessons learned |
| **IPD and MSMF** | Implementation analysis; infrastructure assessment | RQ9. Were the expected outputs produced by the activity?<br>RQ15. Were the expected outputs produced by the activity? | • Project documentation<br>• Site visits<br>• Program monitoring data<br>• KIIs with MCA-N, program implementers, GoN stakeholders<br>• FGDs with beneficiaries | • Number of SSI systems that were constructed<br>• Quality of construction materials<br>• Trainings conducted<br>• Number of participants |

Note: Some research questions in the table are abbreviated versions of full-text questions in Chapter IV.

FGD = focus group discussion; GoN = Government of Niger; IPD = Irrigation Perimeter Development Activity; KII = key informant interview; MCA-N = Millennium Challenge Account-Niger; MSMF = Management Services and Market Facilitation Activity; SSI = small-scale irrigation; SSA = Agricultural Support Services Sub-activity; UNOPS = United Nations Office for Project Services.

## 2. Methods and data sources

The **implementation analysis** will use three primary data sources: program documentation, KIIs, and FGDs. Because we expect implementation to evolve over time, we will collect program documentation regularly with the support of our local research coordinator. We will conduct KIIs and FGDs shortly after the end of the compact, in 2023.

We will begin by conducting a desk review to assess project implementation plans, such as work plans, terms of references for consultant(s) implementing the activities, and original M&E plans. We will then review any progress reports or other project deliverables. As we conduct the review, we will document any discrepancies between project plans and project progress reports to identify issues to discuss with and receive clarification from stakeholders.

Our desk review will also help inform our selection of KII participants and the guiding questions. For each activity and sub-activity, we will interview the primary point of contact at MCA-N and MCC, the MCA-N M&E lead, key program stakeholders at the national level and those specific to the project area in the Dosso-Gaya region, as well as any other actors involved in program implementation, such as the external consultants. We will also interview planners and engineers responsible for installing the SSI infrastructure, officials involved in establishing land rental contracts, individuals responsible for training farmers, and persons responsible for SSI Operations and Maintenance (O&M), as these interventions are core to IMAP's success. (The roads evaluation contractor is tasked with conducting a comprehensive evaluation of the RMA implementation.) Through these interviews, we will map out key decisions throughout the implementation timeline, noting the activities, key players, and rationale guiding such decisions. These interviews will also help us identify any lessons learned and perspectives on possible improvements that we might be able to recommend for future programming. We will keep abreast of new stakeholders or transitions in staff to ensure we have the perspectives of stakeholders who were engaged from the start, as well as of those who became involved later in implementation. Finally, through FGDs with beneficiaries in the BT and nearby project areas, we will obtain beneficiary perspectives on how IMAP activities and sub-activities were implemented. These discussions may give us additional insights on some possible reasons why implementation shifted, or some implementation facilitators or barriers that were not identified by stakeholders.

The **sustainability analysis** will draw on KIIs with stakeholders and FGDs with beneficiaries conducted during the endline data collection in 2026 to assess the prospects of sustainability and identify key barriers or facilitators to sustainability. Stakeholders selected for the KIIs will include staff from the Departmental Direction for Agriculture of the General Directorate for Agriculture in Gaya, traders, representatives from COFOCOMs, and members of producer groups. Specifically, we will look at various dimensions of sustainability, including the sustainability of the SSI infrastructure, supporting structures (producer groups and COFOCOMs), technical capacities (at the farmer level and ministry level), and system-level changes (generalized income increases along the key value chains, or land tenure security).

The sustainability analysis will also draw on an **infrastructure assessment**, which our irrigation consultant will conduct through site visits at interim and endline to determine the likely physical sustainability of the SSI infrastructure. We will triangulate the findings from this assessment with qualitative findings from the broader sustainability analysis. For example, we will triangulate with findings about the governance structures and capacity of producer group and COFOCOM, and key challenges and barriers to the sustainability of the infrastructure identified from KIIs with representatives from the organization responsibility for maintenance and sustainability. We discuss the infrastructure assessment in more detail in **Section VI.B.2** and **Section VI.C.2**.

### 3. Analysis approach

As mentioned, we will rely on documents, KIIs, and FGDs to inform our implementation and sustainability analysis. Once we collect program documents, we will organize and categorize the documents according to their source and topic to understand how they relate to the IMAP and the research questions. We will conduct a content analysis to identify themes, with a particular focus on issues related to the research questions, such as successes and challenges with project implementation. We will also document any ideas or issues that emerge from the review that should be explored further in the KIIs or FGDs.

Our analytic approach to analyzing the data collected through interviews and FGDs relies on thematic framing and triangulation and proceeds in four steps (Creswell 2009): (1) raw data review and management, (2) initial coding, (3) detailed coding, and (4) data interpretation and writing. In the first step, we will read the transcripts that the data collection firm provides and group the transcripts according to the data method and source (for instance, FGDs with male household heads or interviews with male producer group leaders). During this step, we will review all data and eliminate any that are incomplete or not useful for our analysis.

In the second step, we will read through the transcripts several times to get a holistic sense of the data. We will further develop the coding scheme, which is a set of themes encountered in the transcripts from the KIIs and FGDs, mapped to the research questions and theory of change (for example, initial themes might include "implementation challenges" and "changes from design"). The third step involves refining the coding scheme and using NVivo or similar qualitative data analysis software to code the transcripts according to key themes. We will review, organize, and analyze the codes produced through this software into themes that relate to the theory of change and the evaluation questions, and that are present across multiple respondents. We will then compare themes and codes by respondent type and location to identify consistent and differing themes across respondent groups. We will interpret responses in the context of interviewees' incentives, experiences, and affiliations. This enables us to confirm key patterns and findings that emerge across stakeholders and stakeholder groups, as well as identify discrepancies in their perceptions and experiences.

Once we have analyzed each qualitative data source, we will triangulate findings from the KIIs, FGDs, and our other data sources. This process will facilitate the identification of new trends and relationships, confirm patterns or findings, and detect discrepancies or disparate experiences. A coding hierarchy will guide the process of triangulating findings across data sources and types. For example, when investigating if implementation went according to plan, we will triangulate information from interviews with MCA-N staff, FGDs, and our document review. When investigating sustainability, we will triangulate information from KIIs and FGDs with our infrastructure assessment. If we find significant inconsistencies, we may request additional interviews to further explore the theme.

The same qualitative analysis approach will be used for the other performance evaluation components. As a result the following evaluation components only feature a subsection on the analysis approach when we introduce a new analysis approach.

## B. Irrigation Perimeter Development Activity

### 1. Evaluation overview

To complement the impact evaluation of the Irrigation Perimeter Development Activity in the BT, we will employ a mixed-methods approach that includes findings from the **infrastructure assessment**, **quantitative descriptive analysis,** and **qualitative analysis**. These components of the performance evaluation are outlined in **Table VI.2** and will focus on the availability and functioning of SSI infrastructure serving the BT, as well as households' experiences with SSI systems. We will assess the extent to which irrigation development activities contributed to changes in irrigation access and availability, and cost, for irrigated plots.

**Table VI.2. Evaluation methods, research questions, data sources, and key outcomes for the performance evaluation of the Irrigation Perimeter Development Activity**

| Evaluation method | Research questions | Data sources | Key outcomes |
|---|---|---|---|
| Infrastructure assessment; qualitative analysis | RQ10. Is the new infrastructure operating and functioning properly? | • Site visits and irrigation assessment<br>• KIIs with MCA-N, program implementers, GoN stakeholders<br>• FGDs with beneficiaries | • Percentage of SSI systems providing irrigation<br>• Proper operation of SSI infrastructure<br>• Proper functioning of SSI infrastructure<br>• Extent of and reasons for defective SSI infrastructure |
| Quantitative descriptive analysis | RQ12. Did irrigated land increase as expected?<br>RQ11. Is water for irrigation in farmers' plots available as expected from the small-scale irrigation systems, including frequency, timing, and amount as planned?<br>RQ13. What is the cost of irrigation, including any fuel costs for pumping water? If water was available before the SSI system was built, how did the cost of irrigation water change?<br>RQ3a. Do agricultural input use, crop choice, agricultural techniques, and agricultural income, volumes, and value of agricultural products differ between landowners and renters or renter groups? | • Surveys of SSI beneficiary and comparison households<br>• FGDs with beneficiaries<br>• Satellite imagery (e.g., Soil Moisture Active Passive) | • Irrigation availability<br>• Irrigation cost (including operations and maintenance costs)<br>• Beneficiary outcome indicators (as for the impact analysis)<br>• Landowners' share of renter agricultural profits |
| Qualitative analysis | RQ11. If water for irrigation in farmers' plots is not available as expected, why not?<br>RQ12. If irrigated land did not increase as expected, why not?<br>RQ3a. If agricultural input use, crop choice, agricultural techniques or agricultural outcomes differ between landowners and renters or renter groups, why? | • KIIs with GoN stakeholders<br>• FGDs with beneficiaries | • Factors affecting irrigation expansion, accessibility to households, and cost<br>• Factors affecting differences in outcomes between landowners and renters |

ERR = economic rate of return; FGD = focus group discussion; GoN - Government of Niger; KIIs = key informant interview; MCA-N = Millennium Challenge Account-Niger; SSI = small-scale irrigation.

### 2. Methods and data sources

We plan to conduct an **infrastructure assessment** at interim and endline, which will consist of a combination of document review, expert visual inspection, and stakeholder interviews with owners and operators of the SSI systems as well as institutions or individuals conducting maintenance. (As of June 2021, we are not aware whether project concepts for post-compact maintenance of SSI systems involve institutions or private sector maintenance technicians. This might be developed once specific SSI systems are selected). Before we conduct each inspection, we will review any relevant documentation, such as the operations manual for the SSI systems, to understand how the systems are intended to function. This, in part, will form a basis against which we will measure infrastructure quality, such as whether the materials actually used in construction were those indicated in project plans. Where appropriate, we will also apply international standards of quality, such as International Organization for Standardization, International Water Management Institute, or American Society of Agricultural and Biological Engineers standards. A review of project documents and international standards will inform the creation of a checklist that we will use during each on-site infrastructure inspection. Such checklists often consist of computing performance indicators to measure various aspects of the irrigation system. Using visual inspection, we will examine whether water is flowing as intended through valves, pipes, and tubes, including being free of debris; that pumps work properly and have appropriate water pressure and functional electromechanical components; and that there are clearly described maintenance and upkeep protocols. We will conduct an infrastructure inspection of 25 SSI systems selected at random, spread across the project zones and phases of the project.

We will use data from the household survey conducted for the impact evaluation at interim and endline to conduct a **quantitative descriptive analysis** to assess household-level outputs and short-term outcomes among households benefiting from new irrigation infrastructure in the BT. For example, we will use the household survey data to answer questions about the availability of water on farmers' plots after construction of the SSI systems to understand how availability compares to project targets. We will also use household survey data to compare the productivity of landowners and renters. We will triangulate self-reports of area cultivated that are used in calculating yields with remote sensing data. Regarding water availability, we will use an SSI management module in a household survey and remote sensing analysis to collect information on the availability, reliability, timing, and perceived adequacy of irrigation water on beneficiaries' plots, with a focus on comparing estimated mean values against project targets.

We will conduct a **qualitative analysis**, drawing on KIIs and FGDs conducted during the interim data collection in 2023, to better understand beneficiaries' experiences in receiving irrigation water through SSI, disaggregated by owner and renter. The qualitative analysis will provide information on beneficiary perspectives and perceptions that can help interpret the causal impact of the Irrigation Perimeter Development Activity estimated through the impact evaluation described in **Chapter V**. We will triangulate information from FGDs and KIIs that present the perspectives of a variety of stakeholders involved at all stages of the project, from planning and implementation through to end users. To allow for beneficiaries' responses to be fully captured, we will use FGDs to elicit factors that may be adversely affecting households' abilities to use irrigation water in cost-effective and reliable ways. In particular, we will focus our conversations on outcome indicators that fall short of project targets, which might be suggestive of material barriers to irrigation access, as well as factors supporting project successes. Because gender is likely to be a salient factor affecting beneficiaries' experiences with irrigation, we will also conduct women-only FGDs to minimize skewed information that might result from male-only FGDs. To improve our understanding of irrigation outcomes, we will interview representatives from MCA-N,

regional Agriculture Chambers, the Ministry of Water and Hygiene, and ONAHA if some component of irrigation maintenance or oversight is delegated to them. The analysis of these qualitative data follows the approach described in **Section VI.A.3**.

### 3. Analysis approach

To analyze the quantitative data collected, we will compute estimated mean values and compare them against project targets. We will also examine how values vary by subgroup of beneficiary, focusing especially on a farmer's status as landowner or renter.

## C. Sustainable Irrigation Systems Management Sub-activity

### 1. Evaluation overview

We will conduct a **qualitative analysis** and draw on the **infrastructure assessment** described above to assess the outputs and outcomes of the SISM Sub-activity related to SSI investments. Our evaluation will focus on measuring the capacity of institutions or market actors charged with conducting maintenance, the capacity of governmental oversight institutions, and whether necessary maintenance is regularly performed. **Table VI.3** summarizes the performance evaluation of the SISM Sub-activity.

**Table VI.3. Evaluation methods, research questions, data sources, and key outcomes for evaluation of the SISM Sub-activity**

| Evaluation method | Research questions | Data sources | Key outcomes |
|---|---|---|---|
| Qualitative analysis | RQ16. Did the project support the institutions or market actors responsible for O&M as planned? What is the capacity of these institutions or market actors, and the government oversight institutions? | • KIIs with GoN stakeholders and (if applicable) private O&M actors (if applicable) | • Type of support for O&M actors<br>• Functioning and capacity of O&M actors and government oversight bodies |
| Infrastructure assessment; qualitative analysis | RQ10. Is the new infrastructure operating and functioning properly?*<br>RQ19. Is the small-scale irrigation infrastructure being maintained properly? | • Site visits and irrigation assessment<br>• KIIs with MCA-N, program implementers, and GoN stakeholders<br>• FGDs with beneficiaries<br>• Program monitoring data | • Percentage of SSI systems providing irrigation<br>• Proper operation and care of SSI infrastructure<br>• Project functioning of SSI infrastructure<br>• Extent of and reasons for defective SSI infrastructure<br>• Infrastructure maintenance<br>• Availability of spare parts |

Notes: Research questions in table are abbreviated versions of full-text questions in Chapter IV.

* Research question is also part of Section V.B.

FGD = focus group discussion; GoN = Government of Niger; KII = key informant interview; MCA-N = Millennium Challenge Account-Niger; O&M= Operations and Maintenance.

### 2. Methods and data sources

The **qualitative analysis** will draw on KIIs conducted in 2023 to assess the extent to which the project supported institutions or market actors for O&M and developed their capacity as planned, and whether these institutions and market actors are operating as envisioned during project design.[16] We will also use information from KIIs with institution staff or market actors to assess whether they have the necessary procedures in place to operate as planned. In addition, we will interview representatives of government oversight bodies, who will provide an external view on the quality of maintenance performed. We will triangulate data from the KIIs and the infrastructure assessment to determine whether the infrastructure is being adequately maintained. Finally, information from FGDs with beneficiaries will provide information on end users' perceptions of the SSI system O&M. Our qualitative analysis approach follows the methodology described in **Section VI.A**.

Our planned **infrastructure assessment**, which we described in detail above, will provide additional insight into whether the infrastructure is functioning properly and whether the operating institutions or market actors are performing the necessary physical maintenance of the newly built infrastructure. Specifically, our irrigation specialist will review maintenance plans and ask landowners to determine if the maintenance schedule was followed and if sufficient resources were available to conduct proper maintenance of the infrastructure. We will also conduct site visits to examine whether irrigation structures are functioning as intended and develop an infrastructure effectiveness metric based on the share of total structures that function properly (Bos et al. 1994). We will also examine the extent to which SSI system replacement parts are accessible through interviews with providers of spare parts and government officials, and the availability of system technicians who can troubleshoot and solve system problems such as pump failures. Maintenance issues may also be diagnosed by first identifying areas where agricultural performance or conditions are relatively low—for example, by relying on remote sensing techniques to detect soil moisture and/or evapotranspiration. We will apply these techniques in advance of selecting FGD participants for the qualitative analysis described above, so that landowners whose SSI systems underperform their neighbors' systems can provide the evaluation team additional information on the drivers and barriers of system performance.

## D. Land Tenure Security Sub-activity

### 1. Evaluation overview

We will carry out a mixed-methods evaluation to assess outcomes of the Land Tenure Security Sub-activity that draws on **quantitative descriptive analysis** and **qualitative analysis**. Anchoring our evaluation in the project's logic model, we will first investigate if the outputs necessary to yield short- and medium-term outcomes related to land security and facilitation of an active rental market are in place. We will study whether land rights have been formalized and whether COFOCOMs have received the necessary training, are using the proper documentation, and are assisting farmers with the creation of rental contracts. We then assess the ease with which landholders in the project area are able to receive rights documentation and establish rental contracts, the frequency of disputes and conflicts over landholdings and rights claims, and differences in land tenure security and agricultural outcomes for

[16] As of June 2021, it is not yet clear which institutions will intervene in the provision of sustainable infrastructure operations and maintenance, or in the supervision of this service provision. We will determine the appropriate stakeholders for KIIs once this has been determined.

landholders versus tenants. **Table VI.4** maps our evaluation methods to the research questions and presents key outcomes we will investigate.

**Table VI.4. Evaluation methods, research questions, data sources, and key outcomes for evaluation of the Land Tenure Security Sub-activity**

| Evaluation method | Research questions | Data sources | Key outcomes |
|---|---|---|---|
| Qualitative analysis; quantitative descriptive analysis | RQ20. Is the land registry used as a tool by local authorities to continually record changes in landholdings? Do landholders have access to the correct documentation according to the project plan?<br>RQ21. Are the local land commissions in the project zone better equipped to ensure sustainable management of land rights in/around the project area?<br>RQ21a. Is the formal land rental process used by landholders? How is it functioning? | • COFOCOM administrative data<br>• Program monitoring data<br>• KIIs with MCA-N, program implementers, GoN stakeholders<br>• FGDs with beneficiaries<br>• Surveys of SSI beneficiary households<br>• Budget outlays | • Number of disputed land and property rights cases<br>• Time required to resolve disputes<br>• Number of parcels incorporated into official land information system<br>• Continuity of land transaction reporting in land registry<br>• Availability of land tenure documents<br>• Ease of accessing land tenure documents<br>• Share of renters and sharecroppers operating under a rental contract<br>• Clarity and specificity of contract language<br>• Satisfaction of renters/landowners with contract terms<br>• COFOCOM revenue and operations costs<br>• Perceptions of COFOCOM effectiveness to manage land conflicts |
| Quantitative descriptive analysis | RQ21b. What are the contractual terms between landowners and renters or renter groups? How are input costs—including costs for the irrigation operation and maintenance— and agricultural outputs shared between owners and renters or renter groups? Have there been disagreements over land usage and contract terms?<br>RQ22b. How do perceptions of land tenure security, risk of land conflict, access to credit, and agricultural inputs, investments, and outputs of landholders compare to tenants and vary among tenants with different contractual terms? | • Surveys of SSI beneficiary households | • Contract terms (duration, payment of inputs, sharing rule for agricultural outputs)<br>• Frequency of contractual conflicts<br>• Perceptions of land tenure security<br>• Land conflicts<br>• Credit access<br>• Use of agricultural inputs and investments<br>• Agricultural output, productivity, and incomes |

Table VI.4 (*continued*)

| Evaluation method | Research questions | Data sources | Key outcomes |
|---|---|---|---|
| Qualitative analysis; impact analysis* | RQ22a. What is the impact of SSI investments and land formalization on land tenure security, and the level and risk of land conflict? | • Surveys of SSI beneficiary households<br>• COFOCOM administrative data<br>• FGDs with beneficiaries | • Perceptions of land tenure security<br>• Land conflicts |

Notes: * The impact analysis is described in Chapter V.

Research questions in table are abbreviated versions of full-text questions in Chapter IV.

COFOCOM = *Commissions Foncières Communales*; FGD = focus group discussion; GoN = Government of Niger; KII = key informant interview; MCA-N = Millennium Challenge Account-Niger; SSI = small-scale irrigation.

## 2. Methods and data sources

We will use COFOCOM administrative data, program monitoring data, and household survey data to conduct a **quantitative descriptive analysis** to (1) understand if the land registry and rental process are functioning correctly and being used by local authorities and landholders, (2) describe contractual terms[17] of the land rental contract between renters and landowners and whether the land rental contracts are a source of disagreements, and (3) understand how key land tenure outcomes and agricultural productivity vary between landowners and tenants and among tenants with different contractual terms. We will conduct an ongoing review of all administrative data and records available to us from the project implementer and COFOCOMs, to understand the number of new land rights entries, the number of conflicts adjudicated, and the timing of resolution. We will supplement the records from these stakeholders with a review of the ongoing monitoring data from MCA-N's Indicator Tracking Sheet on a variety of indicators (land rights formalized indicator, COFOCOMs' capacity, plots registered, and conflicts successfully mediated). The household survey data will be collected at interim and endline and will focus on contractual terms between renters and owners, land tenure security, as well as other land-related outcomes such as credit access and input use.

This quantitative descriptive analysis will enable us to understand how land ownership and different tenancy arrangements are associated with land tenure security and agricultural decisions and outcomes. Because the majority of tenants will not be renting land at baseline, as their tenancy agreements will be created as a result of the requirement for landowners to rent out a portion of their land to be eligible for the installation of SSI, it will not be possible to establish a baseline for renters. For this reason, we will compare outcomes of renters and owner-operators at each point in time to assess the differential between these two groups, rather than conducting a pre-post analysis. As with our other quantitative descriptive analyses, we will present estimated mean values for the full sample as well as different subgroups of interest.

We will conduct KIIs and FGDs in 2023 for our **qualitative analysis** to triangulate and contextualize findings from the impact evaluation, to understand project effects outside of the BT, to contextualize findings from the quantitative descriptive analyses described above, and to understand COFOCOM

[17] The analysis of contractual terms will assess both the type of arrangements—sharecropping, rental or lending land—responsibility for providing inputs (irrigation, seeds, labor and fertilizer), the division of agricultural outputs, and whether transfers are made in-kind or with cash.

effectiveness. One of the research questions related to land tenure security (RQ22a) will be partially addressed through the quasi-experimental impact evaluation method—the matched comparison group design—described in **Chapter V**. We can estimate the impact of project activities on perceptions of land tenure security for owners of land in the treatment and comparison areas. In addition to the effect of formalizing land rights, which is expected to positively contribute to land tenure security, for land rented out there might be a countervailing effect: renters may accrue land usage rights of their own, possibly leading owners to lower their perception of land tenure security. We complement the impact evaluation with qualitative analyses of FGDs with renters and owners to investigate patterns of land tenure security among these two groups. Given that the LTS extends beyond the BT, we also use qualitative analysis of FGDs conducted in those areas to shed light on how perceptions of land tenure security are related to COFOCOM's activities.

We will also use the qualitative analysis to triangulate and contextualize findings from the quantitative descriptive analyses described above. We will carry out FGDs with renters and owner-operators to better understand their experiences in obtaining proper land tenure documentation and interacting with their COFOCOM, and to learn of their perceptions of land tenure security, the level and risk of land conflict, and any factors they believe influenced changes in land tenure security. These discussions will give us a better understanding of whether formalization procedures are clear and consistent.

Finally, we will draw on KIIs conducted in 2023 and project and budget documentation collected throughout implementation to determine if the local land commission is better equipped to sustainably manage land rights. Our analytical approach for all qualitative data collected for the performance evaluation of this sub-activity will be similar to the methodology described in **Section IV.A**.

## E. Agricultural Support Services Sub-activity

### 1. Evaluation overview

For the mixed-methods performance evaluation of the SSA, we will conduct a **quantitative descriptive analysis**, drawing on program monitoring data and household surveys, and a **qualitative analysis** of KIIs and FGDs. The quantitative component of the evaluation will focus on measuring self-reported gains in knowledge and skills across the training domains and the ways participants have internalized and implemented the training material in their own practices. The qualitative component aims to identify barriers to implementing the material as cited by participants, and whether they considered the training material to be relevant to their needs and capabilities. **Table VI.5** provides an overview of the evaluation methods, key research questions, data to be used in answering the research questions, and outcomes of interest.

**Table VI.5. Evaluation methods, research questions, data sources, and key outcomes for evaluation of the Agricultural Support Services Sub-activity**

| Evaluation method | Research questions | Data sources | Key outcomes |
|---|---|---|---|
| Quantitative descriptive analysis | RQ26. Did participants perceive that they learned new skills/knowledge? Did this vary by subgroup?<br>RQ27. What percentage of participants of adult functional literacy and numeracy report improvement in their skills (basic reading and writing) after the training? What percentage of them indicate improved knowledge of nutrition and hygiene, and budgeting and record keeping (inasmuch as these concepts were introduced as part of the literacy and numeracy training)?<br>RQ28. What percentage of participants self-report increased knowledge of sustainable land and water resources management?<br>RQ29. What percentage of participants show an active knowledge of improved agricultural practices that they did not know before the training?[18]<br>RQ30. What percentage of members of *comités de gestion* within the producer groups indicate improved knowledge of producer group management?<br>RQ31. Have participants applied new practices and technologies? Was this different for women/men or youth/non-youth participants?<br>RQ32a. Were savings and loans groups created and fostered by the project? | • Surveys of SSI beneficiary households<br>• Program monitoring data<br>• Program implementer reports | • Self-reported knowledge gains<br>• Test-based outcomes<br>• Self-reported improvements in literacy and numeracy skills<br>• Self-reported management skills<br>• Self-reported knowledge of improved production practices<br>• Self-reported application of improved production practices<br>• Number of savings and loan groups |
| Qualitative analysis | RQ26. If training participants didn't perceive learning/acquiring new knowledge, why not?<br>RQ31. If training participants have not applied knowledge, why not?<br>RQ32b. Based on their participation, have savings and loans group participants indicated they have improved access to credit?<br>RQ33. How are producer groups applying knowledge? | • KIIs with MCA-N, program implementers, and GoN stakeholders<br>• FGDs with beneficiaries and producer groups<br>• Program implementer reports | • Perceptions of training relevance and/or suitability<br>• Perceived barriers to knowledge application<br>• Participants' perception of credit access<br>• Examples of knowledge application |

FGD = focus group discussion; GoN= Government of Niger; KII = key informant interview; MCA-N = Millennium Challenge Account-Niger; SSI = small-scale irrigation.

[18] Active knowledge is defined as being able to name and explain at least two or three new or improved agricultural practices that they did not know before the training.

### 2. Methods and data sources

We will draw on household survey data collected at interim and endline in conjunction with the contractor reports submitted to MCC/MCA-N[19,20] to conduct a **quantitative descriptive analysis** to assess self-reported gains in skills and knowledge levels for participants attending trainings. Because administering comprehensive knowledge exams across all the domains in which respondents receive training would likely impose large respondent burden, our priority in this evaluation will be to capture participants' perceptions of knowledge increases. Our household survey modules will be training specific, with questions focused on the content and key objectives of each type of training, such as financial literacy and natural resource management. We will ask participants which concepts and skills they believe they acquired and will examine whether households have applied the practices and technologies promoted in the trainings. These questions will be included in both the interim and endline household surveys.[21]

Because adoption decisions for new agricultural practices and technologies should be observable within two years of the training—for example, BenYishay and Mobarak (2018)—data collected in the endline will indicate the extent to which the new agricultural practices have been adopted. Over this time frame, farmers are likely able to resolve constraints inhibiting their ability to apply knowledge. We will use the comparison of results from the interim and the endline to identify where short-run knowledge gains did not translate into long-run adoption.

We will aggregate responses by subgroups of interest, such as women, and youth between 15 and 35 years old, to test for any statistically meaningful differences in their responses from those of men and non-youth. The results of this descriptive comparison may be useful in targeting revisions to training content or methodology for future training iterations elsewhere. As with our other quantitative descriptive analyses, we will present estimated mean values for the full sample as well as different subgroups of interest, such as gender.

We will review program implementer reports and conduct FGDs with beneficiaries and KIIs with stakeholders in 2023 for our **qualitative analysis**. Because this sub-activity has a strong focus on training women and youth, we will use the FGDs to obtain perspective on the extent to which training methods were differentially employed for these groups, and whether the methods and content were sufficiently targeted to trainees' needs, preferences, and constraints. For example, trainings on profitable economic activities will be provided to youth with the aim of reducing out-migration, and our youth-focused FGDs will address whether skills they were taught have influenced their decision to continue residing in the project area. Information from our FGDs will also allow us to better understand possible barriers to adoption, especially if the quantitative data reveal that adoption rates lagged targeted levels. Our FGDs

[19] We will use attendance information from the contractor to gauge whether participants attending the full training program indicate more growth in skills and knowledge than participants who only partially attended.
[20] Material covered in the training is likely to be new for the majority of participants. As a result, any baseline data collected before the trainings begin should indicate little to no familiarity with the training concepts, yielding limited value for evaluation purposes. A pre-post design that leverages baseline knowledge levels is unlikely to contribute much information about the effectiveness of the trainings beyond what is obtainable through the proposed descriptive analysis of outcomes collected after the training.
[21] Our baseline survey also features questions on agricultural practices, but final decisions on which practices are promoted in the agricultural trainings are yet to be made. For practices that ultimately are targeted in training sessions, we will be able to conduct pre-post analyses.

will also allow us to obtain perceptions from women on whether access to credit has increased as a result of participation in savings and loans groups.

Finally, we will conduct KIIs with a variety of stakeholders to obtain perceptions on how training outcomes have affected communities as a whole. We will interview the consultants implementing the activity, as well as representatives from the Ministry of Agriculture, and specifically the General Directorate for Agriculture and the Departmental Directorate for Agriculture. To obtain perceptions on improved technology adoption, we will interview staff from the *Direction de la Vulgarisation et de Transfert de Téchnologie* from the Ministry of Agriculture. KIIs with Regional Agriculture Chambers and traders will provide qualitative information on perceived changes in agricultural marketing practices, and the relationship between new marketing outlets and training participants' ability to translate agricultural trainings into improved production practices. These KIIs not only provide information about farmer training and adoption but will provide additional information on how producer groups applied knowledge. We will use the same analytical approach to analyze these qualitative data as described previously.

## F. Roads for Market Access outcomes for SSI beneficiaries

### 1. Evaluation overview

We will conduct a performance evaluation comprised of a **pre-post analysis, quantitative descriptive analysis**, and **qualitative analysis** to evaluate the effect of the RMA on SSI beneficiary outcomes.[22]

**Table VI.6** provides an overview of the evaluation methods, key research questions, data to be used in answering the research questions, and outcomes of interest.

**Table VI.6. Evaluation methods, research questions, data sources, and key outcomes for evaluation of the Roads for Market Access Sub-activity**

| Evaluation method | Research questions | Data sources | Key outcomes |
|---|---|---|---|
| Pre-post analysis; quantitative descriptive analysis | RQ40. To what extent did the activity lead to a change in transportation method, travel time, vehicle operating costs, and transportation costs for traders and farmers in the BT and surrounding areas? | • Survey of SSI beneficiary and comparison households<br>• Surveys of traders<br>• Surveys with village leaders | • Transportation method<br>• Travel time<br>• Vehicle operating costs<br>• Transportation costs |
| Quantitative descriptive analysis | RQ41. Are more input and output traders present in the Dosso-Gaya region as a result of the roads improvements? | • Market records<br>• Surveys with village leaders | • Presence and number of input and output traders |

[22] MCC contracted International Development Group to evaluate the RMA. Mathematica is only assessing to what extent the RMA is contributing to improved outcomes for beneficiaries who also benefit from SSI investments.

Table VI.6 (*continued*)

| Evaluation method | Research questions | Data sources | Key outcomes |
|---|---|---|---|
| Pre-post analysis; quantitative descriptive analysis; qualitative analysis | RQ42. To what extent did the activity contribute to increased volumes and values of agricultural products traded from the BT area? How has the activity changed the quality of crops, in particular produce, brought to market and the quantity of crops lost in transportation post-harvest? | • Survey of SSI and beneficiary households<br>• Survey of traders<br>• Surveys with village leaders<br>• KIIs with traders | • Quantity of crops sold<br>• Crop sales and quality of crops sold<br>• Location of sales<br>• Quantity of crops lost in transit<br>• Perceptions of effect of roads on production |

BT = *Basse Terrasse*; KII = key informant interview; SSI = small-scale irrigation.

### 2. Methods and data sources

The evaluation will draw on household survey data collected at baseline, interim, and endline to conduct a **quantitative pre-post analysis** to measure how SSI beneficiary outcomes—including prices received for crops, travel time, transportation costs, and quantity of crops sold—change over time. This comparison will enable us to document the changes in farmer expenses and income that improvements in the quality of roads have contributed to as a result of the RMA. We will also compare the pre-post changes for different subgroups of interest, such as female beneficiaries versus male beneficiaries, to understand how the RMA might have differentially affected different groups.

In addition to our household survey, we will also conduct a survey of traders in Dosso-Gaya to implement a **quantitative descriptive analysis**, which will describe trader outcomes at different points in time. At the end of each growing season at baseline, interim, and endline, we will survey approximately 30 itinerant and local/fixed traders from five different markets in Dosso-Gaya who transport and sell focus crops. We will ask traders about the quantity and quality of the crops they transported, their origin and destination, their travel time, their vehicle operating costs, and the quantity of crops lost in transit. The information on origin and destination of crops bought and sold will provide information on the changes to economic linkage between the BT and the wider national and international economy; information on the other outcomes will provide suggestive evidence about the economic benefits of improved roads to traders. This will be a descriptive analysis rather than a pre-post analysis because the sample size will likely be too small to conduct a formal statistical test of the change in outcomes over time.

To estimate the change in the number of input and output traders in the area over time, which the sub-activity might have contributed to, we will we will also request trader registration records from these five markets in Dosso-Gaya and conduct brief surveys with village leaders to inquire about the number of traders who purchase at the farm gate. We will request these records while we conduct the trader surveys at the end of each season at baseline, interim, and endline. We will implement the quantitative descriptive analysis using the same approach described previously to describe outcomes at baseline, interim, and endline.

Finally, for the qualitative analysis we will conduct KIIs with traders about the extent to which the improved roads facilitated their own trade with areas outside of the BT. These KIIs will also provide information on how the portfolio of these traders might have changed due to changes in road conditions or the increased production of higher value crops in the BT. We will use the same analytical approach to analyze these qualitative data, as described previously.

### 3. Analytical approach

To implement the **pre-post analysis** we will use the ordinary least squares regression model in **Eq. VI.1** using data collected in the pre period (baseline) and post period (interim or endline).

$$\text{Eq. VI. 1} \quad y_{it} = \beta * Post_t + \lambda_i + \epsilon_{it} \ ,$$

where *i* is an index denoting households and *t* indicates time (baseline or follow-up rounds). $Post$ indicates whether data was collected in the pre or post period, and respectively takes on the values of 0 and 1. Outcome $y_{it}$ is specific to a household at a given time and may be a continuous or binary variable. The estimate of interest is $\beta$ and measures the average difference in outcomes between pre and post periods. Household characteristics that do not change over the time frame of the evaluation, such as the gender or educational attainment of the household head, are controlled for through the inclusion of household fixed effects, $\lambda_i$. To understand how outcomes differentially respond for members of a given subgroup, we will include an interaction of the treatment term with an indicator for subgroup membership.

# VII. DATA COLLECTION

In this chapter, we describe our approach to collecting quantitative household survey data and qualitative KII and FGD data. Our description covers our local data collection partners. We then provide an overview of the data collection timeline and a summary of all data collection activities, sample sizes, relevant modules, and anticipated exposure periods for outcomes of interest. The chapter concludes with our COVID-19 risk mitigation measures.

## A. Local data collection partners

Mathematica has previously contracted with a local data collection partner, Société de Developpement International (SDI) to collect household survey data with an option of also collecting qualitative data. SDI collected quantitative baseline data on the Konni perimeter in 2020, and will be tasked with collecting baseline data in the Dosso-Gaya region, as well as interim and final evaluation data in both project areas. Additionally, our in-country coordinator, Mr. Saidou Amadou Moussa, will work with local youth to collect data for listing purposes in the comparison areas using a smart phone-based data collection application called POKET.

## B. Data collection and reporting timeline

**Table VII.1** presents the timetable for the planned implementation activities in the project area in the Dosso-Gaya region (top panel), the timing for collecting each type of data that will be used in our evaluation (middle panel), and the timeline for the delivery of each report (bottom panel).[23] This table allows for ready comparison of how our data collection timing will align with the status of project activities. For example, our interim quantitative data collection will be scheduled to monitor the effects of project implementation, which will not yet be completed, whereas the endline will provide for a two-year window after the conclusion of implementation to allow more time for impacts to emerge. For any changes in implementation timing that would influence our data collection, we will discuss with MCC and MCA-N whether revising data collection timing would be appropriate.

Data collection timing is specific to the evaluation method for which the data will be used. Baseline, interim, and endline quantitative data will be collected to monitor progress in outcomes from before any IMAP activities begin to more than two years after activity completion to allow sufficient time for farmers to modify their practices and realize increases in agricultural productivity and consumption. The majority of qualitative data will be collected within one year of the conclusion of IMAP activities so that all implementation-related questions can be answered completely; however, the endline infrastructure assessment site visits will also include a small number KIIs to assess the sustainability and maintenance of the irrigation infrastructure.

[23] The implementation timing is based on our reading of the most current project documents available. We will revise this table with any updated timing provided by MCC/MCA-N.

**Table VII.1. Timetable for planned implementation and data collection activities**

| Year | 2021 | | | | 2022 | | | | 2023 | | | | 2024 | | | | 2025 | | | | 2026 | | | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quarter | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 4 |
| **Implementation activities** | | | | | | | | | | | | | | | | | | | | | | | | | |
| SSI construction | | | | | | | | | | | | | | | | | | | | | | | | | |
| BT training activities | | | | | | | | | | | | | | | | | | | | | | | | | |
| Roads for markets | | | | | | | | | | | | | | | | | | | | | | | | | |
| Policy reforms | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Data collection activities** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Baseline household survey | | | | | | | | | | | | | | | | | | | | | | | | | |
| Interim household survey | | | | | | | | | | | | | | | | | | | | | | | | | |
| Endline household survey | | | | | | | | | | | | | | | | | | | | | | | | | |
| Trader, market, and village leader survey | | | | | | | | | | | | | | | | | | | | | | | | | |
| Qualitative data collection | | | | | | | | | | | | | | | | | | | | | | | | | |
| Infrastructure assessment site visits | | | | | | | | | | | | | | | | | | | | | | | | | |
| Project documents and monitoring data | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Reporting timeline** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Baseline report - first draft | | | | | | | | | | | | | | | | | | | | | | | | | |
| Baseine report - final draft | | | | | | | | | | | | | | | | | | | | | | | | | |
| Interim report - first draft | | | | | | | | | | | | | | | | | | | | | | | | | |
| Interim report - final draft | | | | | | | | | | | | | | | | | | | | | | | | | |
| Final report - first draft | | | | | | | | | | | | | | | | | | | | | | | | | |
| Final report - final draft | | | | | | | | | | | | | | | | | | | | | | | | | |
| Denotes end of Niger Compact | | | | | | | | | | | | | | | | | | | | | | | | | |

BT = *Basse Terrasse*; SSI = small-scale irrigation.

**Tables VII.2 and VII.3** present the sample unit, sample size, relevant modules, and exposure period for the quantitative and qualitative data sets we will collect. The exposure period indicates the time required after an intervention for a change in outcome to be observed. The exposure periods draw on findings from literature, where possible, and otherwise are based on an outcome's relative position in the project's logic model.

**Table VII.2. Summary of quantitative data collection**

| Data collection | Timing | Sample unit / respondent | Sample size | Relevant instruments / modules | Exposure period |
|---|---|---|---|---|---|
| Administrative / institutional data from COFOCOMs in Tanda, Gaya, and Tounouga communes; market register information | Annually | N/A | N/A | • Land use rights documentation delivered<br>• Land conflict monitoring system dispute outcomes<br>• COFOCOM financial reports and annual budgets<br>• Number of traders in markets | We estimate that outcomes will be responsive over varying time frames. |
| Project data from MCA-N, IPD contractor, SISM contractor, LTS contractor, SSA contractor | Quarterly/annually | N/A | N/A | • Irrigation construction monitoring information<br>• SSA monitoring information on training participant outcomes for SSA modules on literacy, village savings and loan programs, improved productive activities, and natural resources management<br>• Land conflict monitoring system dispute outcomes | We estimate that outcomes will be responsive over varying time frames. |
| Household survey for impact analysis and quantitative descriptive analysis | Baseline: Q3 2021<br>Interim: Q1 2023<br>Endline: Q1 2026 | Household | 1,675 households;<br>BT-based households are all SSI land owners from the project database as well as randomly selected renters; non-BT households will be selected based on matching procedure after conducting a listing exercise in selected comparison areas. | • Household roster<br>• Poverty Probability Index<br>• Landholdings and leasing/rentals<br>• Farm and livestock assets<br>• Cropping pattern<br>• Agricultural inputs and practices<br>• Agricultural outcomes (e.g., harvest, yield, sales)<br>• Agricultural and non-agricultural income<br>• Irrigation access and usage<br>• Food and nutritional security<br>• Consumer expenditure<br>• Self-reported knowledge gains from agricultural trainings | We estimate that outcomes will be responsive over different time frames, and will vary from the following:<br>For irrigation-related outcomes:<br>• 12–24 months after completion of irrigation construction for changes in agricultural practices to be measurable |

Table VII.2 (*continued*)

| Data collection | Timing | Sample unit / respondent | Sample size | Relevant instruments / modules | Exposure period |
|---|---|---|---|---|---|
| Household survey for impact analysis (continued) | Baseline: Q3 2021<br>Interim: Q1 2023<br>Endline: Q1 2026 | Household | | • Self-reported knowledge gains from nonagricultural trainings<br>• Land tenure security perceptions and experience with land disputes and their resolution<br>• Financial services access and usage | • 36–60 months after completion of irrigation construction for changes in agricultural production and household consumption to be measurable<br>• For training-related outcomes:<br>• 0–12 months after training for self-assessed gains in knowledge to be reported<br>• 12–24 months after training for improved practices to be adopted<br>• 24–60 months after training for increases in productivity to be detectable |
| Trader, market, and village leader survey | Baseline: Q3 2021<br>Interim: Q1 2023<br>Endline: Q1 2026 | Traders;<br>Village leaders;<br>Market records | 30 traders; 10 village leaders; 5 markets | • Presence and number of input and output traders<br>• Transportation method, time, costs<br>• Crop transportation losses<br>• Patterns of crop trade | • 0–12 months after completion of roads<br>• 0–24 months after SSI systems completed to sell dry season production |
| Satellite imagery and data products | Continuous | Land parcel / pixel | Comprehensive across the project area in the Dosso-Gaya region | • Remote sensing-derived map of predicted cropland (cropland mask)<br>• Remote sensing-derived map of predicted crop type (crop type map)<br>• Predicted crop yields<br>• Irrigation water availability and consumption | • 0–12 months after completion of roads<br>• 0–24 months after SSI systems completed to sell dry season production |

Table VII.2 (*continued*)

| Data collection | Timing | Sample unit / respondent | Sample size | Relevant instruments / modules | Exposure period |
|---|---|---|---|---|---|
| Crop cuts | Rainy season 2022, Dry season 2022/2023 | Land parcel | 150 in rainy season, 500 in dry season | • Harvested output by measurement square<br>• Estimated crop yields<br>• Predicted crop yields for non-sampled plots | • 0–12 months after completion of roads<br>• 0–24 months after SSI systems completed to sell dry season production |

BT = *Basse Terrasse*; COFOCOM = *Commissions Foncières Communales*; IPD = Irrigation Perimeter Development Activity; LTS = Land Tenure Security Sub-activity; MCA-N = Millennium Challenge Account/Niger; N/A = Not applicable; SISM = Sustainable Irrigation System Management Sub-activity; SSA = Agricultural Support Services Sub-activity.

**Table VII.3. Summary of qualitative data collection**

| Data collection | Timing (include multiple rounds) | Sample unit / respondent | Sample size | Relevant themes | Exposure period |
|---|---|---|---|---|---|
| Interviews with key informants | Q3/4 2023 | Stakeholders | Approximately 20 (see Appendix Table E.1 for a listing of all KIIs) | *Each interview will have a targeted protocol. Depending on the knowledge of the interviewee, we will cover some of the following topics:*<br>• Project implementation<br>• Functioning of improved irrigation<br>• Perceptions regarding changes of cost of water and community-level outcomes<br>• Role, leadership, and functioning of producer groups (as relevant)<br>• Land tenure registry process and perceptions of land security<br>• Perceptions of training program and outcomes<br>• Cost and access to improved inputs<br>• Access to markets for irrigated crops | The exposure period between the intervention and when outcomes can be observed will vary based on the activity and outcomes of interest. Table VII.2 provides further details on the exposure period by outcome of interest. We do not expect respondents to have developed a reliable perception of outcomes until late in 2023. We will, however, keep abreast of activities to determine the most appropriate time to conduct interviews—particularly for the implementation analysis. We aim to follow progress regularly throughout the evaluation. |
| Focus group discussions | Q3/Q4 2023 | Beneficiaries and producer groups | A total of 7 focus groups | • Discussion guides and protocols for FGDs will be tailored to the participants. Depending on the respondent, the themes could include questions related to the following:<br>• Experiences with implementation<br>• Perceptions of functioning of new/improved irrigation<br>• Adequacy, efficiency, and cost of water for irrigation | We hope to conduct FGDs in late in 2023 because we believe at that point we will be able to observe perceptions of outcomes among the largest share of beneficiaries. |

Table VII.3 (*continued*)

| Data collection | Timing (include multiple rounds) | Sample unit / respondent | Sample size | Relevant themes | Exposure period |
|---|---|---|---|---|---|
| Focus group discussions (continued) | Q3/Q4 2023 | Beneficiaries and producer groups | A total of 7 focus groups | • Perceptions of changes in outcomes based on new/improved irrigation<br>• Outcomes for women<br>• Outcomes for youth<br>• Perceptions of the role, leadership, and participation in producer groups (as relevant)<br>• Land tenure registry process and perceptions of land security<br>• Perceptions of the training program and outcomes<br>• Perception of cost and access to improved inputs<br>• Perception of access to markets | |
| Site visits | Interim: Q2/Q3 2022<br><br>Follow-up: Q3/Q4 2025 | *Basse Terrasse* project area small-scale irrigation infrastructure | 150 tube wells | • Inspection of physical infrastructure<br>• Operational systems and maintenance protocols<br>• In-depth engineering analysis of 25 SSI systems selected at random | For infrastructure-related outcomes, we anticipate an exposure period of 12–24 months after completion of SSI construction for maintenance practices to be observable. An exposure period of 36–48 months should be sufficient to understand the sustainability of maintenance practices. |

FGD = focus group discussion; KII = key informant interview; SSI = small-scale irrigation.

## C. COVID-19 mitigation protocols

To ensure the safety and health of all staff, subcontractors, enumerators, and respondents, Mathematica will assess the COVID-19 related risk associated with each data collection activity and implement risk mitigation protocols in accordance with corporate and MCC guidelines and with respect to all local and national health ordinances. Protocols may include limiting travel for Mathematica staff, conducting remote training and data collection when possible, compulsory wearing of masks by local staff, enumerators, and respondents, screening individuals for symptoms of COVID-19, routine handwashing, and social distancing of at least six feet between individuals. Although the risk and spread of COVID-19 in Niger remains relatively low,[24] we anticipate that COVID-19 risk mitigation protocols will be necessary for baseline data collection and will reassess the situation before subsequent data collection as the situation evolves in Niger.

[24] As of June 4, 2021, Niger had recorded a cumulative total of 5,643 cases and a total of 192 deaths, with 184 cases and 1 death recorded in May 2021 (Johns Hopkins University & Medicine 2021).

# VIII. ADMINISTRATIVE ISSUES

## A. Summary of institutional review board requirements and clearances

Mathematica is committed to protecting the rights and welfare of human subjects and will prepare and submit an application for approval of the research and data collection plans to an institutional review board (IRB) registered with the Office for Human Research Protections, U.S. Department of Health and Human Services. We intend to use Health Media Lab as our IRB because of our positive experience with it on other MCC projects. For each IRB application, we will submit a set of required documents, including a research protocol that provides details of the study and data collection activities, copies of all data collection instruments, and a completed IRB questionnaire summarizing the key elements of the research protocol and plans for protecting participants' confidentiality. The data collection instruments we will prepare and submit to the IRB will include consent statements approved by MCC that guarantee the confidentiality of respondents to the extent possible.

We will provide evidence of IRB approval to MCC. IRB approval is valid for one year; we will submit annual renewals for subsequent approvals as data collection proceeds through follow-up collection processes. We expect the annual renewals to require only minimal updates to the core application materials because we will collect similar data from year to year. If data collection instruments change substantially from those approved by the IRB, we will reapply for review. Small changes to the instruments (such as rewording or reordering of questions, or editing changes) do not require reapplication, but the final instruments must be submitted to the IRB for documentation. We will submit the instruments for review in both English and French. We will collaborate with SDI to obtain approval for conducting fieldwork from the National Statistics Institute in Niger.

## B. Data protection

Mathematica, SDI, and our in-country coordinator will ensure the confidentiality of all data collection respondents, including for data collection participation, personally identifiable information, and other sensitive data. The data collection instruments (both the quantitative instruments and qualitative protocols) will include consent statements approved by MCC that guarantee the confidentiality of respondents to the extent possible. If data are collected on paper instruments, SDI will ensure the safe handling and transport of the instruments from the field to the main office for data entry; the instruments will be stored there in lock-and-key cabinets. If data are collected electronically (our preferred approach), they will be stored on a secure server approved by Mathematica. SDI and POKET will share electronic data files with Mathematica via a secure file transfer system, such as a file transfer protocol or file exchange website (FX or BOX site). The data will be stored on a secure Mathematica server and will be accessible only to project team members who use them. All project team members have signed a nondisclosure agreement pertaining to confidential information. For internal control and audit purposes, SDI will retain the data files, both in paper and electronic form, for the entire duration of the project, including the base contract and the subsequent option contracts. All of the collected data and databases are the property of Mathematica and will be delivered to us at the end of the contract.

## C. Preparing data files for access, privacy, and documentation

Public use data will enable any stakeholder, researcher, or agency to understand the source data and analysis behind MCC evaluations and may inspire a wide range of new policy-relevant research, thus

maximizing the benefits of MCC's investments in large-scale data collection efforts in developing countries. The Mathematica team will prepare public use quantitative data files following MCC's Evaluation Microdata Guidelines and will deliver complete data packages for the MCC Evaluation Catalog. In addition to de-identified quantitative data files, we will provide user manuals and codebooks according to the most recent guidelines set forth by MCC. Public use data files will be free of personal or geographic identifiers that would enable unassisted identification of individual respondents or their households, and we will remove or adjust variables that introduce reasonable risks of deductive disclosure of the identity of individual participants. We will also recode unique and rare data by using top and bottom coding or replacing affected observations with missing values. If necessary, we will also collapse any variables that make an individual highly visible because of geographic or other factors into less easily identifiable categories.

Unlike quantitative data, for which we will be able to use fairly straightforward processes to provide anonymity, many of the key informants and focus group participants who will be invited to participate in the qualitative data collection may have a unique perspective (for example, as the leader of a certain institution). We might need to make substantial changes to the transcripts to protect these respondents' identities. These modifications to the transcripts might render them less valuable as a public good; without such protections, however, respondents would be unlikely to offer complete and honest answers to questions essential to the evaluation. If we provide public use versions of the transcripts without rendering them adequately anonymous, participants could be at risk of social or professional repercussions if powerful institutions or individuals learned of any negative comments made during the interviews. We will attempt to redact FGDs such that no identifiers will remain that could be used to link respondents to their comments. We do not, however, believe this redaction is possible with respect to KIIs. We will seek IRB guidance and advice on how to balance MCC's desire for data accessibility with the need to protect respondents' identities.

## D. Dissemination plan

The Mathematica team will present evaluation findings in person at both MCC and MCA-N headquarters. We will also participate in any other MCC-financed dissemination and training events related to the findings from the baseline, interim, and final reports. To ensure that the results and lessons from the evaluation reach a wide audience, we will work with MCC to increase the visibility of the evaluation and findings within the agriculture sector, especially for policymakers and practitioners. After acceptance of the interim and final evaluation reports, the team will develop a policy brief with findings and analysis relevant to MCC, MCA-N, and Government of Niger decision makers. We expect the broader research community to have a strong interest in the evaluation findings. To facilitate wider dissemination of findings and lessons, we will collaborate with MCC and other stakeholders to identify additional forums—conferences, workshops, and publications—for disseminating the results.

## E. Evaluation team roles and responsibilities

Our team has vast experience in Niger and combined expertise in irrigation infrastructure, agriculture development projects, rigorous performance and impact evaluations, complex data collection, and French language skills, and therefore will be able to meet MCC's evaluation needs. Our program manager, **Mr. Matt Sloan,** oversees the project team and provides technical leadership and quality assurance on all deliverables. He ensures coordination with various partners and the team and serves as MCC's primary point of contact. **Dr. Christopher Ksoll** serves as the agricultural development senior analyst and principal investigator, leading all quantitative evaluation design and analysis tasks. **Dr. Anthony Louis**

**D'Agostino** will assist Dr. Ksoll as senior analyst, working on the design of the performance evaluations, including the incorporation of GIS information into the data analysis. **Dr. Esteban Quinones** serves as an expert on the quantitative data analysis in the agriculture sector and will oversee the development of the quantitative data collection instruments. **Ms. Margo Berends**, a junior analyst, will support the training, data collection, and analysis tasks. **Ms. Patricia Costa**, a senior analyst, will oversee the qualitative parts of the evaluation, with support from a junior analyst, **Ms. Galina Lapadatova**. **Ms. Poorva Upadhyaya** manages the project internally for Mathematica. **Mr. Saidou Amadou Moussa,** our in-country coordinator, is a native of Niger and will oversee data collection fieldwork, data quality monitoring, the coordination of site visits, assisting with communications with MCA-N, and keeping our team apprised of project implementation.

**This page has been left blank for double-sided copying.**

# REFERENCES


Abric, S., M. Sonou, B. Augeard, F. Onimus, D. Durlin, A. Soumila, and F. Gadelle. "Lessons Learned in the Development of Smallholder Private Irrigation for High-Value Crops in West Africa." The World Bank, FAO, IFAD, Practica, ARID and IWMI Joint Discussion Paper 66917. Washington, DC: World Bank, 2011.

Aker, Jenny. "Dial 'A' for Agriculture: A Review of Information and Communication Technologies for Agricultural Extension in Developing Countries." *Agricultural Economics*, vol. 42, no. 6, 2011, pp. 631–647.

Ali, Daniel A., Matthew Collin, Klaus Deininger, Stefan Dercon, Justin Sandefur, and Andrew Zeitlin. "Small Price Incentives Increase Women's Access to Land Titles in Tanzania." *Journal of Development Economics*, vol. 123, no. C, 2016, pp. 107–122.

Ali, Daniel A., Klaus Deininger, and Markus Goldstein. "Environmental and Gender Impacts of Land Tenure Regularization in Africa: Pilot Evidence from Rwanda." *Journal of Development Economics*, vol. 110, no. C, 2014, pp. 262–275.

Anderson, Jock R., and Gershon Feder. "Agricultural Extension: Good Intentions and Hard Realities." *The World Bank Research Observer*, vol. 19, no. 1, 2004, pp. 41–60.

Arnot, Chris D., Martin K. Luckert, and Peter C. Boxall. "What is Tenure Security" Conceptual Implications for Empirical Analysis." *Land Economics*, vol. 87, no. 2, 2011, pp. 297-311.

Aw, Djibril, and Geert Diemer. *Making a Large Irrigation Scheme Work.* Washington, DC: World Bank, 2005.

Backiny-Yetna, Prospere, and Kevin McGee. "Gender Differentials and Agricultural Productivity in Niger." Policy Research Working Paper 7199. Washington, DC: World Bank, 2015.

Balana, Bedru B., Jean-Claude Bizimana, James W. Richardson, Nicole Lefore, Zenebe Adimassu, and Brian K. Herbst. "Economic and Food Security Effects of Small-Scale Irrigation Technologies in Northern Ghana." *Water Resources and Economics*, vol. 29, 2020, p. 100141.

Benin, Samuel, Mohamed Ahmed, John Pender, and Simeon Ehui. "Development of Land Rental Markets and Agricultural Productivity Growth: The Case of Northern Ethiopia." *Journal of African Economies*, vol. 14, no. 1, March 2005, pp. 21–54.

Benjaminsen, Tor A., Stein Holden, Christian Lund, and Espen Sjaastad. "Formalisation of Land Rights: Some Empirical Evidence from Mali, Niger and South Africa." *Land Use Policy,* vol. 26, no. 1, 2009, pp. 28–35.

BenYishay, Ariel, and A. M. Mobarak. "Social Learning and Incentives for Experimentation and Communication." *The Review of Economic Studies,* vol. 95, 2018, pp. 1–34.

Berg, Claudia N., Brian Blankespoor, and Harris Selod. "Roads and Rural Development in Sub-Saharan Africa." *The Journal of Development Studies*, vol. 54, no. 5, 2018.

Bezu, Sosina, and Stein Holden. "Demand for Second-Stage Land Certification in Ethiopia: Evidence from Household Panel Data." *Land Use Policy*, vol. 41, 2014, pp. 193–205.

Bos, M. G., D. H. Murray-Rust, D. J. Merrey, H. G. Johnson, and W. B. Snellen. "Methodologies for Assessing Performance of Irrigation and Drainage Management." *Irrigation and Drainage Systems*, vol. 7, 1994, pp. 231–261.

Bradbury, A., J. Hine, P. Njenga, A. Otto, G. Muhia, and S. Willilo. "Evaluation of the Effect of Road Condition on the Quality of Agricultural Produce: Phase 2 Report." London, UK: TRL Limited and IFRTD, September 2017.

Buckley, S. M., P. S. Agram, J. E. Belz, R. E. Crippen, E. M. Gurrola, S. Hensley, M. Kobrick, M. Lavalle, J. M. Martin, M. Neumann, Q. D. Nguyen, P. A. Rosen, J. G. Shimada, M. Simard, and W. W. Tung. "NASADEM." National Aeronautics and Space Administrative, Jet Propulsion Laboratory, January 2020.

Buehren, Niklas, Markus Goldstein, Ezequiel Molina, and Julia Vaillant. "The Impact of Strengthening Agricultural Extension Services: Evidence from Ethiopia." World Bank Policy Research Working Paper, 2017, pp. 1–28.

Burney, Jennifer, Lennart Woltering, Marshall Burke, Rosamond Naylor, and Dov Pasternak. "Solar-Powered Drip Irrigation Enhances Food Security in the Sudano-Sahel." *Proceedings of the National Academy of Sciences*, vol. 107, no. 5, 2010, p. 1848-1853.

Burney, Jennifer A., and Rosamond L. Naylor. "Smallholder Irrigation as a Poverty Alleviation Tool in Sub-Saharan Africa." *World Development*, vol. 40, no. 1, 2012, pp. 110–123.

Burney, Jennifer A., Rosamond L. Naylor, and Sandra L. Postel. "The Case for Distributed Irrigation as a Development Priority in Sub-Saharan Africa." *Proceedings of the National Academy of Sciences*, vol. 110, no. 31, 2013, pp. 12513–12517.

Casaburi, Lorenzo, Rachel Glennerster, and Tavneet Suri. "Rural Roads and Intermediated Trade: Regression Discontinuity Evidence from Sierra Leone." Cambridge, MA: Harvard University, Massachusetts Institute of Technology and MIT Sloan School of Management, August 2013.

CIA (Central Intelligence Agency). "The World Factbook: Niger." December 10, 2018. Available at https://www.cia.gov/library/publications/the-world-factbook/geos/ng.html. Accessed January 4, 2019.

Corral, Carolina, Xavier Giné, Aprajit Mahajan, and Enrique Seira. "Improving Yields with Improved Recommendations." In *Learning for Adopting: Technology Adoption in Developing Country Agriculture*, edited by Alain de Janvry, Karen Macours, and Elisabeth Sadoulet. Chapter 10. Clermont-Ferrand, France: Ferdi, 2016, pp. 103–106.

Creswell, John W. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (3rd ed.). Thousand Oaks, CA: Sage Publications, Inc., 2009.

Crewett, Wibke, and Benedikt Korf. "Ethiopia: Reforming Land Tenure." *Review of African Political Economy*. vol. 35, no. 116, 2008, pp. 203–220.

D'Agostino, Anthony Louis, Christopher Ksoll, Patricia Costa, Galina Lapadatova, and Matt Sloan. "Niger Irrigation and Market Access: Evaluation Design Report." Report submitted to the Millennium Challenge Corporation. Washington, DC: Mathematica, December 2019.

Davis, K., E. Nkonya, E. Kato, D. A. Mekonnen, M. Odendo, R. Miiro, and J. Nkuba. "Impact of Farmer Field Schools on Agricultural Productivity and Poverty in East Africa." *World Development*, vol. 40, no. 2, 2012, p. 402–413.

de Fraiture, Charlotte and Mark Giordano. "Small Private Irrigation: A Thriving but Overlooked Sector." *Agricultural Water Management*, vol. 131, 2014, pp. 167–174.

de Fraiture, Charlotte, Gael Ndanga Kouali, Hilmy Sally, and Priva Kabre. "Pirates or Pioneers? Unplanned Irrigation Around Small Reservoirs in Burkina Faso." *Agricultural Water Management*, vol. 131, 2014, pp. 212–220.

Deininger, Klaus, Daniel A. Ali, and Tekie Alemu. “Impacts of Land Certification on Tenure Security, Investment, and Land Market Participation: Evidence from Ethiopia.” *Land Economics*, vol. 87, no. 2, 2011, pp. 312–334.

Deininger, Klaus, Daniel A. Ali, Stein Holden, and Jaap Zevenbergen. “Rural Land Certification in Ethiopia: Process, Initial Impact, and Implications for Other African Countries.” *World Development*, vol. 36, no. 10, 2008, pp. 1786–1812.

Deininger, Klaus, and Hans P. Binswanger. “Rent Seeking and the Development of Large-Scale Agriculture in Kenya, South Africa, and Zimbabwe.” *Economic Development and Cultural Change*, vol. 43, no. 3, 1995, pp. 493–522.

Deininger, Klaus, and Aparajita Goyal. “Going Digital: Credit Effects of Land Registry Computerization in India.” *Journal of Development Economics*, vol. 99, no. 2, 2012, p. 236–243.

Deininger, Klaus, and Songqing Jin. “Tenure Security and Land-Related Investment: Evidence from Ethiopia.” *European Economic Review*, vol. 50, no. 5, 2006, p. 1245–1277.

Deininger, Klaus, and Songqing Jin. “Securing Property Rights in Transition: Lessons from Implementation of China’s Rural Land Contracting Law.” *Journal of Economic Behavior & Organization*, vol. 70, 2009, p. 22–38.

Deininger, Klaus, Fang Xia, and Sara Svastano. “Smallholders’ Land Ownership and Access in Sub-Saharan Africa: A New Landscape?” Policy Research Working Paper 7285. Washington, DC: World Bank Group, June 2015.

Delgado, Luciana, Monica Schuster, and Maximo Torero. “The Reality of Food Losses: A New Measurement Methodology.” Discussion Paper 01686. Washington, DC: International Food Policy Research Institute, December 2017.

Devoto, Florencia, Esther Duflo, Pascaline Dupas, William Parienté, and Vincent Pons. “Happiness on Tap: Piped Water Adoption in Urban Morocco.” *American Economic Journal: Economic Policy*, vol. 4, no. 4, 2012, pp. 68–99.

Dillon, Andrew. “The Effect of Irrigation on Poverty Reduction, Asset Accumulation, and Informal Insurance: Evidence from Northern Mali.” *World Development*, vol. 39, no. 12, 2011, pp. 2165–2175.

Domènech, Laia. “Is Reliable Water Access the Solution to Undernutrition?” International Food Policy Research Institute, IFPRI Discussion Paper, 2015, pp. 1–36.

Duflo, Esther, and Rohini Pande. “Dams.” *The Quarterly Journal of Economics*, vol. 122, no. 2, 2007, pp. 601–646.

Dugje, I. Y., L. O. Omoigui, F. Ekeleme, A. Y. Kamara, and H. Ajeigbe. “Farmers’ Guide to Cowpea Production in West Africa.” Ibadan, Nigeria: International Institute of Tropical Agriculture.

Evenson, Robert E. “Economic Impacts of Agricultural Research and Extension.” In *Handbook of Agricultural Economics*, edited by Bruce L. Gardner and Gordon C. Rausser. Elsevier Science B.V., 2001.

Evenson, Robert and Douglas Gollin. “Assessing the Impact of the Green Revolution, 1960 to 2000.” *Science*, vol. 300, no. 5260, 2003, pp. 758-762.

FAO (Food and Agriculture Organization). 2021a. Agriculture Production Data. Available at http://www.fao.org/faostat/en/#data/RT. Accessed June 2, 2021.

FAO (Food and Agriculture Organization). 2021b. WaPOR, Remote Sensing for Water Productivity. Available at http://www.fao.org/in-action/remote-sensing-for-water-productivity/en/. Accessed May 10, 2021.

FAO (Food and Agriculture Organization). 2016. AQUASTAT Main Database, Food and Agriculture Organization of the United Nations (FAO). Accessed: May 21, 2019.

Feder, Gershon, Richard E. Just, and David Zilberman. "Adoption of Agricultural Innovations in Developing Countries: A Survey." *Economic Development and Cultural Change*, vol. 33, no. 2, 1985, pp. 255–298.

Foster, Andrew D., and Mark R. Rosenzweig. "Microeconomics of Technology Adoption." *Annual Review of Economics*, vol. 2, no. 1, 2010, pp. 395–424.

Funk, Chris, Pete Peterson, Martin Landsfeld, Diego Pedreros, James Verdin, Shraddhanand Shukla, Gregory Husak, James Rowland, Laura Harrison, Andrew Hoell, and Joel Michaelsen. "The Climate Hazard Infrared Precipitation with Statons – A New Environmental Record for Monitoring Extremes." *Scientific Data*, vol. 2, no, 1, 2015.

Giordano, Meredith, and Charlotte de Fraiture. "Small Private Irrigation: Enhancing Benefits and Managing Trade-Offs." *Agricultural Water Management*, vol. 131, 2014, pp. 175–182.

Glendenning, Claire, Suresh Babu, and Kwadwo Asenso-Okyere. "Review of Agricultural Extension in India: Are Farmers' Information Needs Being Met?" International Food Policy Research Institute, IFPRI Discussion Paper, 2010, pp. 1–48.

Goldstein, Markus, Kenneth Houngbedji, Florence Kondylis, Michael O'Sullivan, and Harris Selod. "Formalizing Rural Land Rights in West Africa: Early Evidence from a Randomized Impact Evaluation in Benin." Policy Research Working Paper 7435. Washington, DC: World Bank, 2015.

Gottlieb, Charles, and Jan Grobovsek. "Communal Land and Agricultural Productivity." *Journal of Development Economics*, vol. 138, 2019, pp. 135–152.

Hampshire, Katherine, Rachel Casiday, Kate Kilpatrick, and Catherine Panter-Brick. "The Social Context of Childcare Practices and Child Malnutrition in Niger's Recent Food Crisis." *Disasters*, vol. 33, no. 1, 2009, pp. 132-151.

Hine, J., M. Abedin, R. J. Stevens, T. Airey, and T. Anderson. "Does the Extension of the Rural Road Network Have a Positive Impact on Poverty Reduction and Resilience for the Rural Areas Served? If So How, and If Not Why Not? A Systematic Review." London, UK: EPPI-Centre, Social Science Research Unit, UCL, 2016.

Hine, J., and A. Bradbury. "Ex-Post Evaluation of AFD/GOK Roads 2000: Final Report". London, UK: TRL Limited, 2016.

Ho, Peter, and Max Spoor. "Whose Land? The Political Economy of Land Titling in Transitional Economies." *Land Use Policy*, vol. 23, no. 4, 2006, pp. 580–587.

Hossain, M., F. Naher, and Q. Shahabuddin. "Food Security and Nutrition in Bangladesh: Progress and Determinants." *Electronic Journal of Agricultural and Development Economics*, vol. 2, no. 2, 2005, pp. 103–132.

Hughes O. 2014. "Literature Review of Land Tenure in Niger, Burkina Faso, and Mali: Context and Opportunities." Baltimore: CRS, 2014.

Hussain, Intizar, and Munir A. Hanjra. "Irrigation and Poverty Alleviation: Review of the Empirical Evidence." *Irrigation and Drainage,* vol. 53, no. 1, 2004, pp. 1–15.

Hussain, Syed S., Derek Byerlee, and Paul W. Heisey. "Impacts of the Training and Visit Extension System on Farmers' Knowledge and Adoption of Technology: Evidence from Pakistan." *Agricultural Economics*, vol. 10, no. 1, 1994, pp. 39–47.

Illiassou, Mossi Maïga. "La Gestion Collective des Systèmes Irrigués : Cas des Aménagements Hydroagricoles Rizicoles Dans la Vallée du Fleuve Niger au Niger." Mémoire en Vue de l'Obtention de Diplôme d'Études Approfondies, Université Toulouse-le Mirail. 2005.

Jacoby, Hanan G. "Access to Markets and the Benefits of Rural Roads: A Nonparametric Approach." Washington DC: World Bank, 1998.

Jin, Songqing, and Thomas S. Jayne. "Land Rental Markets in Kenya: Implications for Efficiency, Equity, Income, and Poverty." *Land Economics*, vol. 89, no. 2, 2013, pp. 246–271.

Johns Hopkins University & Medicine. "COVID-19 Dashboard." 2021. Available at https://coronavirus.jhu.edu/map.html. Accessed June 4, 2021.

Kondylis, Florence, Valerie Mueller, Glenn Sheriff, and Siyao Zhu. "Do Female Instructors Reduce Gender Bias in Diffusion of Sustainable Land Management Techniques? Experimental Evidence from Mozambique." *World Development*, vol. 78, 2016, pp. 436–449.

Kondylis, Florence, Valerie Mueller, and Jessica Zhu. "Seeing Is Believing? Evidence from an Extension Network Experiment." *Journal of Development Economics*, vol. 125, no. C, 2017, pp. 1–20.

Krishnan, P., and M. Patnam. "Neighbors and Extension Agents in Ethiopia: Who Matters More for Technology Adoption?" *American Journal of Agricultural Economics*, vol. 96, no. 1, 2013, pp. 308–327.

Ksoll, Christopher, Chantal Toledo, Seth Morgan, Anca Dumitrescu, and Kristen Velyvis. "Evaluation of the Burkina Faso Agriculture Development Project: Design Report." Washington, DC: Mathematica Policy Research, June 6, 2017.

Ksoll, Christopher, Margo Berends, Esteban J. Quiñones, Anthony Louis D'Agostino, Poorva Upadhyaya. "Niger Irrigation and Market Access: Baseline Report." Report submitted to the Millennium Challenge Corporation. Washington, DC: Mathematica, May 2021.

Kuyu, Chala G., Yetenayet B. Tola, and Gemechu G. Abdi. "Study on Post-Harvest Quantitative and Qualitative Losses of Potato Tubers from Two Different Road Access Districts of Jimma Zone, South West Ethiopia." *Heliyon*, vol. 5, 2019.

Larsen, Anna F., and Helene B. Lilleør. "Beyond the Field: The Impact of Farmer Field Schools on Food Security and Poverty Alleviation." *World Development,* vol. 64, no. C, 2014, pp. 843–859.

Lawry, Steven, Cyrus Samii, Ruth Hall, Aaron Leopold, Donna Hornby, and Farai Mtero. "The Impact of Land Property Rights Interventions on Investment and Agricultural Productivity in Developing Countries: A Systematic Review." *Journal of Development Effectiveness,* vol. 9, no. 1, 2017, pp. 61–81.

Lawry, Steven, Cyrus Samii, Ruth Hall, Aaron Leopold, Donna Hornby, and Farai Mtero. "The Impact of Land Property Rights Interventions on Investment and Agricultural Productivity in Developing Countries." The Campbell Collaboration, 2014.

Lund, Christian. "Struggles for Land and Political Power: On the Politicization of Land Tenure and Disputes in Niger." *The Journal of Legal Pluralism and Unofficial Law*, vol. 30, no. 40, 1998, pp. 1–22.

Macours, Karen, Alain de Janvry, and Elisabeth Sadoulet. "Insecurity of Property Rights and Social Matching in the Tenancy Market." *European Economic Review*, vol. 54, no. 7, October 2010, pp. 880–899.

Millennium Challenge Corporation (MCC). "Millennium Challenge Compact Between the United States of America Acting Through the Millennium Challenge Corporation and the Republic of Niger Acting Through the Ministry in Charge of Foreign Affairs and Cooperation." Washington, DC: Millennium Challenge Corporation, July 29, 2016.

MCC and UC-PMC. "Rapport sur le Foncier et Recommandations pour l'Activité de Sécurisation Foncière—Périmètre de Konni." 2017.

McKenzie, David. 2012. "Beyond Baseline and Follow-Up: The Case for More T in Experiments." *Journal of Development Economics*, vol. 99, 2012, pp. 210–221.

Merrey, Douglas J., and Hilmy Sally. 2014. "Improving Access to Water for Agriculture and Livestock in Niger: A Preliminary Analysis of Investment Options for the Millennium Challenge Corporation." Submitted to Millennium Challenge Corporation.

Migot-Adholla, Shem, Peter Hazell, Benoit Blarel, and Frank Place. "Indigenous Land Rights Systems in Sub-Saharan Africa: A Constraint on Productivity?" *The World Bank Economic Review*, vol. 5. no. 1, 1991, pp. 155–175.

Mullan, Katrina, Pauline Grosjean, and Andreas Kontoleon. "Land Tenure Arrangements and Rural-Urban Migration in China." *World Development*, vol. 39, no. 1, 2011 pp. 123–133.

Muraoka, Rie, Songqing Jin, and Thomas S. Jayne. "Land Access, Land Rental and Food Security: Evidence from Kenya." *Land Use Policy*, vol. 70, 2018, p. 611–622.

Mwangi, Joseph K., and Wibke Crewett. "The Impact of Irrigation on Small-Scale African Indigenous Vegetable Growers' Market Access in Peri-Urban Kenya." *Agricultural Water Management*, vol. 212, 2019, pp. 295–305.

Nkwae, Boipuso and Dixon Dumba. "From Certificates of Rights to Long-Term Leaseholds in Botswana." *Habitat International*, vol. 34, no. 4, 2010. pp. 367–373.

Place, F., and K. Otsuka. "Land Tenure Systems and Their Impacts on Agricultural Investments and Productivity in Uganda." *Journal of Development Studies*, vol. 38, no. 6, 2002, pp. 105–128.

Place, Frank. "Land Tenure and Agricultural Productivity in Africa: A Comparative Analysis of the Economics Literature and Recent Policy Strategies and Reforms." *World Development*, vol. 37, no. 8, 2009, pp. 1326–1336.

Prindex. "Prindex Comparative Report: March 2019." Prindex, 2019.

Ragasa, Catherine, Guush Berhane, Fanaye Tadesse, and Alemayehu S. Taffesse. "Gender Differences in Access to Extension Services and Agricultural Productivity." International Food Policy Research institute (IFPRI), ESSP II Working Paper, 2012.

Ricker-Gilbert, Jacob, and Jordan Chamberlin. "Transaction Costs, Land Rental Markets, and Their Impact on Youth Access to Agriculture in Tanzania." *Land Economics*, vol. 94, no. 4, November 2018, p. 541–555.

Rosenzweig, Mark R. and Christopher Udry. "External Validity in a Stochastic World: Evidence from Low-Income Countries." *Review of Economic Studies*, vol. 87, 2020, pp. 343-381.

RTI Exploration. "*Rapport Final sur la Composante A: Etudes pour le développement d'outils pour la Planification de la gestion des ressources en eaux souterraines et le renforcement des capacités au Niger (télédétection, étude hydrogéologie, et renforcement des capacités).*" Contrat No. IR/MSM/2/F.0045/19. Report submitted to the Millennium Challenge Corporation, Washington, DC, 2020.

RTI Exploration and UNLV. "*Rapport Final sur la Composante B: Etudes pour le développement d'outils pour la planification de la gestion des ressources en eaux souterraines et le renforcement des capacités au Niger (télédétection, étude hydrogéologie, et renforcement des capacités)*." Contrat No. IR/MSM/2/F.0045/19. Report submitted to the Millennium Challenge Corporation, Washington, DC, 2020.

Sayers, M. W., Gillespie, T. D., & Paterson, W. D. (1986). Guidelines for Conducting and Calibrating Road Roughness Measurements. Washington, D.C. USA: The World Bank

Sekhri, Sheetal. "Wells, Water, and Welfare: The Impact of Access to Groundwater on Rural Poverty and Conflict." *American Economic Journal: Applied Economics*, vol. 6, no. 3, 2014, pp. 76–102.

Shamdasani, Yogita. "Rural Road Infrastructure & Agricultural Production: Evidence from India." New York: Columbia University, June 2018.

Sibomana, M. S., T. S. Workneh, and K. Audain. "A Review of Postharvest Handling and Losses in the Fresh Tomato Supply Chain: A Focus on Sub-Saharan Africa." *Food Security*, vol. 8, 2016, pp. 389–404.

Sitko, Nicholas J., Jordan Chamberlin, and Munguzwe Hichaambwa. "Does Smallholder Land Titling Facilitate Agricultural Growth?: An Analysis of the Determinants and Effects of Smallholder Land Titling in Zambia." *World Development,* vol. 64, no. C, 2014, pp. 791-802.

Sotelo, Sebastian. "Domestic Trade Frictions and Agriculture." Working paper. 2019.

Steyn, W. J., B. Nokes, L. du Plessis, R. Agacer, N. Burmas, and L. Popescu. "Evaluation of the Effect of Rural Road Condition on Agricultural Produce Transportation." *Journal of the Transportation Research Board*, no. 2473, 2015, pp. 33–41.

Swanson, Burton E. "Changing Extension Paradigms Within a Rapidly Changing Global Economy." *Proceedings of the European Seminar on Extension Education Theory and Practice of Advisory Work in a Time of Turbulences.* Perugia, Italy: INEA, 2009.

Tack, Jesse, and Jenny C. Aker. "Information, Mobile Telephony, and Traders' Search Behavior in Niger." *American Journal of Agricultural Economics*, vol. 96, no. 5, 2014, pp. 1439–1454.

Turiansky, Abbie, Christopher Ksoll, Caroline Lauver, and Matt Sloan. "Niger Irrigation and Market Access: Evaluability Assessment." Mathematica Policy Research Technical Report. Washington, DC: Mathematica Policy Research, November 8, 2018.

UN (United Nations). "Human Development Data: All Tables and Dashboard." Available at http://hdr.undp.org/en/content/download-data. Accessed April 27, 2021.

Villholth, K. G. "Groundwater Irrigation for Smallholders in Sub-Saharan Africa—A Synthesis of Current Knowledge to Guide Sustainable Outcomes." *Water International*, vol. 38, no. 4, 2013, pp. 369–391.

Waddington, Hugh, Birte Snilstveit, Jorge Hombrados, Martina Vojtkova, Daniel Phillips, Philip Davies, and Howard White. "Farmer Field Schools for Improving Farming Practices: A Systematic Review." The Campbell Collaboration, 2014.

Wang, Sherrie, Stefania Di Tommaso, Jillian M. Deines, and David B. Lobell. "Mapping Twenty Years of Corn and Soybean Across the US Midwest Using the Landsat Archive." *Nature: Scientific Data*, vol. 7, no. 307, 2020, pp. 1–14.

Wooldridge, Jeffrey M. "Inverse Probability Weighted Estimation for General Missing Data Problems." *Journal of Econometrics*, vol. 141, no. 2, 2007, pp. 1281-1301.

World Bank. "Agricultural Sector Risk Assessment in Niger: Moving from Crisis Response to Long-Term Risk Management." Washington, DC: 2013.

World Bank. "Développement de l'Irrigation au Niger: Diagnostic et Options Stratégiques." Rapport 49379. Washington, DC: 2009.

World Bank. "Project Information Document/Integrated Safeguards Data Sheet (PID/ISDS)." Report No. PIDISDSC23726. 2018.

World Bank. "Republic of Niger: Priorities for Ending Poverty and Boosting Shared Prosperity—Systematic Country Diagnostic." Report No. 115661-NE. 2017.

WFP (World Food Programme). "Niger Factsheet." Available at http://www1.wfp.org/countries/niger. Accessed August 10, 2018.

Yami, Mastewal, and Katherine A. Snyder. "After All, Land Belongs to the State: Examining the Benefits of Land Registration for Smallholders in Ethiopia." *Land Degradation & Development*, vol. 27, no. 3, 2016. pp. 465–478.

You, Liangzhi, Claudia Ringler, Ulrike Wood-Sichra, Richard Robertson, Stanley Wood, Tingju Zhu, Gerald Nelson, Zhe Guo, and Yan Sun. "What Is the Irrigation Potential for Africa? A Combined Biophysical and Socioeconomic Approach." *Food Policy*, vol. 36, 2011, pp. 770-782.

Zeweld, Woldegebrial, Guido V. Huylenbroeck, Assefa Hidgot, M. G. Chandrakanth, and Stijn Speelman. "Adoption of Small-Scale Irrigation and Its Livelihood Impacts in Northern Ethiopia." *Irrigation and Drainage*, vol. 64, no. 5, 2015, pp. 655–668.

# APPENDIX A.

## Evaluation questions and links to logic model

**This page has been left blank for double-sided copying.**

**Table A.1. Evaluation questions and links to program logic**

| Activity | Question group | | Key outcomes | Theory of change level |
|---|---|---|---|---|
| **Overarching questions** | | | | |
| | **RQ1** | Did the project components interact as envisioned during project design to reach a common objective? If yes, what facilitated the interaction and if not, why not? Was there close coordination and planning among the different contractors designing and implementing the activity (land governance, infrastructure, training in infrastructure management, and agricultural services)? Did UNOPS in the role of project management consultant facilitate the rollout and coordination of activities? | • Implementation fidelity<br>• Implementation barriers and facilitators<br>• Lessons learned<br>• Implementation coordination and examples of cross-agency planning | Compact activities and outputs; program logic assumptions |
| | **RQ3** | What is the impact of SSI investments on beneficiary households' incomes, volumes, and value of agricultural products sold and traded, food and nutritional security, and production of cash crops? | • Cropping pattern<br>• Agricultural sales<br>• Agricultural and non-agricultural income<br>• Food and nutritional security | Long-term beneficiary outcomes |
| | **RQ3a** | Do agricultural input use, crop choice, agricultural techniques and agricultural income, volumes, and value of agricultural products differ between landowners and renters or renter groups? If so, why? | • Cropping pattern<br>• Agricultural sales<br>• Agricultural and non-agricultural income<br>• Food and nutritional security<br>• Landowners' share of renter agricultural profits<br>• Factors affecting differences in outcomes between landowners and renters | Long-term beneficiary outcomes |
| | **RQ4** | Do stakeholders believe the project was well designed to achieve the project objective? What changes to implementation occurred and why? | • Project design and rollout<br>• Barriers and facilitators<br>• Lessons learned | Compact activities and outputs |
| | **RQ5** | If the project produced results, are they expected to be sustained? | • Sustainability of achievements | Sustainability of project area and beneficiary outcomes; sustainability of compact outputs |

Table A.1 (*continued*)

| Activity | Question group | | Key outcomes | Theory of change level |
|---|---|---|---|---|
| | **RQ6** | What lessons can be drawn to inform future projects? | • Design and rollout<br>• Barriers and facilitators<br>• Lessons learned | Compact activities; Compact outputs; project area outcomes; beneficiary outcomes; program logic assumptions |
| | **RQ7** | What is the post-compact ERR of the Project (except for the Roads for Market Access Activity)? | • Construction costs<br>• Agricultural and non-agricultural incomes<br>• Irrigation access, costs, and usage<br>• Perceptions of market distortions of inputs and outputs | Long-term project area outcomes |
| **Irrigation Perimeter Development Activity** | | | | |
| | **RQ8** | Were project activities implemented as planned? If not, what changes occurred? | • Design and rollout of irrigation activities<br>• Barriers and facilitators for irrigation activity<br>• Lessons learned | Compact activities |
| | **RQ9** | Were the expected outputs produced by the activity? | • Number of SSI systems that were constructed<br>• Quality of construction materials | Compact outputs |
| | **RQ10** | Is the new infrastructure operating and functioning properly? | • Percentage of SSI systems providing irrigation<br>• Proper operation of SSI infrastructure<br>• Proper functioning of SSI infrastructure<br>• Extent of and reasons for defective SSI infrastructure | Short-term project area outcomes |
| | **RQ11** | Is water for irrigation in farmers' plots available as expected from the SSI systems, including frequency, timing, and amount as planned? If not, why not? | • Irrigation availability<br>• Factors affecting irrigation accessibility to households | Short-term project area outcomes |

Table A.1 (*continued*)

| Activity | Question group | | Key outcomes | Theory of change level |
|---|---|---|---|---|
| | **RQ12** | Did irrigated land increase as expected? If not, why not? | • Land under irrigation<br>• Factors affecting irrigation expansion | Medium-term project area outcomes |
| | **RQ13** | What is the cost of irrigation, including any fuel costs for pumping water? If water was available before the SSI system was built, how did the cost of irrigation water change? | • Irrigation cost (including operations and maintenance costs)<br>• Factors affecting irrigation cost | Medium-term project area outcomes |
| **Management Services and Market Facilitation Activity** | | | | |
| | **RQ14** | Were project activities implemented as planned? If not, what changes occurred? | • Design and rollout of SSA activities<br>• Barriers and facilitators for SSA<br>• Coordination with beneficiaries<br>• Lessons learned | Compact activities |
| | **RQ15** | Were the expected outputs produced by the activity? | • Trainings conducted<br>• Number of participants | Compact outputs |
| **SISM** | **RQ16** | Did the project support the institutions or market actors responsible for O&M as planned? What is the capacity of these institutions or market actors, and the government oversight institutions? | • Type of support for O&M actors<br>• Functioning and capacity of O&M actors and government oversight bodies | Compact outputs |
| **SISM** | **RQ19** | Is the SSI infrastructure being maintained properly? | • Infrastructure maintenance<br>• Availability of spare parts | Medium-term beneficiary outcomes |

Table A.1 (*continued*)

| Activity | Question group | | Key outcomes | Theory of change level |
|---|---|---|---|---|
| **LTS** | **RQ20** | Is the land registry used as a tool by local authorities to continually record changes in landholdings? Do landholders have access to the correct documentation according to the project plan? | • Number of parcels incorporated into official land information system<br>• Continuity of land transaction reporting in land registry<br>• Availability of land tenure documents<br>• Ease of accessing land tenure documents<br>• Number of disputed land and property rights cases<br>• Time required to resolve disputes | Compact outputs and outcomes; short-term beneficiary outcomes |
| **LTS** | **RQ21** | Are the local land commissions in the project zone better equipped to ensure sustainable management of land rights in/around the BT project area? | • COFOCOM revenue and operations costs<br>• Perceptions of COFOCOM effectiveness to manage land conflicts | Short-term institutional outcomes |
| **LTS** | **RQ21a** | Is the formal land rental process used by landholders? How is it functioning? | • Share of renters and sharecroppers operating under a rental contract<br>• Clarity and specificity of contract language<br>• Satisfaction of renters/landowners with contract terms | Short-term institutional outcomes; short-term beneficiary outcomes |
| | **RQ21b** | What are the contractual terms between landowners and renters or renter groups? How are input costs—including costs for the irrigation operation and maintenance— and agricultural outputs shared between owners and renters or renter groups? Have there been disagreements over land usage and contract terms? | • Contract terms (duration, payment of inputs, sharing rule for agricultural outputs)<br>• Frequency of contractual conflicts | Long-term beneficiary outcomes |
| **LTS** | **RQ22a** | What is the impact of SSI investments and land formalization on land tenure security, and the level and risk of land conflict? | • Perceptions of land tenure security<br>• Land conflicts | Medium-term beneficiary outcomes |

Table A.1 (*continued*)

| Activity | Question group | | Key outcomes | Theory of change level |
|---|---|---|---|---|
| **LTS** | **RQ22b** | How do perceptions of land tenure security, risk of land conflict, access to credit, and agricultural inputs, investments, and outputs of landholders compare to tenants and vary among tenants with different contractual terms? | • Perceptions of land tenure security<br>• Land conflicts<br>• Credit access<br>• Use of agricultural inputs and investments<br>• Agricultural output, productivity, and incomes | Medium-term beneficiary outcomes; long-term beneficiary outcomes |
| **SSA** | **RQ26** | Did participants perceive that they learned new skills/knowledge? Did this vary by subgroup? If they didn't perceive learning/acquiring new knowledge, why not? | • Self-reported knowledge gains<br>• Perceptions of training relevance and/or suitability<br>• Perceived barriers to knowledge application | Short-term beneficiary outcomes |
| **SSA** | **RQ27** | What percentage of participants of adult functional literacy and numeracy report improvement in their skills (basic reading and writing) after the training? What percentage of them indicate improved knowledge of nutrition and hygiene, and budgeting and record keeping? | • Test-based outcomes<br>• Self-reported improvements in literacy and numeracy skills | Short-term beneficiary outcomes |
| **SSA** | **RQ28** | What percentage of participants' self-report increased knowledge of sustainable land and water resources management? | • Self-reported management skills | Short-term beneficiary outcomes |
| **SSA** | **RQ29** | What percentage of participants show an active knowledge of improved agricultural practices that they did not know before the training? | • Self-reported knowledge of improved production practices | Short-term beneficiary outcomes |
| **SSA** | **RQ30** | What percentage of members of *comités de gestion* within the producer groups indicate improved knowledge of producer group management? | • Self-reported management skills | Short-term beneficiary outcomes |
| **SSA** | **RQ31** | Have participants applied new practices and technologies? Was this different for women/men or youth/non-youth participants? If knowledge was not applied, why not? | • Perceived barriers to knowledge application | Medium-term beneficiary outcomes |
| **SSA** | **RQ32** | Were savings and loans groups created and fostered by the project? Based on their participation, have group participants indicated they have improved access to credit? | • Number of savings and loan groups<br>• Participants' perception of credit access | Short-term beneficiary outcomes |
| **SSA** | **RQ33** | How are producer groups applying knowledge? | • Examples of knowledge application | Medium-term beneficiary outcomes |

Table A.1 (*continued*)

| Activity | Question group | | Key outcomes | Theory of change level |
|---|---|---|---|---|
| **Roads for Market Access Activity** | | | | |
| | **RQ40** | To what extent did the activity lead to a change in transportation method, travel time, vehicle operating costs, and transportation costs for traders and farmers in the BT and surrounding areas? | • Transportation method<br>• Travel time<br>• Vehicle operating costs<br>• Transportation costs | Short-term beneficiary outcomes; medium-term beneficiary outcomes |
| | **RQ41** | Are more input and output traders present in the Dosso-Gaya region as a result of the roads improvements? | • Presence and number of input and output traders | Medium-term beneficiary outcomes |
| | **RQ42** | To what extent did the activity contribute to increased volumes and values of agricultural products traded from the BT area? How has the activity changed the quality of crops, in particular produce, brought to market and the quantity of crops lost in transportation post-harvest? | • Quantity of crops sold<br>• Crop sales and quality of crops sold<br>• Location of sales<br>• Quantity of crops lost in transit<br>• Perceptions of effect of roads on production | Long-term outcomes |

BT = *Basse Terrasse*; COFOCOM = *Commissions Foncières Communales* ; ERR = estimated rate of return; LTS = Land Tenure Security Sub-activity; O&M = Operations and Maintenance; SISM = Sustainable Irrigation System Management Sub-activity; SSA = Agricultural Support Services Sub-activity; SSI = small-scale irrigation; UNOPS = United Nations Office for Project Services.

**Table A.2. Evaluation methods, research questions, data sources, and key outcomes for implementation analysis of the Policy Reform Activity**

| Research question | Data sources | Key outcomes |
|---|---|---|
| **Policy Reform** | | |
| RQ38. Did the Fertilizer Reform Sub-activity experience any changes to the original design? | • Project documentation<br>• KIIs with MCA-N, Ministry of Agriculture, CAIMA, traders<br>• FGDs with board members of producer groups | • Design and rollout of fertilizer reform activities<br>• Barriers and facilitators for fertilizer support activity<br>• Lessons learned |
| RQ39. Did the National Statistical Capacity Sub-activity experience any changes to the original design? | • Project documentation<br>• KIIs with MCA-N, National Statistics Institute | • Design and rollout of national statistical capacity building activities<br>• Implementation<br>• Barriers and facilitators<br>• Lessons learned |

CAIMA = *Centrale d'Approvisionnement en Intrants et Matériels Agricoles* (Supply Center for Agricultural Inputs and Materials); FGD = focus group discussion; GoN = Government of Niger; KII = key informant interview; MCA-N = Millennium Challenge Account-Niger.

# APPENDIX B.

## Konni and Dosso-Gaya research questions

**This page has been left blank for double-sided copying.**

**Table B.1. Research questions for Konni and Dosso-Gaya**

| RQ # | Research question—Konni | Research question—Dosso-Gaya |
|---|---|---|
| **Overarching questions** | | |
| **RQ1** | Did the project components interact as envisioned during project design to reach a common objective? If yes, what facilitated the interaction and if not, why not? | Did the project components interact as envisioned during project design to reach a common objective? If yes, what facilitated the interaction and if not, why not? Was there close coordination and planning among the different contractors designing and implementing the activity (land governance, infrastructure, training in infrastructure management and agricultural services)? Did UNOPS in the role of project management consultant facilitate the rollout and coordination of activities? |
| **RQ1a** | Was there close coordination and planning among the different contractors designing and implementing the activity (land allocation, infrastructure, and agricultural services)? Did UNOPS in the role of project manager facilitate the rollout and coordination of activities? | N/A |
| **RQ2** | To what extent did the project interact with the grant facility of the Climate-Resilient Communities Project? What facilitated the interaction and what didn't? | N/A |
| **RQ3** | Did project-affected person (PAP) households experience changes in their household incomes, volumes, and value of agricultural products sold and traded, food and nutritional security, and production of cash crops? | What is the impact of SSI investments on beneficiary households' incomes, volumes, and value of agricultural products sold and traded, food and nutritional security, and production of cash crops? |
| **RQ3a** | N/A | Do agricultural input use, crop choice, agricultural techniques, and agricultural income, volumes, and value of agricultural products differ between landowners and renters or renter groups? If so, why? |
| **RQ4** | Do stakeholders believe the project was well designed to achieve the project objective? What changes occurred and why? | Do stakeholders believe the project was well-designed to achieve the project objective? What changes to implementation occurred and why? |
| **RQ5** | If the project produced results, are they expected to be sustained? If the project did not meet its expected results, why not? | If the project produced results, are they expected to be sustained? |
| **RQ6** | What lessons can be drawn to inform future projects? | What lessons can be drawn to inform future projects? |
| **RQ7** | What is the post-compact ERR of the project (except for the RMA)? | What is the post-compact ERR of the project (except for the RMA)? |
| **Irrigation Perimeter Development Activity** | | |
| **RQ8** | Were project activities implemented as planned? If not, what changes occurred? | Were project activities implemented as planned? If not, what changes occurred? |
| **RQ9** | Were the expected outputs produced by the activity? | Were the expected outputs produced by the activity? |
| **RQ10** | Is the new/improved infrastructure functioning properly in terms of water flow? | Is the new infrastructure operating and functioning properly? |

Table B.1 (*continued*)

| RQ # | Research question—Konni | Research question—Dosso-Gaya |
|---|---|---|
| **RQ11** | Is water for irrigation in farmers' plots available as expected from the irrigation system, including frequency, timing, and amount as per planned irrigation schedules? If not, why not? | Is water for irrigation in farmers' plots available as expected from the SSI systems, including frequency, timing, and amount as planned? If not, why not? |
| **RQ12** | Did irrigated land increase as expected (as a whole and per family)? If not, why not? | Did irrigated land increase as expected? If not, why not? |
| **RQ13** | Did the cost of irrigation water change? If not, why not? | What is the cost of irrigation, including any fuel costs for pumping water? If water was available before the SSI system was built, how did the cost of irrigation water change? |
| **Management Services and Market Facilitation Activity** | | |
| **RQ14** | Were project activities implemented as planned? If not, what changes occurred? | Were project activities implemented as planned? If not, what changes occurred? |
| **RQ15** | Were the expected outputs produced by the activity? | Were the expected outputs produced by the activity? |
| **RQ16** | Were IWUAs set up? How many were set up? | Did the project support the institutions or market actors responsible for O&M as planned? What is the capacity of these institutions or market actors, and the government oversight institutions? |
| **RQ17** | What was the profile of the participants [to the IWUA training*, clarification of the evaluator*] (total number of participants disaggregated by sex and age)? | N/A |
| **RQ18** | What percentage of IWUA leadership committee members at the end of the compact were women? | N/A |
| **RQ19** | Are IWUAs functioning as expected? Is the irrigation infrastructure being maintained properly? | Is the SSI infrastructure being maintained properly? |
| **RQ20** | Is a land tenure registry functioning according to plan? Is the land registry used as a tool by local authorities to continually record changes in landholdings? Do land holders have access to the correct documentation (*contrats d'occupation* or long-term leases for farmers, publicly held property titles of overall perimeters) according to the project plan? Were land use plans at the commune level successfully completed? | Is the land registry used as a tool by local authorities to continually record changes in landholdings? Do landholders have access to the correct documentation according to the project plan? |
| **RQ21** | Are the local land commissions in the project zone better equipped to ensure sustainable management of land rights in/around the perimeter? | Are the local land commissions in the project zone better equipped to ensure sustainable management of land rights in/around the BT project area? |
| **RQ21a** | N/A | Is the formal land rental process used by landholders? How is it functioning? |
| **RQ21b** | N/A | What are the contractual terms between landowners and renters or renter groups? How are input costs—including costs for the irrigation operation and maintenance— and agricultural outputs shared between owners and renters or renter groups? Have there been disagreements over land usage and contract terms? |

Table B.1 (*continued*)

| RQ # | Research question—Konni | Research question—Dosso-Gaya |
|---|---|---|
| **RQ22** | Was the level and risk of land conflict reduced? Did land tenure security increase? | N/A |
| **RQ22a** | N/A | What is the impact of SSI investments and land formalization on land tenure security, and the level and risk of land conflict? |
| **RQ22b** | N/A | How do perceptions of land tenure security, risk of land conflict, access to credit, and agricultural inputs, investments, and outputs of landholders compare to tenants and vary among tenants with different contractual terms? |
| **RQ23** | What are the income, food security, and agricultural productivity impacts of granting irrigated land to vulnerable populations? | N/A |
| **RQ24** | When given productive land and comprehensive training in best agricultural practices, do disadvantaged populations achieve crop yields comparable to those of existing landholders? If not, is there a trend toward convergence in productivity? Do beneficiaries engage in similar land investment behaviors as existing landholders? | N/A |
| **RQ25** | What is the effect of women's land ownership on agricultural decision making, access to productive inputs and intra-household control of resources? | N/A |
| **RQ26** | Did participants perceive that they learned new skills/knowledge? Did this vary by subgroup? If they didn't perceive learning/acquire new knowledge, why or why not? | Did participants perceive that they learned new skills/knowledge? Did this vary by subgroup? If they didn't perceive learning/acquiring new knowledge, why not? |
| **RQ27** | What percentage of participants of adult functional literacy and numeracy report improvement in their skills (basic reading and writing) after the training? What percentage of them indicate improved knowledge of nutrition and hygiene, and budgeting and record keeping (inasmuch as these concepts were introduced as part of the literacy and numeracy training)? | What percentage of participants of adult functional literacy and numeracy report improvement in their skills (basic reading and writing) after the training? What percentage of them indicate improved knowledge of nutrition and hygiene, and budgeting and record keeping? |
| **RQ28** | What percentage of participants' self-report increased knowledge of sustainable land and water resources management? | What percentage of participants' self-report increased knowledge of sustainable land and water resources management? |
| **RQ29** | What percentage of participants can name and explain at least two or three new or improved agricultural practices that they did not know before the training? | What percentage of participants show an active knowledge of improved agricultural practices that they did not know before the training? |
| **RQ30** | What percentage of members of *comités de gestion* within the cooperatives indicate improved knowledge of cooperative management? | What percentage of members of *comités de gestion* within the producer groups indicate improved knowledge of producer group management? |
| **RQ31** | Have participants applied new practices and technologies? Was this different for women/men or youth/non-youth participants? If knowledge was not applied, why not? | Have participants applied new practices and technologies? Was this different for women/men or youth/non-youth participants? If knowledge was not applied, why not? |

Table B.1 (*continued*)

| RQ # | Research question—Konni | Research question—Dosso-Gaya |
|---|---|---|
| **RQ32** | Were savings and loans groups created and fostered by the project? Based on their participation, have group participants indicated they have improved access to credit? | Were savings and loan groups created and fostered by the project? Based on their participation, have group participants indicated they have improved access to credit? |
| **RQ33** | How are cooperatives applying knowledge? | How are producer groups applying knowledge? |
| **RQ34** | Which contact farmer incentive scheme is more effective in encouraging knowledge dissemination? | N/A |
| **RQ35** | Which contact farmer incentive scheme is more effective in encouraging the adoption and application of new agricultural practices? | N/A |
| **RQ36** | Which contact farmer incentive scheme is more effective in increasing agricultural productivity? | N/A |
| **RQ37** | Which contact farmer incentive scheme is more effective in encouraging farmers with initially low crop yields to adopt improved practices? | N/A |
| **Policy Reform Activity** | | |
| **RQ38** | Did the Fertilizer Reform Sub-activity produce the expected outputs? What changes occurred to the original design? Did the sub-activity lead to increased private sector participation in the fertilizer sector? If not why not? Have reform activities made fertilizer more affordable and accessible? | Did the Fertilizer Reform Sub-activity produce the expected outputs? What changes occurred to the original design? Did the sub-activity lead to increased private sector participation in the fertilizer sector? If not why not? Have reform activities made fertilizer more affordable and accessible? |
| **RQ39** | Did the National Statistical Capacity Sub-Activity produce the expected outputs? What changes occurred to the original design? Have reform activities improved GoN's statistical capacities in data collection, analysis, and reporting? | Did the National Statistical Capacity Sub-activity produce the expected outputs? What changes occurred to the original design? Have reform activities improved GoN's statistical capacities in data collection, analysis, and reporting? |
| **Roads for Market Access Activity** | | |
| **RQ40** | N/A | To what extent did the activity lead to a change in transportation method, travel time, vehicle operating costs, and transportation costs for traders and farmers in the BT and surrounding areas? |
| **RQ41** | N/A | Are more input and output traders present in the Dosso-Gaya region as a result of the roads improvements? |
| **RQ42** | N/A | To what extent did the activity contribute to increased volumes and values of agricultural products traded from the BT area? How has the activity changed the quality of crops, in particular produce, brought to market and the quantity of crops lost in transportation post-harvest? |

ERR = estimated rate of return; N/A = not applicable; O&M = Operations and Maintenance; SSA = Agricultural Support Services Sub-activity; SISM = Sustainable Irrigation System Management Sub-activity; SSI = small-scale irrigation; UNOPS = United Nations Office for Project Services; RMA = Roads for Market Access Activity; IWUA = irrigation water use association; GoN = Government of Niger; BT = *Basse Terrasse*.

# APPENDIX C.

# Technical description of first stage matching process for the impact evaluation

**This page has been left blank for double-sided copying.**

The first stage of the matching process sought to shortlist comparison parcels that were similar to parcels in the initial BT treatment areas in terms of hydrogeological characteristics and agricultural production. To narrow down candidate comparison areas, we focused on the regions that are not adjacent to the BT (because adjacent areas might experience some project benefits) but are located upriver and downriver from the BT. Such areas would presumably have similar groundwater access, and consequently cropping patterns, to the BT. Conversely, areas that are far from the BT are more likely to be dissimilar along those dimensions. Our selection of candidate comparison areas was designed to balance those competing factors and to increase the likelihood that comparison areas would face economic and environmental circumstances similar to those in the BT, in terms of proximity to national borders and exposure to cross-border trade, composition of livelihoods, and suitability of land for irrigated agriculture. We then used information on groundwater access using Watex data (RTI Exploration 2020; RTI Exploration and UNLV 2020), which predict the availability and access to groundwater using microwave radar technology to identify the geological presence of water molecules. Based on Watex information, we limited possible comparison areas to areas that are similarly water rich to the BT.

We then subdivided the BT areas proposed for SSI investment into 100 m × 100 m (1 hectare) cells, to approximate the area footprint each SSI system is expected to irrigate. Similarly, we gridded the potential comparison areas into 1-hectare cells, each comprising a candidate area from which an actual land parcel could be selected and included in the comparison group. This approach is not designed to produce cells that conform to the true land parcel boundaries, but rather to cover a footprint of the same magnitude of actual parcels for the purpose of estimating covariate values that are likely to be similar to those of actual parcels. We will provide enumerators with the cell centroid's location, which enumerators will visit to identify the corresponding land parcel for each selected cell. For each cell, both in treatment and comparison areas, we merged multiple data sets on land cover characteristics, spectral reflectance, climate, and groundwater availability, as shown in column 2 of **Table C.1**, all of which are likely to be related to outcomes of interest.[25] We incorporate these data sets into a propensity score matching procedure that identifies the cells from comparison areas that are most similar to cells in the treatment area. As a key input into this process, we constructed pixel-wise normalized difference vegetation index (NDVI) values, a proxy for crop productivity, using Sentinel-2 satellite data for June 2015 to the present. Because agricultural production in Niger can occur in two seasons, the rainy season and—when access to irrigation is available—the dry season, we constructed this time series to cover both agricultural seasons. We then fitted a two-cycle harmonic regression to that time series, which summarizes the timing, trend, and amplitude of intra-annual variation in land cover greenness over multiple years into six pixel-level coefficients (Wang et al. 2020). We then averaged all pixel-level values across all pixels encompassed by each 1-hectare cell. Although these covariates provide long-term information about land use practices and productivity, we also complement them with year-season-specific median NDVI values, which better capture the cultivation status of each potential growing season over the past several years. The latter

[25] We do not include precipitation in the matching algorithm because differences in values between treated and comparison areas are likely to be driven by data construction artifacts. Given the small number of nearby weather monitoring stations from which the Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) data are derived, it is possible that differences in precipitation values across areas of interest are caused by spatially interpolating station-level data into a gridded data set, not actual differences in precipitation. We exclude elevation from the matching process because differences in elevation across treatment and comparison are acceptable so long as they do not influence cropping patterns or groundwater access, which are matching inputs. Regardless, we display balance test results for these measures in **Table C.1**.

information is particularly useful to match 1-hectare cells based on prior patterns of cultivation during the dry season.

**Table C.1. Variables used in matched comparison group selection and assessment processes**

| Variable | Used in matching | Balance tested | Dataset | Source | Time period | Spatial resolution |
|---|---|---|---|---|---|---|
| Long-term NDVI harmonic regression coefficients | X | X | Sentinel-2 | Copernicus Sentinel-2 TOA | 2015–2021 | 10m |
| Season-specific NDVI median values | X | X | Sentinel-2 | Copernicus Sentinel-2 TOA | 2017–2021[a] | 10m |
| Average daily precipitation | | X | CHIRPS | Funk et al. 2015 | 2010–2021 | 0.05° |
| Elevation | | X | NASADEM | Buckley et al. 2020 | 2000 | 30 m |
| Slope | X | X | NASADEM | Buckley et al. 2020 | 2000 | 30 m |
| Gross biomass water productivity | X | X | WaPOR | FAO 2021b | 2019 | 100 m |
| Actual evapotranspiration and interception | X | X | WaPOR | FAO 2021b | 2019 | 100 m |
| Cropland share | X | X | WaPOR Land cover classification | FAO 2021b | 2019 | 100 m |
| Groundwater availability | X | X | Watex | RTI Exploration 2020; RTI Exploration and UNLV 2020 | 2020 | 30 m |

Note: CHIRPS = Climate Hazards Group infrared precipitation with station; NASADEM = NASA digital elevation model; NDVI = normalized difference vegetation index; TOA = top of atmosphere; WaPOR = water productivity through open-access of remotely sensed derived data.

[a] We consistently use rainy and dry season windows of July 15 through September 5, and December 15 through February 28, from which "peak" season median composites are constructed.

Using a nearest-neighbor matching procedure without replacement, the "likeness" of a comparison cell to a cell identified as a likely treatment area is judged according to its propensity score—a unidimensional measure of a cell's probability of assignment into the treatment group. By selecting comparison cells with the closest propensity scores to those of treatment plots, this matching process selects comparison units with minimum differences in characteristics along the dimensions that are meaningfully associated with treatment assignment and outcomes.

Because data collection costs rise with dispersed respondents, we set out to identify geographic clusters of matches in which data collection could be cost-effective. We identified three clusters—Gaya-Tounouga, Bombodji-Koulou, and Saboula-Kotaki—where matches were concentrated yet distant enough from the BT to minimize concerns about spillover effects in rental or labor markets. To further investigate these possible matches, we contacted an official from the office of the mayor of Tanda, the commune in which the majority of the BT is based, to obtain a qualitative assessment of how economic activity and

agricultural production in these comparison areas and the BT compare. Although the official noted some differences in the importance of economic activities across the different areas, our assessment of his qualitative findings is that many households were engaged in the same activities as those in the BT and neither of these areas can be a priori excluded from the groups of possible clusters.[26] An initial presentation of these areas to staff from the MCC land team, however, raised the possibility that one of the proposed clusters (Gaya-Tounouga), southeast of the BT, could benefit from the Land Tenure Security Sub-activity of the MSMF through support to the COFOCOMs. To the extent that the implementation of the LTS would lead to improved short-term and long-term outcomes both in terms of land tenure and agricultural outcomes, this has the potential of biasing the estimated impact estimates downward. Based on this information, we determined that it would be prudent to exclude the Gaya-Tounouga potential comparison area, which left two potential comparison clusters—Bombodji-Koulou and Saboula-Kotaki.

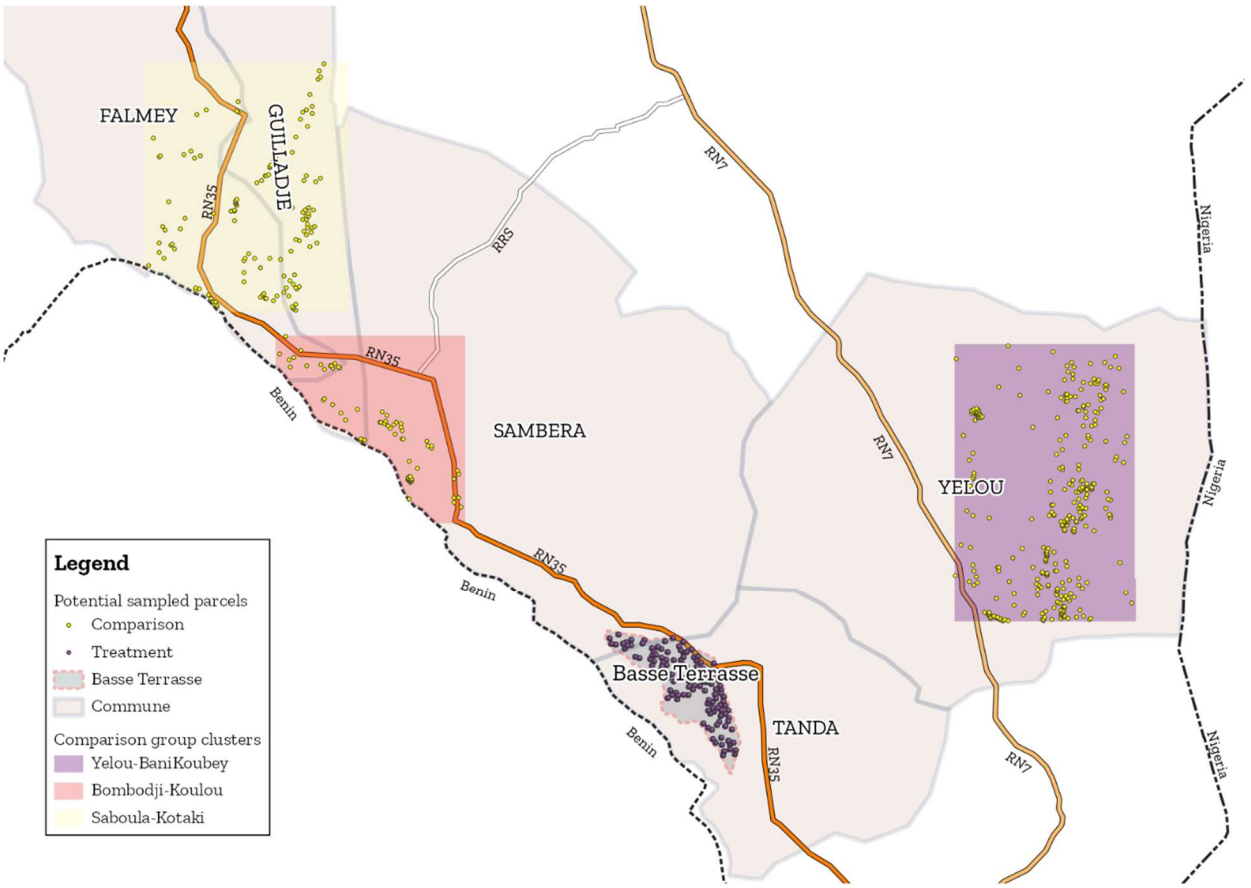
After an initial version of this first stage of the land-level matching process was completed, we gained access to the Watex groundwater data. The Watex data enabled us to assess (1) whether cells selected by the matching procedure to form the comparison group in fact have groundwater availability profiles similar to those of cells in the BT treatment area, because groundwater had not been an input into the matching process, and (2) whether our initial process of selecting upriver and downriver locations neglected other areas close to the BT with potentially comparable groundwater conditions. The upriver and downriver bands we had initially selected encompassed large areas that in fact do not have groundwater availability similar to that in the BT. We therefore made two adjustments to the two comparison group clusters we had considered. First, we identified a third comparison group cluster northeast of the BT (Yelou-BaniKoubey), which encompasses groundwater-rich land that had been excluded from our initial run because of its relative distance to the Niger River. Second, we used the Watex data on groundwater formations to reshape cluster boundaries so that all clusters would have groundwater access roughly similar to that at the treatment locations. As there are still gradations in groundwater availability within these Watex-constrained areas, we also include Watex values in the matching process. As a result, comparison units would be selected on the basis of their historical similarity to treatment units with respect to factors like NDVI and evapotranspiration, as well as their potential to leverage groundwater-based irrigation, to maximize the comparison group's usefulness as a counterfactual to the IMAP investments.

We then implemented another iteration of the first-stage matching process where possible matches and therefore comparison group cells are limited to the three clusters shown in **Figure C.1**.[27] From each cluster, we formed a grid of 1-hectare cells that could serve as potential comparison units. Cells that were selected by the matching algorithm because of their similarity to the treatment cells are shown as yellow points. Treatment cell centroids are displayed as purple points.

[26] The main differences were as follows: In the area around Falmey and Guilladje, some households grow sugar cane, cassava, and sweet potatoes, which are not grown in the BT. Moreover, some individuals are engaged in selling gasoline. In the Yelou cluster, more households depend on rearing livestock than in the BT and there is no dry season rice cultivation.

[27] As the program's implementation details are still evolving, we will consider changes to the number of clusters from which comparison units are selected by using information about the intensity and extent of the intervention. For example, we may consider parcels from a fourth cluster located in the Tounouga commune if the LTS sub-activity in that commune has limited reach. Similarly, comparison units from the Sambera commune may be excluded if IMAP investments in that commune are significant enough to reject them as being untreated by the intervention.

**Figure C.1. Map of treatment and potential comparison areas**




Note: Both treatment and comparison parcels are based on gridding the selected cluster areas into cells of 100 m × 100 m. Communes that are anticipated to participate in any portion of the IMAP impact evaluation are depicted in light pink.

We formally test for the quality of matches through balance tests. By conducting balance tests, through *t*-tests between the treatment and control groups, we can statistically discern whether the comparison units are sufficiently similar to proceed with this analysis. If estimated mean values between the two groups are not statistically distinguishable, then the groups are considered to be balanced. We subject each of the variables shown in **Table C.2** to a balance test, which includes all variables used for estimating the propensity score, in addition to elevation.

The balance test results indicate that along most dimensions, the two groups are quite comparable. Among the variables subject to balance tests whose results are reported in **Table C.2**, elevation and average daily precipitation indicate a statistically significant imbalance. Although elevation is a meaningful variable in that it partially governs crop choice and depth to groundwater, it is in essence superseded by the lack of imbalance in NDVI history and other NDVI composite values that proxy for agricultural outcomes and crop productivity. Similarly, given that the CHIRPS precipitation data are interpolated and gridded with fewer than 20 reporting rain-monitoring stations in all of Niger, differences between treatment and control are more likely to reflect interpolation processes than material differences

in observed rainfall.[28] In spite of these noted differences in elevation and precipitation, we believe that the overall balance between selected comparison units and treatment units is high and will result in a credible comparison group.

We conduct a second type of balance test in addition to the multiple dimension-specific tests, whether the covariates are jointly associated in treatment assignment. If so, then there would be systematic differences between treatment and comparison units that are not addressed in the matching process. A joint orthogonality test of the coefficients of all covariates equaling 0 cannot be rejected, indicating that there are not systematic differences between our selected treatment and comparison cells.

**Table C.1. Covariate balance results for key variables of interest**

| Variable | Treatment mean | Comparison mean | Difference (standard deviations) | *p*-value |
|---|---|---|---|---|
| **Historical (long-run) agricultural productivity proxies** | | | | |
| NDVI Harmonics – constant term | 0.288 | 0.256 | 0.043 | 0.493 |
| Trend term | 0.002 | 0.008 | 0.008 | 0.901 |
| First cosine term | -1.128 | -1.141 | 0.011 | 0.86 |
| Second cosine term | -0.744 | -0.774 | 0.04 | 0.524 |
| First sine term | -0.686 | -0.683 | 0.002 | 0.97 |
| Second sine term | 0.486 | 0.493 | 0.007 | 0.906 |
| **Historical (seasonal) agricultural productivity proxies** | | | | |
| Rainy 2018 NDVI median | 0.737 | 0.688 | 0.051 | 0.418 |
| Rainy 2019 NDVI median | 0.411 | 0.441 | 0.029 | 0.648 |
| Rainy 2020 NDVI median | 0.554 | 0.516 | 0.041 | 0.515 |
| Dry 2018 NDVI median | -0.021 | -0.062 | 0.04 | 0.525 |
| Dry 2019 NDVI median | -0.044 | -0.089 | 0.047 | 0.456 |
| Dry 2020 NDVI median | -0.043 | -0.097 | 0.048 | 0.444 |
| **Environmental characteristics** | | | | |
| Slope | 0.564 | 0.608 | 0.037 | 0.559 |
| Elevation | -1.294 | -0.305 | 1.317 | 0*** |
| Daily precipitation | 1.28 | 0.266 | 0.875 | 0*** |
| Share of area that is cropland | -0.421 | -0.413 | 0.012 | 0.85 |
| Evapotranspiration | 0.39 | 0.389 | 0.002 | 0.981 |
| Gross biomass water productivity | -0.044 | -0.065 | 0.02 | 0.744 |
| **Groundwater availability indicators** | | | | |
| Watex Band 1 | 120.731 | 117.796 | 0.05 | 0.424 |
| Watex Band 2 | 172.23 | 166.647 | 0.098 | 0.116 |
| Watex Band 3 | 170.78 | 171.46 | 0.012 | 0.847 |

Notes: *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level.
Except for the three Watex band values, all variables were standardized prior to matching.

NDVI = normalized difference vegetation index.

[28] For maps of the number of active rain monitoring stations by month, please see http://data.chc.ucsb.edu/products/CHIRPS-2.0/diagnostics/chirps-n-stations_byCountry/Niger/.

As discussed earlier, we are able to conduct this first stage of the matching process because it relies on already available data retrieved and/or processed from satellite imagery, or gridded data sets that are constructed by third parties that do not require knowledge about household location and total landholdings. Although the results presented here are preliminary, because we still have to complete the second stage of the matching process (household-level), they provide us sufficient assurance that this procedure can identify land parcels outside the BT that approximate the status and growing conditions of parcels inside the BT.

# APPENDIX D.

## Input values for minimum detectible impact estimates

**This page has been left blank for double-sided copying.**

In **Section V.B** we presented the minimum detectable impacts for several outcomes of interest. **Table D.1** reports all parameter values used in the power calculations.

**Table D.1. Parameter values used in statistical power calculations**

| | Outcomes | | | |
|---|---|---|---|---|
| | Total annual household profits ('000 CFA) | Annual household agricultural expenditures ('000 CFA) | Household had no food to eat at least once in the previous month (%) | Plot-level fertilizer application (kilograms per hectare) |
| | (1) | (2) | (3) | (4) |
| **Minimum detectable impacts** | | | | |
| For small-scale irrigation treatment and comparison | 16% | 15% | 6 pp | 19% |
| **Observed values for Konni baseline data** | | | | |
| Difference between households with and without irrigation access | 31% | 195% | −6 pp | 120% |
| **Inputs to MDI calculations** | | | | |
| Estimated mean | 2,682 | 337 | 19 | 441 |
| Estimated standard deviation | 2,920 | 328 | 39 | 540 |
| Coefficient of variation | 1.088 | 0.97 | N/A | 1.22 |
| Within-group variance explained | 0.16 | 0.08 | 0.05 | 0.02 |
| Variance in treatment assignment explained by covariates | 0.15 | 0.15 | 0.15 | 0.15 |

Source: Mathematica calculations using Ksoll et al. (2021) baseline survey data collected for the Konni perimeter.

Notes: MDI calculations are based on two-tailed tests at 80 percent power and 95 percent level of statistical significance for individuals with non-random treatment assignment. Values are based on completed surveys of 600 SSI treatment households and 900 comparison group households, responding to both a baseline and either the interim or the endline survey. Reported means are based on responses to the Konni baseline survey (Ksoll et al. 2021). The reported MDIs are not adjusted for multiple hypothesis testing.

CFA = *Coopération financière en Afrique centrale*; MDI = minimum detectable impacts; N/A = not applicable; pp = percentage points.

**This page has been left blank for double-sided copying.**

# APPENDIX E.

## List of key informant interviews and focus group discussions

**This page has been left blank for double-sided copying.**

**Table E.1. Qualitative data collection, by activity and source**

| Data source | Data collection method | Number of interviews | Activity | Area of focus |
|---|---|---|---|---|
| **Project documentation** | | | | |
| Compact documents | Desk review | N/A | All project activities | Project design and implementation/deviations from design |
| Implementation reports | Desk review | N/A | All project activities | Project design and implementation/deviations from design/project outcomes |
| Monitoring data | Desk review | N/A | All project activities | Project implementation/deviations from design/project outcomes |
| **MCA/IMAP implementers/other implementing agencies/GoN** | | | | |
| Former and current staff from MCA-N and project implementers, including UNOPS | Interviews | TBD | All project activities | Project implementation/deviations from design/project outcomes<br>Overall perceptions of outcomes |
| ONAHA (or other government entity responsible for SSI infrastructure oversight) | Interviews | 1 | Irrigation Perimeter Development Activity | Perceptions of functioning of new/improved irrigation infrastructure<br>Lifespan of SSI infrastructure and evolution of land productivity |
| Ministry of Agriculture/ General Directorate for Agriculture/ Departmental Direction for Agriculture | Interviews | 1 | Management Services and Market Facilitation Activity | Project implementation/deviations from design/project outcomes<br>Perceptions of growth, composition, management, and sustainability of project-supported producer groups |
| Ministry of Agriculture/ *Direction de la Vulgarisation et de Transfert de Technologie* | Interviews | 1 | Management Services and Market Facilitation Activity | Implementation and outcomes<br>Perceptions of growth, composition, management, and sustainability of project-supported producer groups<br>Perceptions of adoption of new technology and practices |
| Ministry of Agriculture/ *Direction des Actions de Coopération et de Soutien aux Organisations Rurales* | Interviews | 1 | Management Services and Market Facilitation Activity | Project implementation/deviations from design<br>Capacity and sustainability of producer groups<br>Gender integration/women's empowerment within producer groups |
| Ministry of Water and Hygiene | Interviews | 1 | Irrigation Perimeter Development Activity, and<br>Management Services and Market Facilitation Activity | Project implementation/deviations from design/project outcomes<br>Perceptions of functioning of SSI infrastructure<br>Knowledge of nutrition and hygiene |

Table E.1 (*continued*)

| Data source | Data collection method | Number of interviews | Activity | Area of focus |
|---|---|---|---|---|
| *Mouvement des Jeunes pour le Dévelopment et l'Education Citoyenne* | Interviews | 1 | Management Services and Market Facilitation Activity | Youth participation and outcomes |
| Regional Agriculture Chambers | Interview | 1 | Irrigation Perimeter Development Activity,<br>Management Services and Market Facilitation Activity,<br>Roads for Market Access Activity | Project implementation/deviations from design<br>Regional perspectives on anticipated outcomes (particularly related to increased agricultural productivity, access to other inputs/technology) |
| Local land commissions | Interviews | 1 | Management Services and Market Facilitation Activity | Project implementation/deviations from design<br>Land tenure registry process and perceptions of land security |
| **Beneficiaries & others** | | | | |
| Beneficiaries (beneficiary focus groups, women only beneficiary focus groups, and youth-only focus groups) | Focus group discussions | 5 | Irrigation Perimeter Development Activity,<br>Management Services and Market Facilitation Activity,<br>Roads for Market Access Activity, and<br>Policy Reform Activity | Project implementation<br>Perceptions of functioning of small-scale irrigation<br>Maintenance of small-scale irrigation<br>Adequacy and efficiency of water for irrigation<br>Perceptions of changes of cost of water<br>Perceptions of changes in outcomes based on new irrigation<br>Gender-specific changes in outcomes<br>Land tenure registry process and perceptions of land security<br>Perceptions of training program and outcomes<br>Perceptions of cost and access to improved inputs<br>Perceptions of access to markets<br>Perceptions of producer groups' effects on improving market access |
| Traders | Interviews | 4 | Roads for Market Access Activity | Changes in market access<br>Changes in road quality, transportation time, and transportation costs<br>Reduction in spoilage |

Table E.1 (*continued*)

| Data source | Data collection method | Number of interviews | Activity | Area of focus |
|---|---|---|---|---|
| Members of producer groups in Dosso-Gaya | Focus group discussions | 2 | Management Services and Market Facilitation Activity | Producer group capacity, and determinants of capacity<br>Sustainability of producer groups<br>Perceptions of training outcomes and application of new practices/technologies |
| Leaders of producer groups | Interviews | 2 | Management Services and Market Facilitation Activity | Producer group capacity and determinants of capacity<br>Sustainability of producer groups<br>Perceptions of training outcomes |
| Maintenance technician | Interviews | 2 | Management Services and Market Facilitation Activity | Maintenance of SSI |
| **Site visits** | | | | |
| New irrigation infrastructure | Site visits | 2 (interim & final) | Irrigation Perimeter Development Activity | Condition of irrigation infrastructure<br>Operation of infrastructure<br>Maintenance of infrastructure |

IMAP = Irrigation Perimeter Development Activity; MCA-N = Millennium Challenge Account-Niger; N/A = not applicable; ONAHA = *l'Office National des Aménagements Hydro-Agricoles*; SSI = small-scale irrigation; TBD = to be determined; UNOPS = United Nations Office for Project Services.

**This page has been left blank for double-sided copying**

# APPENDIX F.

# MCC comments on draft report

**This page has been left blank for double sided copying.**

**Table F.1. EMC Comments**

| # | Name & Sector | Comments & Questions | Response to MCC |
|---|---|---|---|
| 1 | Andrew Tarter, MCC GSI | RQ3 gets at household changes to agricultural production and income. (This is currently in the impact portion)<br><br>RQ3a is the analogous question, but for renter groups. (This is currently in the performance portion)<br><br>So in RQ3a, it's stated that 'agricultural outcomes' between groups and landowners (households (?)) will be compared.<br><br>1. My question: Is 'outcomes' of RQ3a the same as 'income, volumes, and value of agricultural products' in RQ3?<br><br>Suggestions:<br>2. Can we rework RQ3a to explicitly state what we are after—a comparison of whether the productivity and incomes of renter groups differs from the productivity and incomes changes of landowners/households? We want to know if groups or individual households are better at increasing productivity and income on a given plot of land (holding all other variability of the land constant; matching).<br><br>3. Also, for me, this requires some sort of between comparison of the renter groups themselves. For example, perhaps female renter groups would be more productive or have larger increases in income than male renter groups AND the default (household-landowners).<br><br>And we'd want to know about that variation between groups, not only a binary comparison of groups vs. households, but a comparison that considers multiple types of groups (women, youth, men, mixed) vs. household/landowner.<br><br>Otherwise, its likely that important differences between the types of renter groups (RQ3a) may be erased/averaged/lost if we want to make the comparison to landowners/households (RQ3).<br><br>4. And the comparison we are after is simply an inquiry into which of the two models (households and groups) were more effective at bringing more land under production and raising overall income tied to a given plot. | Your comment and suggestions raise several issues<br>**1.** Yes, the 'outcomes' referenced in RQ3a encompasses 'income, volumes and value of agricultural products' from RQ3.<br>**2.** We won't be able to rigorously answer the first piece of the suggestion-which is whether the income changes for renters are the same as the income changes for landowners- since there will not be renters in the comparison areas to serve as the control group for renters in the treatment area. We will compare owners' outcomes at interim and endline to the outcomes of renters as a group to determine if they are different. Based on our plan of interviewing 300 renters, our power calculations indicate minimum detectible differences of roughly 20-25% for this analysis, which we think is high but not unachievable. This test does not require any additional data, so we plan to implement it with the caveat that we are likely underpowered.<br>**3.** You also suggest comparing different types of renter groups to each other. This would require a much larger sample size than we had planned for as it would require being statistically powered to detect differences for each subgroup. Under a 'best case statistical scenario' of 2 sub-groups, each comprising 50% of the renter population (N1 = 150, N2 = 150), our power calculations indicate a minimum detectible difference of 32-42%. We do not believe differences of this magnitude will arise between two sub-groups of renters since |

Table F.1 (*continued*)

| # | Name & Sector | Comments & Questions | Response to MCC |
|---|---|---|---|
| | | | both are treated with a very similar package. In addition, we do not believe increasing the sample size is possible to address this statistical power constraint because we are already planning to interview a very large share of prospective renters. If the BT investments were larger in scale, covering a larger geography, then we would have proposed larger sample sizes to test these research questions.<br>**4.** Regardless of the statistical feasibility of the aforementioned quantitative analyses, we will include questions in our qualitative instruments (especially focus group discussions) to better understand the factors potentially leading to differences in observed outcomes for the groups of interest. |
| 2 | Bob Fishbein - MCC Infra | "...this area will benefit from the first-time construction of irrigation infrastructure, which comprises small-scale systems, each covering 1 hectare to serve multiple households, and using drip irrigation technologies." The actual irrigated areas will be determined based on the land tenure surveys as well as an assessment of groundwater yields from test boreholes. Also, the number of clustered "blocks", will also depend on the above-mentioned land tenure arrangements and groundwater capacity.<br><br>Suggestion: Adjust the description to account for the approximate nature of the numbers. | We have included language that suggests that these plans (area cultivated per system and number of blocks) may change based on the land tenure surveys and the assessment of groundwater yields from test boreholes. |
| 3 | Kent elbow, MCC Land | There are multiple references in the document to "land allocation." However, since SK2 was redesigned as a small-scale irrigation activity land allocation is no longer planned or anticipated. The SK2 land activity now consists primarily of land inventories, land rights formalization and support for developing and formalizing land-sharing agreements such as loans and leasing, as well as capacity-reinforcement of local land commissions to implement and maintain land rights and arrangements.<br><br>Suggestion: In most places in the document where the word "allocation" appears the word "governance" should be used in its place. | We have replaced the the word "allocation" with the word "governance" where appropriate. |

Table F.1 (*continued*)

| # | Name & Sector | Comments & Questions | Response to MCC |
|---|---|---|---|
| 4 | Hamissou Samari, M&E | Will the evaluation measure the learning/knowledge levels of COFOCOM members? | No, the evaluation will present self-reported knowledge levels of COFOCOM members, as well as assessments of their knowledge by key informants. It is outside the scope of work to develop knowledge tests for each of the capacity-building activities of the compact. |
| 5 | Hamissou Samari, M&E | Will the evaluation attempt to compare differentials in the implementation methodologies on SK vs. Konni?<br><br>Suggestion: Controlling for everything else, it'll be useful to see how some select aspects of the implementation methods fare across the 2 regions. | The set of research questions does not include conducting an assessment of differences in implementation between SK and Konni. We can add this research question if the EMC would like to. |
| 6 | Hamissou Samari, M&E | "*The pre-post outcomes analysis of the RMA in Dosso-Gaya will provide additional evidence on the relationship between roads investments and crop prices. It will also provide insight into how the activity interacts with the other project activities to accrue benefits to farmers and enable us to understand the relationship between market access and agricultural activity and outcomes in the region*"<br><br>Does easier access to an improved road system make SK farmers better off vs. Konni counterparts? | The set of research questions does not include conducting an assessment of farmers on the Konni perimeter and in the BT. We could add this research question if this is of interest to the EMC. |
| 7 | Sarah Lane, Evaluation Lead | This is the objective in the compact: "increase rural incomes through improvements in agricultural productivity and increases in sales resulting from modernized irrigated agriculture and flood management systems with sufficient trade and market access;" | We have adapted the language to better capture the project objective contained in the compact. We drop the words "and flood management" since the Dosso-Gaya project will not focus on flood management any more. |
| 8 | Sarah Lane, Evaluation Lead | Can we link to the catalog entry for this evaluation? | We have included a link to the IMAP evaluation catalog page. |
| 9 | Sarah Lane, Evaluation Lead | 2024? Does compact extension change this timing? | As of the drafting of this report, GoN has not requested a compact extension and, therefore, our timeline does not account for a possible extension. However, if a compact extension were requested and approved, we would modify the data collection timeline. |

Table F.1 (*continued*)

| # | Name & Sector | Comments & Questions | Response to MCC |
|---|---|---|---|
| 10 | Sarah Lane, Evaluation Lead | Is there a reason this list is in a different order than described in the paragraph above? | We have changed the sequence of sub-activity descriptions to mirror the preceding paragraph's order. |
| 11 | Kent elbow, MCC Land | Land allocation is no longer planned for SK. | We have revised the language to specify that land allocation is not planned for SK2, but that part of the activities are to encourage land rentals to groups without their own land and property rights. |
| 12 | Sarah Lane, Evaluation Lead | It should be explicitly stated that this activity is covered by another evaluation. https://data.mcc.gov/evaluations/index.php/catalog/254 | Have noted that IDG is the independent evaluator and included a footnote linking to their catalog page. |
| 13 | Sarah Lane, Evaluation Lead | Should the compact level objective be in the logic?<br><br>Also, can you flag what parts of the logic will be tested using the impact evaluation vs. the performance evaluation? | Your comment raises several issues:<br>1. In response to your comment, we have change the language from "Goal/impact" to "Compact goal/objective".<br>2. We note that the objective in the logic model differs from the objective in the compact that you refer to earlier. Our logic model combines and attempts to harmonize various compact and project logic models from the M&E plan. Several of these logic models contain only "increased rural incomes" as objective; while others include "increased rural incomes & improved food security". If there is an updated M&E plan that is available, we would harmonize the logic model with that document.<br>3. We have indicated the parts of the logic model that are addressed using an impact evaluation for the Dosso-Gaya evaluation using different shapes. (Note, because the logic models covers both Konni and Dosso-Gaya, the figure note will indicate that this applies only to the DG design). |

Table F.1 (*continued*)

| # | Name & Sector | Comments & Questions | Response to MCC |
|---|---|---|---|
| 14 | Sarah Lane, Evaluation Lead | Why is RMA red? | The RMA inputs, outputs, and short-term outcomes are in red because they fall outside the scope of the evlauation. We have added a legend to indicate this. |
| 15 | Sarah Lane, Evaluation Lead | Probably not a question for Mathematica, but why are so many more farmers expected to get training when the size of the scheme is so much smaller? Will training also be for farmers outside of the perimeter? | The SAA program also includes activities that are open to farmers who don't benefit from SSI investments. We include this clarification in the table notes. |
| 16 | Sarah Lane, Evaluation Lead | Is the IRR of 40 percent just for the SSI? | Yes, the 40% IRR is only for small-scale irrigation. The authors estimate the IRR on large-scale irrigation as 9.3%. |
| 17 | Sarah Lane, Evaluation Lead | It would be interesting to include some of the learning from other MCC irrigation evaluations and how we are making changes or not based on those findings. | We agree that it would be interesting to document this issue as part of the Niger evaluation design. Since this adds a new (important) research question, we suggest that the EMC determine if it should be added. We would suggest a new research question: Did the design and the implementation of the IMAP incorporate lessons learned from previous MCC irrigation interventions, and if so, how? |
| 18 | Sarah Lane, Evaluation Lead | Isn't it the case that roads linkages just lower transportation costs? I have wondered if there are times when we can posit how the lower transportation costs might manifest in the economy. Isn't it possible that it would be cheaper to bring food into rural areas so farmers could be less likely to be profitable? I wonder under what circumstances we could determine if roads are likely to result in increased farmer profits. | While trade costs would be reduced from improved linkages, there are several conflicting effects that can arise which do not provide an a priori clear sign of which farmers will benefit and to what degree (see Sotelo, 2020). We have modified the introductory paragraph to better elucidate this point, that farmers can switch crops in response to competitive pressures from more productive producers elsewhere, or because of new market opportunities created through foreign trade (e.g., producing crops which have limited domestic demand, but large foreign demand that was inaccessible prior to the roads investments). We are hesitant to forecast who |

Table F.1 (*continued*)

| # | Name & Sector | Comments & Questions | Response to MCC |
|---|---|---|---|
| | | | will benefit/be harmed from transportation improvements, because it will largely depend on a multitude of factors (e.g., comparative advantage in land productivity across crops, responsiveness of regional trade flows to roads investments, capital access to enable crop switching, etc.) that we do not believe are available. |
| 19 | Sarah Lane, Evaluation Lead | What do the A-F refer to in this table? Is A Overarching and the other letters refer to the activities they sit next to? | Yes. Overarching research questions for both the performance and impact evaluation are grouped under the letter A and letters B-F correspond to the relevant activity or sub-activity. These letters also correspond to the sections of chapters V and VI in which they are discussed. We have added clarifying text. Some of the letters were slightly misplaced in the figure, so we have updated that as well. |
| 20 | Sarah Lane, Evaluation Lead | Overall, I find this graphic a little hard to follow.<br><br>On RMA, how will Mathematica coordinate with the other evaluation that is focused solely on the road? | We have dropped the graphic.<br><br>We will review IDG's analysis of the origin-destination data if we can obtain it. If this does not address questions to benefits occurring to the BT specifically, it is possible to access the origin-destination raw data collected by IDG, the sample covers a large enough group of observations whose origin or destination is located within the Basse Terrasse, then we would discuss with the EMC if we should complement IDG's analysis with a focus on the BT. |
| 21 | Sarah Lane, Evaluation Lead | How is this different than the BT? Do these communes include the BT? If so, perhaps be explicit about that. | We have added clarifying text. |
| 22 | Sarah Lane, Evaluation Lead | Can you give a brief description of what you mean by each of these evaluation methods? | As you suggested in a later comment, we have inserted a sentence to indicate that research methods will be described later in the report. |

Table F.1 (*continued*)

| # | Name & Sector | Comments & Questions | Response to MCC |
|---|---|---|---|
| 23 | Sarah Lane, Evaluation Lead | Why are there so many blanks in this column? | Those were formatting issues which have been corrected. |
| 24 | Sarah Lane, Evaluation Lead | You sorted the research questions about in the A-F framework. Why is that not here as well? | We have re-ordered the research questions, indicating the report sections where they are addressed. |
| 25 | Kent elbow, MCC Land | Existing landholders will maintain their land rights so there will be no land allocation. The land activity at SK2 consists primarily of land inventories, land rights formalization and determination of land-sharing arrangements where appropriate. Perhaps the appropriate "umbrella" term to use here (instead of "land allocation") is "land governance." The same adjustment should be made elsewhere in this document where the word "allocation" appears. | We have updated the language to now refer to "land governance." |
| 26 | Sarah Lane, Evaluation Lead | Where is RQ2? | RQ2 was only applicable to Konni and not Dosso-Gaya. Please see footnote #7 on page 19. We have now further elaborated on this footnote and added similar text as a note to Table IV.1 to clarify. "Where possible, we have retained the original research question numbering that was used for the research questions in the evaluation design report for Konni (D'Agostino et al. 2019). Due to differences in project activities and the availability of a comparison group that supports causal attribution, we have reformulated research questions to be relevant to the Dosso-Gaya context. We have also added additional subquestions as needed or omitted research questions that are not relevant for Dosso-Gaya. As a result, research questions are not sequential when Konni-specific questions are not applicable." |
| 27 | Sarah Lane, Evaluation Lead | Will crop cuts also be included? | Yes, we've included this as a data source. |

Table F.1 (*continued*)

| # | Name & Sector | Comments & Questions | Response to MCC |
|---|---|---|---|
| 28 | Sarah Lane, Evaluation Lead | Is this question not part of the impact analysis? | That is correct, since we would not be able to use an impact evaluation to answer a question about the efficacy of the implementation design. This question is part of the impact analysis inasmuch as it helps us understand project impacts, but would rely on qualitative techniques to properly address it. |
| 29 | Andrew Tarter, MCC-GSI | Does 'outcomes' here mean the same as income and productivity, which are mentioned explicitly, in RQ3? | Yes, the 'outcomes' referenced in RQ3a encompasses 'income, volumes and value of agricultural products' from RQ3. |
| 30 | Sarah Lane, Evaluation Lead | Please make sure this is the Project Objective from the compact. | The compact refers to "increase rural incomes" as the IMAP's objective. Our analysis of RQ4 will focus on this objective. |
| 31 | Sarah Lane, Evaluation Lead | What does "Synthesis of evaluation analyses" mean? | Instead of providing a list of lessons learned from each research question, we will synthesize the disparate Mathematica evaluation analyses that address the separate research questions to understand common themes across research questions. |
| 32 | Sarah Lane, Evaluation Lead | What does "Mathematica evaluation analyses" mean? | |
| 33 | Sarah Lane, Evaluation Lead | Should 'crop cuts' be included here as a data source? | Yes, we've included this as a data source. |
| 34 | Sarah Lane, Evaluation Lead | Will this part of the evaluation be able to use data from the road evaluation? | See our response to comment #20. |
| 35 | Sarah Lane, Evaluation Lead | You identify how you are setting up the counterfactual, but what is the analytical approach to determining impact? Is it diff-in-diff? | We have included text indicating that this section includes information about our estimation procedure, which is described on page 30 (referencing the inverse propensity-weighting regression adjustment technique). We use a simple difference approach that compares outcomes between treated and comparison units while controlling for observable household characteristics. |

Table F.1 (*continued*)

| # | Name & Sector | Comments & Questions | Response to MCC |
|---|---|---|---|
| 36 | Sarah Lane, Evaluation Lead | These outcomes don't clearly map to the program logic. Should they? | We have added "Land under irrigation" as a key outcome. Otherwise, the key outcomes map closely to the program logic. Cropping pattern includes whether land is cultivated in the rainy season only, and what type of crops are grown; sales includes volume and value of agricultural products, the remaining two outcomes map into income and food security. |
| 37 | Andrew Tarter, MCC-GSI | Ok…this gets at fix location households. Is there an analogous question for the 'renter groups'? | The analogous question for renters is in RQ22b. Because we will not be able to collect high-quality baseline data from renters (i.e., who will become a renter will not be known at baseline), we will partially address this question by comparing their outcomes to non-renters and conducting qualitative data collection on renters' outcomes. |
| 38 | Sarah Lane, Evaluation Lead | Is this likely that MCC could decide that comparison areas will receive project benefits given where you are planning to do the matching? | It is not likely that the intervention will extend into these areas beyond what is already anticipated (such as through the LTS), but we thought it would still be helpful to explicitly identify this as a potential risk to the empirical approach. |
| 39 | Sarah Lane, Evaluation Lead | Can you explain what you mean by "Sustainability Analysis"? | By sustainability analysis we are referring to the irrigation infrastructure assessment and qualitative interviews that will be conducted to ascertain the long-term sustainability of the small-scale irrigation infrastructure and barriers or facilitators to sustainability. We have added a sentence to mention that this will be discussed in more depth in the following section. |
| 40 | Sarah Lane, Evaluation Lead | Is it possible to map these outcomes to the logic? | The existing Table A.1 mapped research questions to logic model elements, by activity and logic model level. We have now added the indicators from the overview tables to that Appendix Table to facilitate the review. |

Table F.1 (*continued*)

| # | Name & Sector | Comments & Questions | Response to MCC |
|---|---|---|---|
| 41 | Andrew Tarter, MCC-GSI | Does "agricultural outcomes" include income? How are we measuring 'renter group' changes in productivity and income (the analog is R3, which applies to households; curious about the analysis of renter groups). | Yes, total household income is one of the agricultural outcomes. We will compare renters and owners at interim and at endline. For more detail, please see our response to comment #1. |
| 42 | Sarah Lane, Evaluation Lead | Does this reflect the compact extension? | This does not. From earlier conversations with our PM, the decision was to keep all timeframes assuming there is no compact extension until there is official confirmation of one. |
| 43 | Andrew Tarter, MCC-GSI | 9 persons per focus group, or 9 focus groups total? | We meant focus groups total. However, there was actually an error here and this should have been 7 focus groups. We have now corrected the error and clarified the language. |
| 44 | Andrew Tarter, MCC-GSI | Excellent. If the 'why' is based on the type of renter groups (i.e. women's groups, etc.) then I presume data/profiles on the groups would need to be established to answer the 'why' question… | It seems likely that sizable differences in outcomes may arise across groups with different compositions. Given the small sample size we will be relying on qualitative data to help us understand what factors may contribute to between-group differences. |
| 45 | Andrew Tarter, MCC-GSI | Any chance this question could be reworked to focus on direct beneficiaries in SK, rather than the focus on participants in Konni? Otherwise, how will we know how many women and/or youth benefited? | RQ17 in Konni focusses on the participants to the IWUA training in particular. That is why this is N/A. We have now added a clarification for the Konni RQ. |
| 46 | Andrew Tarter, MCC-GSI | Isn't there still some possibility that land will be 'granted' to women's cooperatives? Or at least provided to (access). | Our understanding is that women's cooperatives would be able to rent land (assuming they match with a landholder), and so RQ23 examines the effects of land access on these groups given that some individuals/groups will newly be able to access SSI land. We believe that RQ3a encompasses the effects that providing income from renting land will have on these groups. |
| 47 | | No chance that this could be reworked for 'access' to land (rather than ownership) in the case of SK? | Since the identities of individuals/groups that will participate as renters will not be known at |

Table F.1 (*continued*)

| # | Name & Sector | Comments & Questions | Response to MCC |
|---|---|---|---|
| | | | baseline, we won't have any pre-treatment information about these women and therefore won't be able to assess the effects of their access in a robust way.<br>We will however investigate changes in agricultural decision making and intra-household control of resources over time for a specific group of women, namely those women who are surveyed at baseline because they live in households who own the future SSI plots. To the extent that these women access land between baseline and midline, we are able to investigate changes in indicators of empowerment, agricultural decision making and intra-household control of resources . We note that we will not be able to disentangle which component of MCC's activities influenced any observed changes if these women also participate in other programs. |
| 48 | | I think the number in the other table is 9 | We have updated the other table to 7 - which includes the 5 beneficiary and 2 producer group FGDs enumerated in this table. |

**This page has been left blank for double sided copying.**

# APPENDIX G.

## Local stakeholder comments

**This page has been left blank for double sided copying.**

**Table G.1. Local Stakeholder Comments**

***From the Design presentation***

| Number | Name | Question | Answer |
|---|---|---|---|
| 1 | Samira Durand Trapsida, M&E Specialist | La collecte de données quantitative, il y a au peu près 600 ménages traites et 900 ménages témoins. Comment est-ce que ces chiffres ont été déterminés ? Parce que à ce stage là on n'a pas les listes définitives de bénéficiaires. Donc ces chiffres représentent quoi ? Comment est-ce que ces chiffres peuvent être représentatives des chiffres qui on aura à la fin de la mobilisation ? | The number of observations, (600 treatment and 900 comparison) was limited by the proposed number of hectares under consideration when we did the initial calculations. If there are 600 hectares that are targeted and the households that cultivate them, we want to target 600 hectares. To have reasonable minimum detectable differences we need to have a comparison group that is a little bit larger. So that's why there are 900 households in the comparison group. In terms of the methodology that we used, there isn't one household in the comparison group that will serve as the control for one household in the treatment group. In fact they are weighted by the inverse of their probability of being similar to the treatment group with respect to characteristics that are important to treatment group assignment. If the number of treatment households increases, we would increase the number of households in the treatment group. |
| 2 | Samira Durand Trapsida, M&E Sepcialist | Pour les thèmes clés, accès au financement et sécurité foncière. Quand je regarde le calendrier, on voit que le plan de collecte des données c'est en trois phases 2021, 2023, et 2026. Si on a des contrats de location qui ne vont pas jusqu'à cette période, 2026, est-ce que sur là il y aura un impact sur la performance ou un impact sur les investissements ou un impact sur la mesure de leur performance ? Si les contrats ne sont pas formalisés jusqu'à cette période de 2026 est-ce que on peut voir un impact négatif sur la mesure de la performance de cette activité ? | With respect to long-term impacts, if the renter contracts are not renewed at the end of the Compact because the landowners no longer want to continue renting to their cultivators, that raises a question about the intervention's sustainability. In the interim survey we will see if it's the same cultivators as at baseline, or if there are new cultivators or cultivators outside of the family of the landowners. We will present the results of this analysis and identify whether there are key lessons that would be relevant to future projects. |
| 3 | Hamidou | Comme vous avez bien dit, le méthode quasi-expérimental nécessite rigoureusement le choix d'un contrefactuel, c'est pas une exercice aussi facile. C'est de ça que je vais parler. Vous avez dit qu'il n'y a pas de choix d'échantillon dans la Basse Terrasse pour éviter les effets indus par les avantages autour du groupe traité. A-peu-près, le choix des trois localités là, représentés sur la carte, notamment Yelou, Sambera, et une partie de Falmey. Donc, qu'est-ce qu'il y a motivé le choix de ces trois zones pour le choix du contrefactuel potentiel ? | To choose these potential comparison areas, we selected the proposed five-hectare treatment area polygons initially shared by MCA, and divided them into one-hectare plots. We know these will not perfectly conform to the actual plot boundaries on the ground, but we believe there is sufficient overlap that the actual plots and our one-hectare plots should have similar characteristics. We then divided all land in the rest of the areas neighboring the BT into one-hectare “plots” to perform an initial matching to identify comparison units that are similar to treatment units. We used a matching algorithm to select those comparison unit plots that are most similar to the treatment plots in terms of cropping histories, land cover, and similar |

Table G.1 (*continued*)

| Number | Name | Question | Answer |
|---|---|---|---|
| 4 | Hamidou | Un autre aspect que, comment on dit, le groupe contrefactuel est la plus proche possible du groupe traité. Donc est-ce que à votre avis le choix de ces trois zones sur la carte hors de la zone Basse Terrasse est-ce qu'il n'a pas aussi des faits ou des billets qui risquèrent d'être un peu connecté au méthodologie du fait que les données en cas, comme le socio, économique, et démographique et même les données culturelles peut-être traité différemment par rapport à la Basse Terrasse ? | attributes. This was before we had the Watex data. We observed numerous comparison plots of land selected by our matching algorithm that were in the three zones we have shown, when we had limited the potential comparison zones to not be too far away. There was a fourth zone near Gaya that also had several land matches, but MCC has informed us that in that area there will be land tenure security strengthening efforts that would alter how we interpret impacts since those "comparison" units are in fact receiving part of the treatment. This process balances competing issues—we anticipate that plots near the BT are most likely to be similar to the treatment plots, but they themselves could be receiving part of the treatment and are therefore not suitable comparison plots. However, we could potentially identify exact matches to our treatment plots that are far away from the BT, but would incur expensive data collection costs and we would not know if they are similar along non-environmental dimensions. The choice of zones is a compromise that reduces the distance covered by data collectors, while also ensuring that comparison units are not subject to treatment spillover effects. |
| 5 | Julien Tougouri, M&E Director | J'ai une question de clarification. J'ai compris que dans la Basse Terrasse il n'y a pas de groupe de comparaison. Est-ce que c'est bien ça et si c'est ça, pourquoi il n'y a pas de groupe de comparaison ? Parce que le projet ne concerne pas tous les ménages de la Basse Terrasse - il concerne que les ménages qui disposent de la terre et qui sont disposé au projet. Et au même temps il y a des ménages qui n'ont pas de la terre mais qui sont cultivateurs. Donc tous les ménages ne sont pas concernés. Si on regarde dans la Basse Terrasse, il y a près de 5000 hectares et il y a 640 hectares qui sont utilisés par le projet. Donc nécessairement il y a des ménages qui sont dehors du projet. Mais pourquoi ils ne constituent pas le groupe de comparaison ? | In the BT, not all areas are suitable for SSI. SONED initially identified 128 blocks of 5 ha each for SSI and 55 waitlist blocks, for a total of 183 blocks. We considered taking the waitlist or potential blocks as a comparison group, but the other Compact investments in the BT could fundamentally change the local economy. For example, there are the trainings (farmer education, financial literacy, etc.), indirect effects (for example, those who might cultivate a small area of a land that aren't the owners like groups of women or youth), laborers will be more in demand in the BT because of SSI, etc. As a result, we think it will be difficult to identify in advance the households that will not be affected by the project within the BT. If we used households within the BT who are benefiting from these investments, we would underestimate the impacts of MCC investments. |
| 6 | Hamidou | Deuxième chose, c'est de savoir à-peu-près, les autres, comment on appelle ça, les ménages qui ne sont pas concernés par la Basse Terrasse. Est-ce que les autres qui sont dedans, il n'y a peut-être point d'une suffisance si vous avez reculé, vous pouvez être certainement un peu écarté, par exemple le choix de ce groupe témoin dans cette Basse Terrasse là. | |

Table G.1 (*continued*)

| Number | Name | Question | Answer |
|---|---|---|---|
| 7 | Zacharia | On aimerait bien avoir la présentation si c'est possible. | We have circulated the presentation. |
| 8 | Zacharia | Une autre de mes préoccupations, avec les ménages du groupe de comparaison, vraiment il faut bien passer l'information et la sensibilisation pour ne pas toujours créer des attentes. | We agree completely. It is very important for the enumerators to say clearly that there is no benefit that will accompany our data collection. We will tell them multiple times during the data collection process. The data collection need not explicitly reference the IMAP investments, so that respondents do not know there is a connection between investments in the BT and the household surveys. |
| 9 | Julien Tougouri, M&E Director | L'évaluation de la qualité de l'infrastructure d'irrigation - j'ai entendu que un des vœux de l'évaluation concerne la qualité. Comment vous comptez faire ça parce que la qualité de l'infrastructure d'irrigation est déjà prédéterminée avec le cahier de charge et tout, l'ensemble des choses ? Comment est-ce que, quelle information on peut en compte tirer pour utile pour caractériser la qualité de l'infrastructure ? Est-ce que c'est le maintien, l'opération, les effets de temps sur la dégradation ou, j'aimerais que vous donniez un peu plus de précision sur ça. | We have an engineer who will do site visits and take a sample of the infrastructure to see if it was well installed/implemented based on the specifications, if it is operating in the correct manner, if it is maintained, and if there is any equipment degradation. For the interim period, we will see if the equipment is well-aligned with Compact activities. For the endline, we will focus on long-term equipment maintenance, to see if it is close to the original specifications/maintenance schedule, and to assess whether users are adopting best practices. This data collection is planned for 2025/26. |
| 10 | Julien Tougouri, M&E Director | L'autre question que j'ai, ça concerne le choix du groupe de témoin, il y a un très grand défi que je vois ici [résume de notre approche et méthodologie pour choisir le groupe de comparaison] j'ai noté que vous avez fait un compromis entre la distance pourque on est les zones agro-climatique qui ressemble la plus possible pour détecter les effets qui sont uniquement à l'intervention de MCA-Niger mais je vois un effet de contamination au groupe témoin. Je vois là un très grand défi pour se faire ce travail. Pourquoi n'être pas aller beaucoup plus loin pour limiter l'effet des contaminations ? Pour moi les zones qui sont choisis ne sont pas exempt d'être contaminer par les effets de l'intervention que MCA-Niger va avoir sur la petite irrigation. Je pense qu'on n'aura plus aller un peu plus loin, avoir des groupes d'apparié beaucoup plus semblable, mais qui sont dans la même zone agro-climatique et qui peut aussi être comparer et déduire l'effet net de l'intervention de MCA-Niger. | Your comments raise two issues of the unbiasedness of the comparison group, first in terms of spillovers and second in terms of benefitting from the roads rehabilitation.<br>First, you suggest selecting comparison areas that are located further away to avoid spillovers. As we noted, there is a tradeoff between the probability of experiencing similar environmental and ecological conditions and the risk of spillover. The area under consideration is a little specific. If we move further away, we may not be able to find households that are subject to the same ecological context as the BT. It's an area that is also close to two different countries, so the economic context may be a little different than other areas that are further away. So there is the economic and ecological context that we would like to have as similar as possible. To give you an example, when we initially did the matching there was another area adjacent to the BT that had a lot of matches, but it was too close. So we decided that we should not take areas that are too close or too far away.<br>Second, you point out that all of these areas will benefit from the roads activities. That is likely to be the case for all of the potential comparison areas in the region, because the compact-funded rehabilitation is a major |

Table G.1 (*continued*)

| Number | Name | Question | Answer |
|---|---|---|---|
| 11 | Samira Durand Trapsida, M&E Specialist | Par rapport à l'échantillonnage potentiel, dedans j'ai vu que les potentiels zones ménages sont autour des routes d'accès où MCA est en train de vouloir les réhabiliter. Et nous savons que toutes les activités du Compact sont entreliées. Donc si on choisit les ménages là, au niveau des axes routières du Compact, est-ce qu'on ne veut pas créer une bille lorsque on ne peut pas faire les analyses, parce que toutes les activités sont entreliées, même si ces ménages-là, ne vont pas directement bénéficier des activités de petite irrigation mais ils vont bénéficier des certaines activités, notamment RMA et tout ça, et l'accès ou financement, et prennent comme l'avantage ? | rehabilitation effort. The estimated impacts of SSI will therefore be conditional on the rehabilitated roads from the Compact. Regarding the roads investment itself, we can't directly estimate the impact of the roads, which is why the roads activities are covered by the performance evaluation to see what are the effects of the roads. |
| 12 | Julien Tougouri, M&E Director | Un autre question, est-ce que vous avez confiance de trouver suffisamment de taille de ménage apparié? Atteinte confiance de trouver suffisamment de taille de ménage apparié, comment savoir se faire dans l'étage ? J'ai vu qu'il y a plusieurs passages, trois passages qu'on a été identifiées. Est-ce que à ces périodes de données d'avoir collecté pour les comparer, ou bien avoir quand même des gens qui vont faire des collectes continues sur les temps pour ne pas perdre les effets longitudinaux sur ces ménages de différentes transformations qui vont pouvoir intervenue au cours de tous les cycles ? Si non, si entre deux collectes il y a quand même des temps qui se coule, je me demande si on ne va pas perdre de l'information un an à un an ? | The matching will be based on baseline data. We will follow the same households in the BT and the comparison group over time, from the baseline, to the interim, and through to the endline. |
| 13 | Julien Tougouri, M&E Director | Une dernière question, et peut-être que Hamissou peut aider à répondre à cette question, il y a de plus en plus questions de prolonger le Compact à cause des effets continues de COVID. Certaines activités de programme vont se rallonger et seront reprogrammé par rapport à ce qu'était prévue. Comment est-ce que vous allez tacler ce problème là - la prolongation et la continuation des activités ? | If the Compact is extended we will reschedule data collection as well. We and our data collectors are flexible for both Dosso-Gaya and Konni. |
| 14 | Hadiza, GSI Specialist | On aimerait comprendre comment sera évoluée l'autonomisation de la femme si la méthode ne privilégie que l'enquête ménage? | Our overall approach is a mixed-methods effort to analyze and measure women's empowerment due to the Compact interventions. In our household survey, there is a module on women's empowerment (based on the WEAI) |

Table G.1 (*continued*)

| Number | Name | Question | Answer |
|---|---|---|---|
| 15 | Hadiza, GSI Specialist | Par rapport au thème de l'autonomisation des femmes, on avait posé le question pour savoir si cette autonomisation des femmes va être évaluer dans les enquêtes ménages, ou bien s'il y avait une méthodologie assez spécifique qui permettre d'aller au niveau des individuelles des femmes et autres membres des ménages? | which is addressed directly to the women, answered by the household's female head. This module was in the Konni baseline survey and will also be administered in the baseline survey for Dosso-Gaya, where our efforts will focus on women in households that benefit from the SSI. There will be a complementary qualitative evaluation component. For the interim survey, we will also use a qualitative method and have female-only FGDs to assess for changes in women's empowerment associated with Compact activities. Those results will be complemented by the pre-post analysis of the women's empowerment module. |

***Written comments on the Design report***

| # | Name | Page | Comment | Final response |
|---|---|---|---|---|
| 1 | | 1 | Valeur de Compact - 437 au lieu de 426 millions de dollars | We updated the value of the Compact. |
| 2 | Samira Durand Trapsida, M&E Specialist | 1 | C'est region de Tahoua ou zone de Konni, mais pas région de Konni. | We now use the terms "intervention area" in English and "intervention zone" in French to delimit the areas that the compact is intervening in and to distinguish this from the administrative regions of Niger. |
| 3 | Samira Durand Trapsida, M&E Specialist | 1 | Il n'y a pas d'autoroute, surement un problème de traduction ! | We corrected this. |

Table G.1 (*continued*)

| # | Name | Page | Comment | Final response |
|---|---|---|---|---|
| 4 | Samira Durand Trapsida, M&E Specialist | 5 | Revision: "La phase initiale de test comprend 100 hectares dans la zone 3, suivie de 240 hectares supplémentaires dans les zones 3 et 4, et d'une dernière phase de 300 hectares dans les zones 1, 2 et 5, comme le montre la figure II.2." changé à "La phase initiale de test comprend 100 hectares dans la zone 3 et une partie de la zone 4, suivie de 200 hectares supplémentaires dans les zones 4 et 5, et d'une dernière phase de 340 hectares dans les zones 1 et 2,, comme le montre la figure II.2." | We updated the schedule for construction of SSI systems based on the information you provided. |
| 5 | Samira Durand Trapsida, M&E Specialist | 11 | Dans la nouvelle version du PSE, on parle de 1920 à SK2. | We updated the beneficiary numbers to those provided by you. |
| 6 | Samira Durand Trapsida, M&E Specialist | 11 | Il n'y aura pas de AUEI à SK2, le chiffre est donc 0. | Instead of indicating "not applicable" for the number of planned IWUAs in the BT, we state that the compact is not planning any IWUAs and include the value of "0". |
| 7 | Julien Tougouri, M&E Director | 18 | Pas explicite. | We clarified that language. |
| 8 | Julien Tougouri, M&E Director | 19 | Un phénomène empirique généralement observé est que les terres dont l'accès est rendu possible par le désenclavement ont plus de valeur monétaire (location ou vente) que celles d'accès difficile. Par ailleurs une accessibilité facile aux terrres est susceptible d'attirer plus de producteurs et par ricochet d'accroitre les superficies mises en valeur. | It would be interesting to research whether access to roads increases the rental or sales value of land. However, that is not a research question within our evaluation's scope. Also, we will note that we don't have a robust research design since this would only be pre-post. |

Table G.1 (*continued*)

| # | Name | Page | Comment | Final response |
|---|---|---|---|---|
| 9 | Julien Tougouri, M&E Director | 40 | Cela n'impactera –t-il pas le resultat global ? Si non expliquer. | We have included explanatory text in Chapter V.C on how we would approach churn in the sample population. We will be able to rematch in the endline to minimize any differences between our treatment and comparison groups, given changes in the renter population over time. |
| 10 | Julien Tougouri, M&E Director | 60 | Il sera intéressant de rapprocher les résultats de cette enquête avec ceux d'Origine et destination de IDG systématiquement menée sur une semaine sur les axes routiers afin d'appréhender, la nature, les origines et les destinations des marchandises transportées vers ou en dehors de la zone en empruntant les axes réhabilités. Il est fort probable que le nombre de personnes systématiquement enquêtées sur la période de collecte Origine-Destination sera suffisamment large pour entrainer des conclusions significatives. | We plan to review IDG's analysis of the origin-destination data they are collecting in the Dosso-Gaya region.<br>If this does not address questions to benefits occurring to the BT specifically, it is possible to access the origin-destination raw data collected by IDG. The sample covers a large enough group of observations whose origin or destination is located within the Basse Terrasse, then we would discuss if we should complement IDG's analysis with a focus on the BT. |
| 11 | Julien Tougouri, M&E Director | 66 | Traduire le tableau en francais. | We translated the final version of the tables in French. |

**Mathematica**

Princeton, NJ • Ann Arbor, MI • Cambridge, MA
Chicago, IL • Oakland, CA • Seattle, WA
Tucson, AZ • Woodlawn, MD • Washington, DC

**EDI Global, a Mathematica Company**

Bukoba, Tanzania • High Wycombe, United Kingdom


mathematica.org