

Prioritization of Types of Investments: Operational Tools for MCC Agricultural Investments

IFPRI – MCC Series: Prioritizing Agricultural Investments for Income, Poverty Reduction, and Nutrition

Technical Paper 4



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ACRONYMS AND ABBREVIATIONS

EPA	Environmental Protection Agency
ERR	Economic Rate of Return
CBA	Cost-Benefit Analysis
CGE	Computable General Equilibrium
FDI	Foreign Direct Investment
GIS	Geographic Information System
ICT	Information & Communications Technology
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
MCC	Millennium Challenge Corporation
R&D	Research & Development
SDG	Sustainable Development Goal(s)
SFA	Stochastic Frontier Analysis
TFP	Total Factor Productivity

EXECUTIVE SUMMARY

This report answers the question:

“What guidelines can be used to identify the types of agricultural investments that have the highest economic return, where “agriculture” is broadly defined to include primary production, handling, storage, transportation, distribution, processing, and retailing?”

Using the literature and MCC’s ERR analyses, we explain how agricultural investments fit in a wider development context, identify information useful to MCC’s decision making that is not provided by the ERR analyses, and suggest IFPRI tools for exploratory and ex-ante evaluative analysis that MCC can use in their decision-making process.

We find that economic context matters (Section 2). Policy, other public investment, and the structure of the food system and wider economy can affect the impacts of MCC’s investments. Our tools aim to take these factors into account.

IFPRI tools for exploratory analysis (Sections 3.1–3.3) can answer questions such as: At a high level, what policy or economic factors might be constraining the agricultural sector? Given a certain amount of investment or multiple goals to be reached (e.g., spurring economic growth, reducing poverty, limiting greenhouse gas emissions), where and how are MCC’s funds best spent?

IFPRI tools for ex-ante evaluative analysis (Sections 3.1–3.3) can answer questions such as: Beyond ERR, what outcomes of interest to MCC are likely to be impacted? Accounting for economic feedback effects and policy factors, what will the impact of an investment be?

To develop tools (Section 3.4), IFPRI considers technical aspects that are important to robust, realistic, and accurate analysis, including assumptions specific to developing country economies, capture of second-order effects, changes over time, capture of multiple outcomes of interest, handling of risk and uncertainty, and discounting. Choices made on technical aspects reflect economic assumptions about real-world situations and often contain ethical implications, so they are not taken lightly.

To choose tools (Section 3.5), IFPRI describes the factors determining which tool has the best suitability for a particular investment question and describes feasibility challenges that might be faced for the most sophisticated tools.

In the final section of the report (Sections 4), we illustrate applications of a couple of the IFPRI tools.

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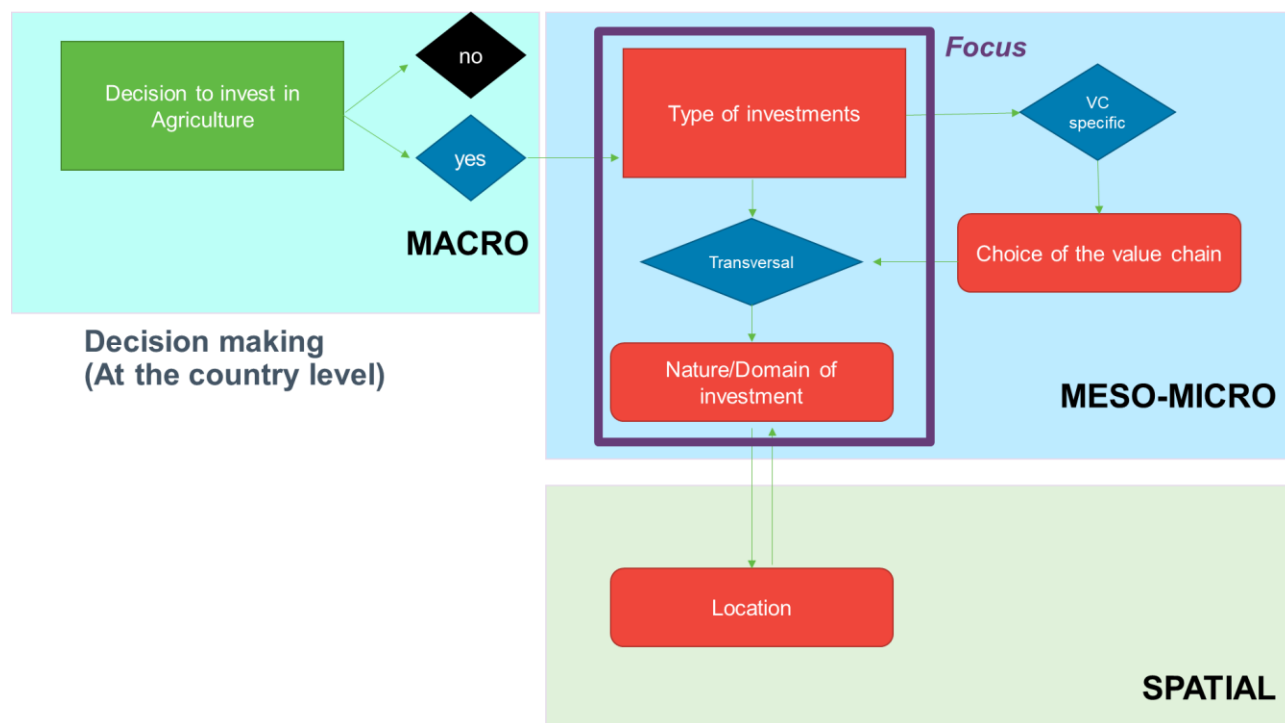
1 INTRODUCTION

1.1 Report Context

MCC recognizes agriculture as a key lever to reduce poverty, improve food security, and achieve economic growth in developing countries. To prepare a strategy for increased agricultural investment in its partner countries, MCC wishes to assess the potential and cost-effectiveness of agricultural investments. IFPRI proposes to conduct this analysis, carefully considering local contexts, drawing on past experience and holistic economic simulation. Past experience includes MCC's experience and academic literature, while economic simulation includes effects from the household level through the macroeconomic level.

Deciding and signing a pro-growth, pro-poor investment strategy in an agri-food system requires answering a set of questions summarized in Figure 1 and reviewed in [Vos and al, 2021]:

Figure 1: Overview of quantitative assessment for MCC investments



Source: Authors' elaboration.

1. Should we prioritize investing in agriculture vs in other sector of the economy? (see Martin, 2021 for a discussion);
2. Within agri-food systems, what sort of investments should be made? This is the specific topic of this paper;
3. Which value chains should be prioritized? (see Martin and Minot, 2021 for a discussion);

4. Which areas should be targeted first, especially when considering both needs (e.g. poverty) and potential for agricultural development? See Maruyama, 2021 for a detailed illustration.

This paper focuses on question 2.

1.2 The Object of This Report

Expanding question 2 above, this paper addressed aimed to answer the following question (IFPRI-MCC workplan, 2019):

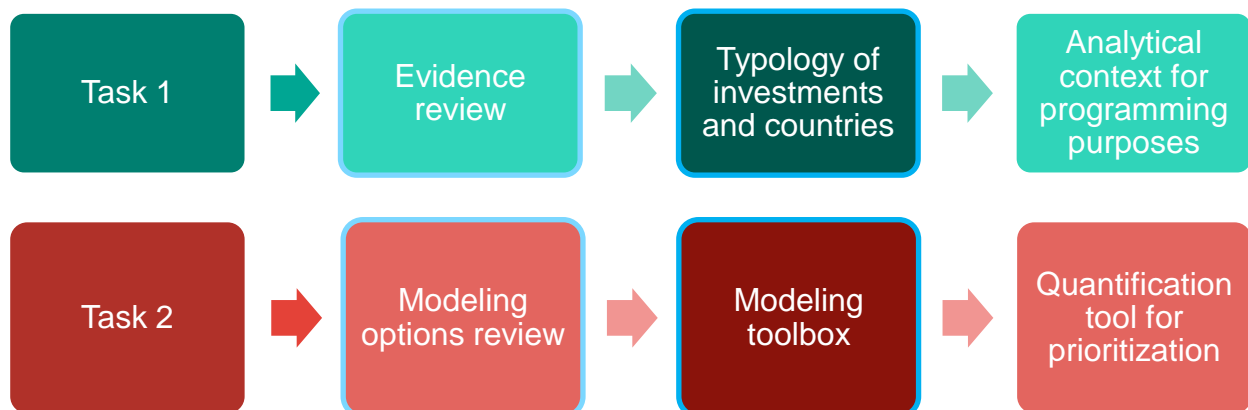
Central Question of this Report:

“What guidelines can be used to identify the types of agricultural investments that have the highest economic return, where “agriculture” is broadly defined to include primary production, handling, storage, transportation, distribution, processing, and retailing?”

Error! Reference source not found. illustrates the structure of our work on question 2, with o utput contained in this document outlined in blue:

- i. an evidence review, to provide guidance on types of investment in agri-food systems most likely to have high returns
- ii. analytical tools to provide ex-ante assessment of investment decisions, considering both micro and macroeconomic effects.

Figure 2: Process to create guidelines for investment strategy

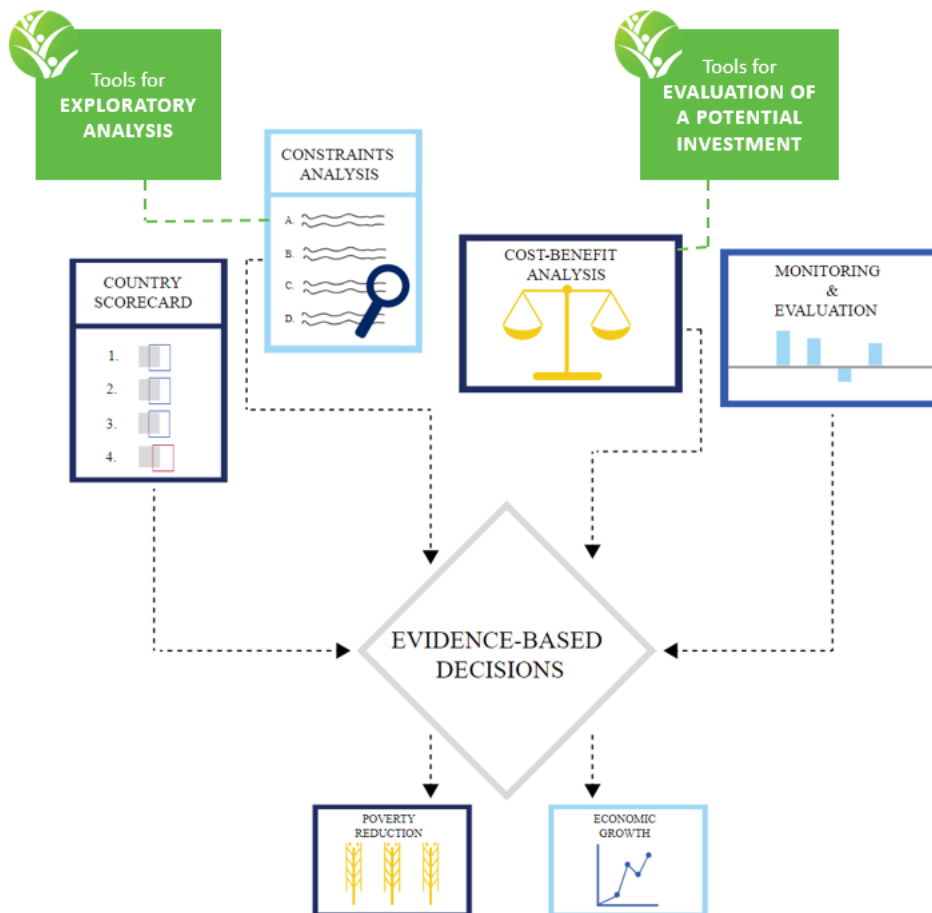


Source: Authors' illustration.

To answer the central question, we first provide background on how public agricultural investments fit into a broader development strategy, detailed in Section 2. This groundwork includes understanding the justification of public investment in agriculture, the landscape of public investments that can affect agriculture, and a review of existing work providing insight on what the “best” agricultural investments are.

In Section 3, we present a suite of tools to augment MCC’s toolkit in both the exploratory analysis phase and the ex-ante evaluative analysis phase. We begin by identifying limitations of the ERR analysis and follow with presentation of IFPRI tools that may be useful in such scenarios. Figure 3 below shows how the tools presented in Section 3 fit into MCC’s current toolkit for evidenced-based decisions.

Figure 3: How IFPRI Tools Relate to MCC’s Toolkit for Evidenced-Based Decisions



Source: Author’s augmentation of MCC’s illustration of its toolkit for evidence-based decisions, available at <https://www.mcc.gov/our-impact>.

Section 0 demonstrates an IFPRI exploratory analysis tool for the case of Malawi.

A wide understanding of “agricultural investments” as encompassing the whole agri-food system drives our tool suggestions. We also account for linkages and interconnections with other parts of the economy, which can contribute to otherwise unforeseen impacts on intended outcomes.

2 HOW DO TYPES OF AGRICULTURAL INVESTMENTS FIT INTO A BROADER DEVELOPMENT STRATEGY?

Understanding Agriculture Projects in the MCC Portfolio

To answer this report's central question, *What guidelines can be used to identify the types of agricultural investments that have the highest economic return, where "agriculture" is broadly defined to include primary production, handling, storage, transportation, distribution, processing, and retailing?*, we provide key background information. First, we review the role of public investment (Section 2.1, "When Is Public Investment Justified?") to theoretically differentiate MCC's work from situations that are more appropriate for private investment. Second, to understand the "types of agricultural investments," we provide a landscape of public policy and investment from an agricultural perspective (Section 2.2, "What Are the Types of Public Policy and Investment? An Agricultural View"). Finally, we synthesize literature that provides some insight on the types of agricultural investments that have the highest economic return (Section 2.3, "What Does the Literature Say about What the Best Agricultural Investments Are?").

2.1 When is Public Investment Justified?

Here, we review the definition and role of public investment to theoretically differentiate MCC's work from situations that are more appropriate for private investment or other types of action.

Defining investment

In this report, we define *investment* as *the allocation of resources to produce capital*. Capital is conceptualized as a stock (rather than a flow) that contributes to production. Capital can be public, private, or mixed. It may depreciate over time, and the stock may be replenished through investment. The benefits generated by capital are produce over the lifetime of the capital. We frame our definition of investment around capital to help differentiate investment from expenditures with only short-run, immediate effects.

A road is a common example of a capital good. Initial investment is required to build the road. The road then contributes to production by making it possible or cheaper to transport goods, for example. Without maintenance, the road will deteriorate over time, so some investment is necessary to maintain the level of benefits it generates.

A road is an example of physical capital, but there are other types of capital and different ways to categorize them. For the sake of the work in this report, we will define the categories of capital to include physical, financial, human, knowledge, social, and natural. Physical capital includes other types of infrastructure, factories, machinery, and vehicles, and which can be public or private. Financial capital has some definitional quirks but refers to an individual or other actor's wealth from the past, present, and future, and their ability to use it. It is relevant to discussions around credit, saving, and risk mitigation, especially crop insurance. Human capital is an individual's privately "owned" knowledge and capabilities, while we use knowledge capital to refer to knowledge and capabilities in the public domain such as R&D capabilities. Social capital

primarily refers to an individual's social network and the benefits it can bring them. Natural capital refers to stocks of ecological goods, such as forests, which can be used by humans in various ways but may need replenishment or maintenance.

Projects typically involve investments in a mix of types of capital. For example, MCC has made important investments in public institutions that help formalize and solidify land rights, as with the [Burkina Faso Compact – Rural Land Governance Project](#). This project invested in physical capital, such as government buildings, knowledge capital, such as the laws defining land rights and processes to establish land rights for owners, and financial capital, in that it helped farmers and others secure land rights, which can then be used as collateral for loans.

Justified public investment

Public investment by actors like MCC is justified in situations when:

1. For a public good – a good that is non-excludable and non-rivalrous – local public authority may not have the financial capacity to achieve the optimal level of public good delivery.
2. Due to market failures in accessing capital (physical, financial, human, knowledge, social, or natural) private investors, including smallholders, cannot achieve the economically optimal level of investment on their own. For example, a small-scale farmer may not purchase a new, high-yield seed variety for multiple reasons, including that she has not had the training (knowledge capital) to use it in a way that makes it the best seed option for her.
3. The private sector in some cases will invest in capital that provides public benefit but is not a pure public good – a cellular network, for example. However, a private actor invests based on its (private) internal rate of return. The social internal rate of return, which is relevant for the public perspective and can include outcomes such as poverty reduction and environmental sustainability, may be higher. Thus, the private sector, acting alone, will underinvest in comparison to the social optimum.

Understanding these situations is key to the discussion of what types of projects MCC should target for investment, since they help identify appropriate investment opportunities and provide insight on how much of the investment should be provided publicly. Situations 2 and 3 yield the insight that public investment doesn't necessarily only involve public goods; it may sometimes involve private goods such as fertilizers, small-scale irrigation, and mechanization goods.

2.2 What Are the Types of Public Policy and Investment? An Agricultural View

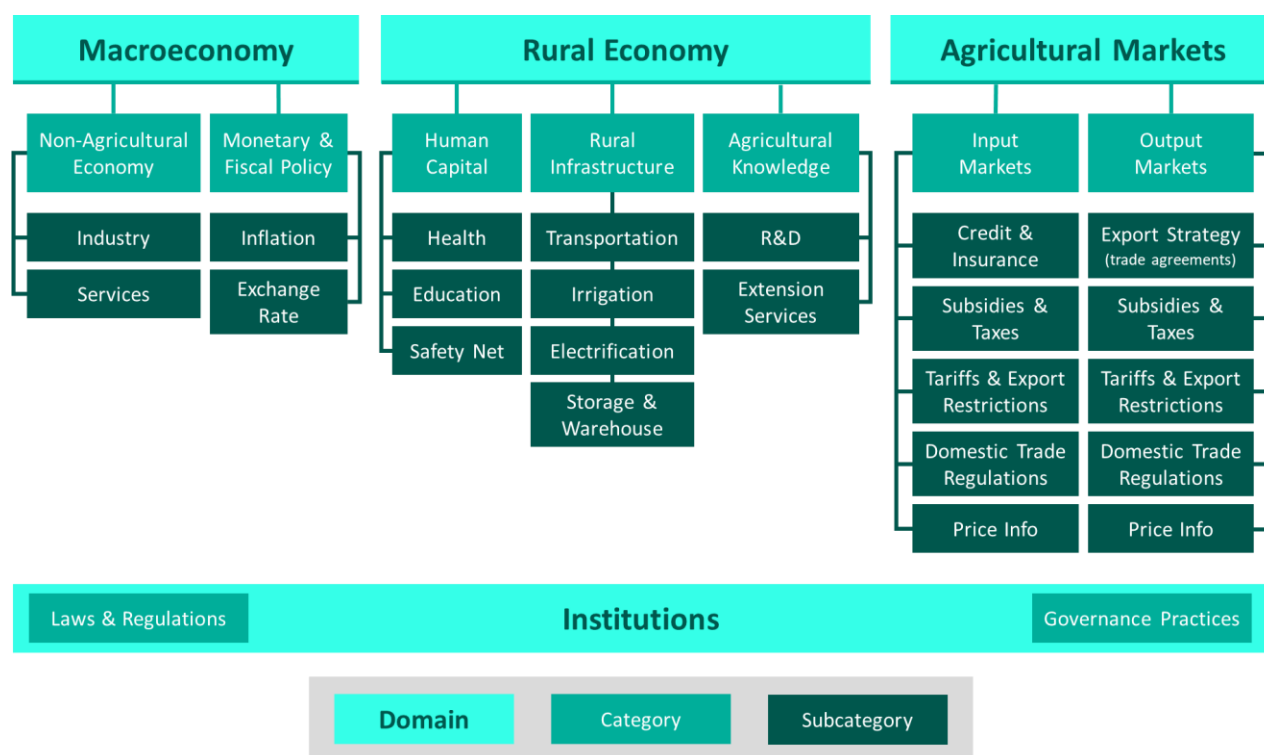
In this section, we present a typology of public policy and investment from an agricultural point of view, discuss how MCC's investments fall into this typology, and then spend some time on understanding the impacts of public infrastructure investment, a type of investment that is particularly key for MCC's agricultural development strategy.

A typology of public policy and investment from an agricultural view

Here, we provide a typology of public policy and investment from an agricultural viewpoint. This typology is useful to lend a consistent policy and investment language to discussions about agricultural development. The typology also sheds light on how policies and investments work within a broader economic context and what interactions they might have with other policies and investments.

We use a slightly adapted version of the typology from Baliño et al. (2019a), Figure 4 below. This typology is highly relevant to MCC's agricultural investments because it is tailored to the agricultural perspective. Although no typology can be perfect, it is designed to be as mutually exclusive, collectively exhaustive, and intuitive as possible. The typology can be used as a tool for constraints analysis, as discussed later in Section 3.

Figure 4: An Agricultural Public Policy and Investment Typology



Source: Adapted from Baliño et al. 2019a.

In Figure 4, domains are the broadest categories of public policy and investment, with further subdivision by category and subcategory. Domains are grouped by their relationship to the agricultural sector: Macroeconomy, Rural Economy, Agricultural Markets, and Institutions. Government Institutions provide a foundation for the operation of the economy. Macroeconomy is a broad, undetailed group that captures how policy and investment far outside the agricultural sector can affect the agricultural sector. Rural Economy captures key enabling aspects of rural economies that aren't strictly part of agricultural markets – such as agricultural R&D, which provides knowledge capital for agriculture but is not a privately used input for production – or even

strictly agricultural – such as rural health, which can improve farmers’ productive ability through less time spent sick, more energy on healthy days, better financial and overall welfare status due to fewer setbacks from illness, and less time spent caring for sick family and friends.

The broader investment context. Importantly, the typology goes beyond the agricultural sector because the agricultural sector does not develop in isolation. It is linked to the rest of society and the economy, as just described for rural health. MCC understands the relationship from agriculture to other parts of the economy well. For example, the [Ghana Compact – Agricultural Project](#) included investments in roads (roads falling under “Transportation” in Figure 4), to facilitate getting agricultural goods to markets, and in Institutions, through the improvement of public sector capacity to meet International Plant Protection Convention standards so that fruits and vegetables could be exported to international markets.

Public policy context. Similarly, the typology goes beyond investments to include public policy, since investments are influenced by public policy context. MCC understands the importance of public policy context, as evidenced in its inclusion of policy performance and commitment to reform into the country selection process and in the policy improvements and reform that are often included in project activities.¹

Baliño et al make the importance of this policy context clear as well: they emphasize that an anti-agricultural bias in policy deters investment in agriculture and reduces the income of farmers and others working in the sector. Detecting and assessing the size of that bias is a crucial step toward achieving agricultural transformation and ensuring that the sector can grow sustainably to its potential.

To illustrate the potential relevance of a typology including investments *and* policy in identifying constraints to development, let us consider a case of a road investment made less effective in improving agricultural incomes due to a constraining exchange rate policy: Suppression of the official exchange rate results in a shortage of formally available foreign currency. Agricultural traders who work across borders aren’t able to exchange currency through formal means; they have to buy it on the black market, paying the market price for the exchange plus a markup for the difficulty and risk of providing the exchange services. A new road, connecting a remote agricultural region with a town in neighboring country, is built, with the expected benefit of facilitating agricultural trade, increasing market access to benefit traders and small-scale farmers. However, the road investment does not yield a return as great as expected, since the traders still face high currency transaction costs.

Agriculture is part of the food system. Another point of clarification: while we mainly refer to “agriculture investments” in this report, agriculture can be understood as a part of the broader food system, from production to consumption and waste. This is somewhat acknowledged in the central question of this report, in which “*agriculture’ is broadly defined to include primary production, handling, storage, transportation, distribution, processing, and retailing.*” The food system is important to keep in mind as MCC addresses its mission through agricultural investments. The food system also becomes an important concept in analysis of certain agricultural

¹ <https://www.mcc.gov/resources/story/story-cdg-introduction>

investments with indirect effects throughout the economy in relation to food and hunger and emerges later in our discussion of IFPRI tools for cost-benefit analysis.

A key takeaway from the structure of this typology is that context matters. While generalist tools can support initial analysis about what to do where, assessment including deeper information on specific context will always be necessary. The literature on effective investments for agricultural development (see Section 2.3) also yields this point, while the tools suggested in sections 3 and 4 bring a deeper level of context to take the analysis of potential investments to the next stage.

What types of investment in agriculture does MCC make?

The analysis in this section is based on a database of MCC projects built by IFPRI. The database was constructed from the ERR analysis spreadsheets² available on MCC's website, and these ERR analyses are the observation level in the database. Publicly available information from these ERRs and on MCC's website was then manually recorded at the ERR-spreadsheet level. IFPRI also mapped each ERR analysis to the areas of the agricultural public policy and investment typology.³ The database is current as of May 2020.

MCC's investments have covered a broad swath of the typology proposed in the previous section.

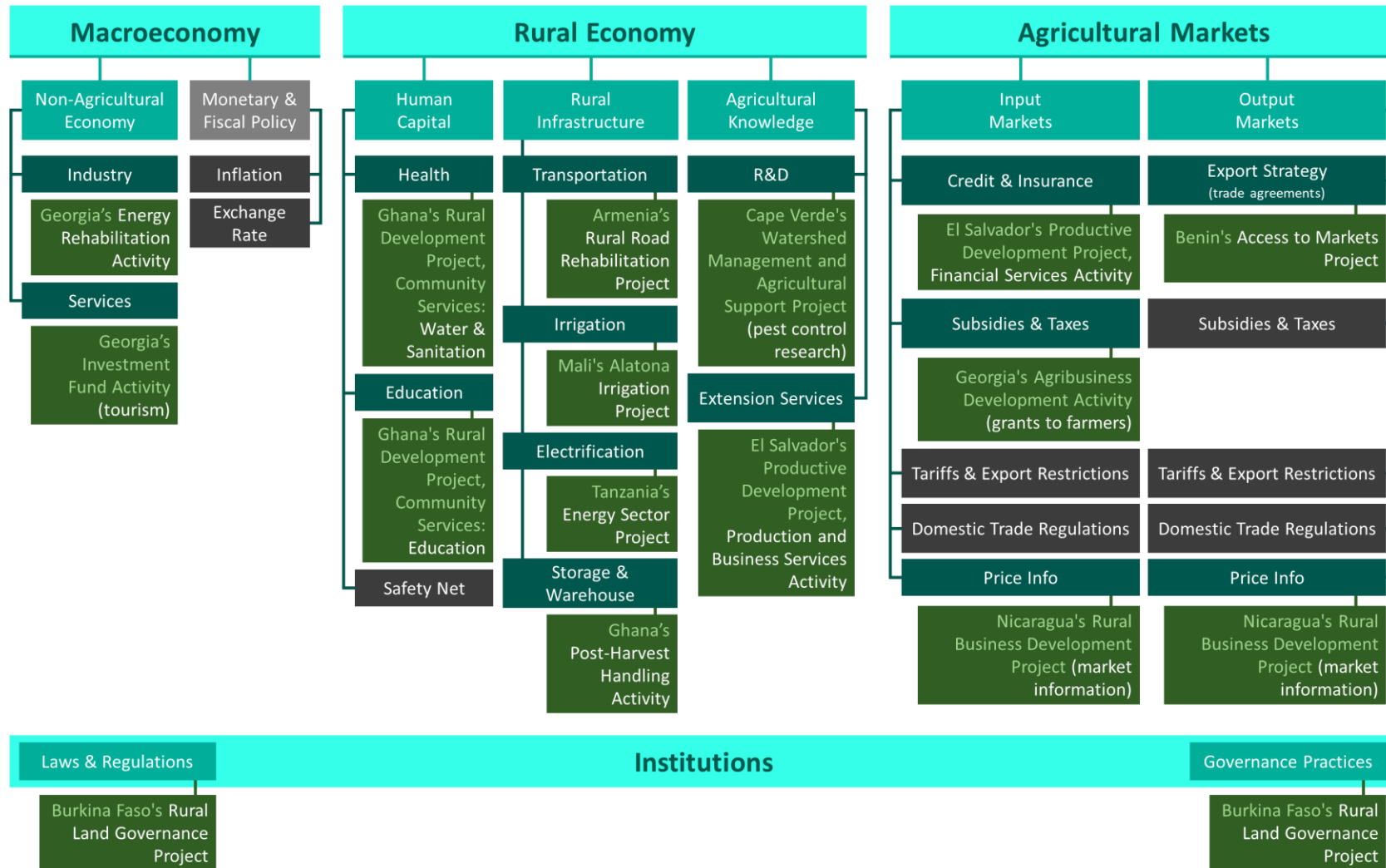
Figure 5 illustrates the coverage by providing examples of MCC's investments in each subcategory, in green. In grey are subcategories for which we have not identified investments by MCC. Rural Economy, Agricultural Markets, and land reform investments, which can fall into both categories of the Institutions domain, are the areas typically targeted by MCC's investments for agricultural development.

Notably, an MCC project, activity, or sub-activity may be tagged in multiple categories when relevant, as noted earlier with the [Ghana Compact – Agricultural Project](#), and as shown below with, for example, [Burkina Faso's Rural Land Governance Project](#), which falls into both Institutions categories.

² We use the "original" and the "closeout" / "revised" ERRs, as available by navigating to the "Country Spreadsheets" section at the bottom of the ["Economic Rates of Return"](#) page (www.mcc.gov/our-impact/err) and clicking the relevant links. Our database does not contain the results of independently conducted, evaluation-based ERRs. Results from these ERRs are available through MCC's [Evaluation Catalog](#) (data.mcc.gov/evaluations/index.php/catalog) within PDF reports. We understand from our communication with MCC that closeout ERRs are still considered ex-ante in that they typically contain updates to cost and target beneficiaries parameters versus original ERRs but not to benefit parameters.

³ The ERR database is not comprehensive of all investment done by MCC, since not every investment has an ERR. It was created to conduct analysis on the economic rates of return from MCC's agricultural investments. To eliminate the possibility of bias in the typological landscape data provided in this report, the best approach would be to build a comprehensive database. Nonetheless, the insights from the typological mapping may be useful to MCC, and we leave it to MCC to consider any bias in how the types of projects with associated ERRs may differ from those without.

Figure 5: Examples of MCC Investments in the Agricultural Public Policy and Investment Typology



Source: Adapted from [Baliño et al., 2019a](#), with investment examples in green from the IFPRI database of MCC's ERR analyses.

While Figure 5 provides examples to better understand MCC's investments in the typology, Figure 6 quantifies MCC's investment portfolio in relation to the typology.

It is key in the interpretation of this graph to remember that information from an ERR analysis spreadsheet can be coded into multiple parts of the typology, and that most evaluations do fall into multiple parts. Thus, percentages for the four Domains will not add to 100%, since an ERR analysis can be coded into more than one Domain. Likewise, Categories and Subcategories will not add vertically to 100%. By the same logic, horizontal addition also does not apply. For example, one ERR analysis can be "counted" in both Laws & Regulations and Governance Practices, but it will only be "counted" once in the Institutions Domain. Furthermore, coding of investments is a simple binary tag; so percentages in Figure 6 are not scaled to the magnitude of the monetary investment going to a particular Domain, Category, or Subcategory.

Interpretation is as follows: any given bar tells the percentage of ERR analyses that fall into that Domain, Category, or Subcategory. For example, about 70 percent of ERR analyses include evaluation of investment in the Rural Economy. This Domain was the most frequently touched by MCC investments, with Macroeconomy, Agricultural Markets, and Investments each appearing in 22 to 25 percent of ERR analyses.

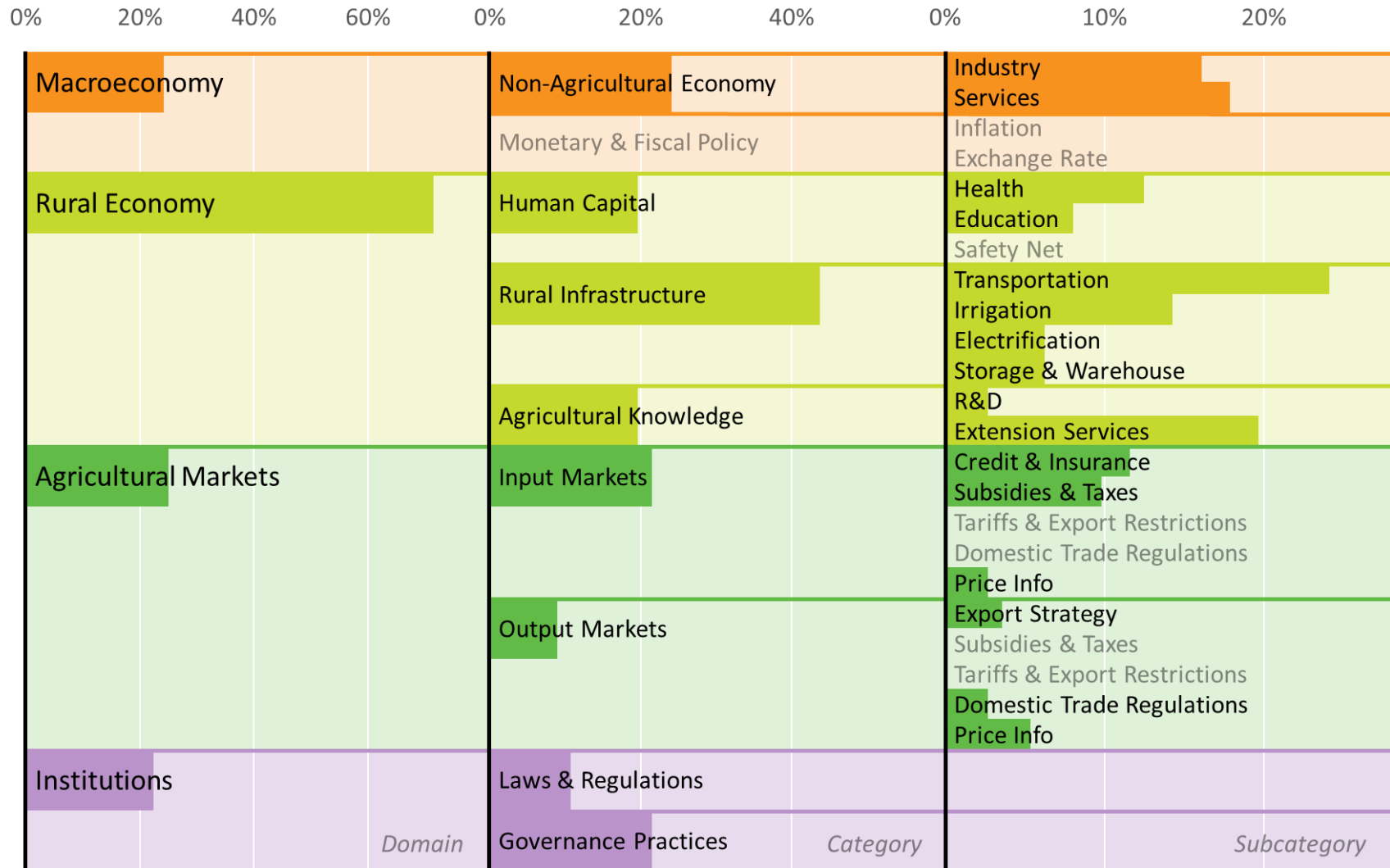
At the Category level, Rural Infrastructure was the Category most frequently receiving investment, with about a quarter of all ERR analyses involving transportation projects – mainly roads. Extension Services in the Agricultural Knowledge Category have also been an important area for MCC investments, included in one in every five ERR analyses. The Governance Practices Category also appeared in one in every five ERR analyses and often involved land reform efforts with farmers in mind. Agricultural Input Markets also appear at this frequency, with investments in efforts such as helping farmers access credit (Credit & Insurance), providing them grants (Subsidies & Taxes), and establishing price information systems (Price Info).

Agricultural Input Market investments were often paired with Rural Infrastructure or Agricultural Knowledge investments, recognizing bottlenecks and opportunities for synergies. Morocco's Fruit Tree Productivity Project – Date Tree Irrigation and Intensification, for example, provided 340,000 date palms to farmers (equivalent to a 100% subsidy; Agricultural Input Markets – Subsidies & Taxes), extension (Agricultural Knowledge – Extension Services), small-scale irrigation (if provided for privately or user-association-owned systems, this can be considered part of Agricultural Input Markets – Subsidies & Taxes), and large-scale irrigation (Rural Infrastructure – Irrigation). The associated ERR analysis spreadsheet can be found [here](#).

The Monetary & Fiscal Policy Category (Domain: Macroeconomy) was not touched by any of the investments in the ERR analyses, nor were Safety Net (Domain: Rural Economy), Tariff and Export Restrictions in Input or Output Markets, Domestic Trade Regulations, or Subsidies & Taxes (Domain: Agricultural Markets). This is unsurprising since these areas tend to be more policy- than investment-relevant, and specifically for two reasons. First, many of the untouched subcategories can involve economic policy decisions that are highly complex and entangled with other policies, and which also must be approached carefully in consideration of country sovereignty in policy making. Inflation, Exchange Rate, Tariffs & Export Restrictions, and Domestic Trade Regulations especially fit this description. Second, some of these subcategories

have more to do with recurring expenditure rather than investment: Safety Net and Subsidies & Taxes in Input and Output Markets fit here. However, an investment may be made here if its purpose is to strengthen a government system, for example, or to provide one-time grants that help get business started. This falls into public investment situation 2 identified in Section **Error! Reference source not found.** above. MCC does in fact have investments in Subsidies & Taxes in Input Markets in this form: Morocco's Fruit Tree Productivity Project, Date Tree Irrigation and Intensification ([link to ERR analysis spreadsheet](#)), which provided 340,000 date palms to farmers (equivalent to a 100% subsidy) as one of many integrated investments done in the project.

Figure 6: Percentage of ERR Analyses with Investments in each Domain, Category, and Subcategory



Source: Author's calculations, based on their database of publicly available MCC ERR analyses.
 Note: A single ERR analysis can be tagged with multiple Domains, Categories, and Subcategories.

While Figure 6 illustrates the frequency of MCC investments in the proposed typology, it doesn't provide a sense of what kinds of investments overlap with each other in a project. Table 1 gives a country-level view of this overlap, using MCC's investment sectors (see www.mcc.gov/sectors) rather than the typology for a different perspective. It also includes information on the total amount spent in each country and whether spending in the country targeted agriculture ("Does Spending Target Agriculture?"). The table is constructed from the IFPRI's database of ERR analyses, with ERR data aggregated by country.

In the "IFPRI-Identified Sector, using MCC categories" columns, green cells indicate that the sector was targeted by investments done in the given country. MCC's 7 sectors are: Agriculture; Roads & Transportation Infrastructure; Water, Sanitation, & Irrigation; Land & Property Rights; Education; Energy; and Health. ERR analyses are not explicitly classified into these sectors, so IFPRI has identified the relevant sector(s) for each. IFPRI also included an "Other" sector, when the investment was not fully described by MCC's sectors (investments here included areas like development of non-agricultural business and government practice reform). Agriculture was the most common sector of investment at the country level, followed closely by Roads & Transportation and Water, Sanitation, & Irrigation.

Table 1 shows that there is a high degree of overlap between certain investment efforts at the country level. Notably, investments in the Agriculture sector are often accompanied by investments in Roads and Transportation.

The "Does Spending Target Agriculture?" column is IFPRI's evaluation of how focused the investments described in an ERR spreadsheet were on agriculture versus on other areas of the economy. This alternate evaluation of agricultural targeting provides a cross-check to categorization in the Agriculture sector column and provides additional nuance. "Directly" indicates that the project description demonstrates clear focus on agriculture. "Indirectly" indicates that agriculture was one of several impact areas intended by a project, or that IFPRI determined that the project would likely affect agriculture, even though agriculture was not explicitly mentioned in the project description. This category largely includes rural infrastructure projects not explicitly targeted to agriculture, land rights and reform efforts, and microfinance investments. "No Targeting" includes projects that seemed unlikely to have an important impact on the agricultural sector or the well-being of farming households, such as urban infrastructure projects, vocational training unrelated to agriculture, and projects clearly targeted toward a different sector of the economy.

The table shows that MCC's investments in two thirds of its partner countries included investments directly targeting agriculture. A further 29 percent, though not including directly agricultural investments, included investments that affected agriculture indirectly in important ways. Only Zambia's ERR analysis portfolio did not appear to include agricultural targeting. At the ERR-analysis level, not pictured, there is relatively even distribution among the three categories (Directly: 36, Indirectly: 37, No Targeting: 29).

Table 1: Agricultural Targeting in MCC’s Compact Countries

Country	Total Amount Spent	Does Spending Target Agriculture?	IFPRI-Identified Sector, using MCC categories							
			Agriculture	Roads & Transportation	Water, Sanitation, & Irrigation	Land & Property Rights	Education	Energy	Health	Other
Armenia	\$ 176,550,239	Directly								
Burkina Faso	\$ 474,743,637	Directly								
Cape Verde	\$ 174,112,458	Directly								
El Salvador	\$ 449,566,761	Directly								
Georgia	\$ 521,012,704	Directly								
Ghana	\$ 536,288,968	Directly								
Honduras	\$ 204,015,014	Directly								
Madagascar	NA	Directly								
Mali	NA	Directly								
Moldova	\$ 259,371,697	Directly								
Mongolia	\$ 268,993,805	Directly								
Morocco	\$ 650,052,711	Directly								
Mozambique	\$ 447,904,512	Directly								
Namibia	\$ 295,719,173	Directly								
Nicaragua	\$ 112,703,083	Directly								
Senegal	\$ 433,318,473	Directly								
Benin	\$ 301,810,356	Indirectly								
Jordan	\$ 272,934,551	Indirectly								
Lesotho	\$ 358,045,892	Indirectly								
Malawi	\$ 339,115,524	Indirectly								
Philippines	\$ 385,072,218	Indirectly								
Tanzania	\$ 694,545,914	Indirectly								
Vanuatu	\$ 65,403,518	Indirectly								
Zambia	\$ 332,140,205	No Targeting								

Source: Author’s calculations, based on their database of publicly available MCC ERR analyses.

Notes:

“Does Spending Target Agriculture?” is IFPRI’s evaluation of how focused the investments described in an ERR spreadsheet were on agriculture versus on other areas of the economy. While the entire project description was read to make this evaluation, project descriptions explicitly mentioning “agriculture-” or “farm-” were generally considered to target agriculture directly.

In the “IFPRI-Identified Sector, using MCC categories” columns, green cells indicate that the Sector was targeted by investments done in the given country. While the Sectors are the categories used to describe MCC’s investments on their website (see www.mcc.gov/sectors), identification of whether an ERR analysis fell into a sector was done by IFPRI. A single ERR analysis can be tagged with multiple sectors.

This table uses information aggregated across all ERR analyses available for each country.

For more analysis of the ERR analysis database built by IFPRI, see Appendix 0, which contains descriptive statistics on Economic Rates of Return by type of investment.

Public infrastructure: understanding an important category of MCC's investment

Rural public infrastructure projects, even when they do not directly target agriculture, can often have an important positive effect on agriculture. As was shown in Figure 6, such projects comprise a substantial portion of MCC's investment portfolio, and Table 1 above hints at their overlap with and importance to agricultural investment strategy. Here, we examine two types of rural public infrastructure – roads and irrigation – to describe their impacts, recount lessons learned, and discuss the challenge of comparing different types of investment.

Roads

Ludwig et al. (Ludwig, Nagarajan, and Zaman 2016) synthesized the findings from 15 studies by farmer-level outcome. The studies showed that road interventions are associated with reduction in transportation costs and time for farmers, increase their incomes, and reduce poverty. Confirming common sense with evidence, the review found that areas that experience adverse weather are likely to benefit more from access to an all-weather road than areas with a milder climate. The review found mixed results on crop production, crop yield, and crop output prices. Although it was not discussed explicitly in any of the studies in the systematic review, road maintenance is increasingly becoming a part of the planning process of road projects as donor agencies work with local governments to ensure investments are sustainable beyond the initial donor investment.

Irrigation

The Malabo Montpellier Panel Report (Malabo Montpellier Panel 2018) highlighted the potential of expanding irrigation to improve agricultural productivity on existing land and extend growing seasons throughout the year, which would reduce poverty, food insecurity, and import dependency across Africa. The case studies on irrigation projects in Africa covered in the report, reveal important lessons about the necessary steps and potential pitfalls for the successful implementation of projects. Projects have been most effective where governments have made irrigation a top policy and investment priority – by creating conducive fiscal environments, providing supportive infrastructure, and deploying smart regulations. Government regulations and cooperation with the private sector are necessary to minimize the potential risks of irrigation to human health and the environment.

The Challenge of Comparing Types of Investment: Roads and Irrigation

Evaluation of investment in public goods can be difficult. It requires consideration of the role of the public good, estimation of the value of non-priced resources, and consideration of both direct and indirect effects of the good in the economy.

Irrigation is a relatively simple example: on the benefit side, investments at a given period will lead to a direct increase in physical production and productivity (measured by output per unit of

land or labor through a yield increase) of the agricultural activities directly impacted by the irrigation project. In economic evaluations, this can be captured by an increase in the total factor productivity (TFP) for existing factors of production in the agricultural sector. On the cost side, irrigation has initial, fixed costs and recurrent costs for maintenance, energy, and other upkeep. Together, the costs and benefits can be simulated in an economic model through a modification of an agricultural production function. However, some complication arises as both intertemporal costs and intertemporal benefits must be properly actualized for a cost-benefit analysis. Presenting perhaps the greatest complexity, non-priced inputs often need to be considered to ensure sustainability – for example, water use, especially in water-scarce regions, should be included in the analysis.

Rural roads are yet more complicated. While road investments directly affect the transportation sector through reduced depreciation of trucks, time saved, and other impacts, they have the potential to deliver large benefits to rural communities and the agricultural sector. They may reduce mark-up and transaction costs on inputs and outputs, increase competition, open access to larger markets and new agricultural product markets, and reduce post-harvest losses. Measurement of such benefits is difficult. Effects are substantial but indirect, and they contribute significantly to the agricultural sector but are not exclusive to it. Depending on economic context, there may be an increase in economic productivity of farmers (more profits due to higher output prices and decreased input prices) but no change in the physical productivity of factors of production (no change in physical yields, for example).

2.3 What Does the Literature Say about What the Best Agricultural Investments Are?

Drawing on IFPRI's professional expertise, we conducted a limited review of the literature related to the central question of this report, "*What guidelines can be used to identify the types of agricultural investments that have the highest economic return, where "agriculture" is broadly defined to include primary production, handling, storage, transportation, distribution, processing, and retailing?*" We draw from several key strands of work on the subject and summarize the evidence they bring around three main messages. Then, we examine the evidence they provide by type of investment.

The main sources we draw from are:

- ❖ [*Effective Public Investments to Improve Food Security*](#), a brief based on a review of the evidence for food security investment (Bizikova et al. 2017)
- ❖ [*Agricultural Transformation*](#), a project to understand the policies, investments, and contexts that impact the evolution of countries' agricultural sectors (Laborde et al. 2019) (Baliño et al. 2019a) (Baliño et al. 2019b)
- ❖ A [*Meta-Evidence Review on the Impacts of Investments in Agricultural and Rural Development on Sustainable Development Goals 1 and 2*](#) published by IFAD (Bernstein, Johnson, and Arslan 2019)
- ❖ The [*Food Systems and Nutrition Evidence Gap Map*](#) by 3ie (Moore et al. 2021)

- ❖ [Ceres2030: Sustainable Solutions to End Hunger](#), a project that sought to answer two questions related to Sustainable Development Goal (SDG) 2: (i) What does the published evidence tell us about agricultural interventions that work, in particular to double the incomes of small-scale producers and to improve environmental outcomes for agriculture? (ii) What would it cost governments to end hunger, double the incomes of small-scale producers, and protect the climate by 2030? (Laborde Debucquet et al. 2020) (Laborde, Parent, and Smaller 2020) (“Sustainable Solutions to End Hunger” 2020)

Message 1: Context matters – How effective an investment will be is highly dependent on context

The policy brief *Effective Public Investments to Improve Food Security* puts it well: “The focus is less about finding the right intervention and more about ensuring that interventions are designed and implemented with the context in mind” (Bizikova et al. 2017). The research found that interventions that were successful often conducted an ex-ante analysis or baseline assessment, as MCC does, while some investments that had no or even negative impacts on food security had failed to consider broader community challenges, gender inequality, and wealth inequality.

IFAD’s *Meta-Evidence Review on the Impacts of Investments in Agricultural and Rural Development on Sustainable Development Goals 1 and 2* also emphasizes the importance of analysis of contextual factors, including agroecological environment, institutions, infrastructure, and markets (Bernstein, Johnson, and Arslan 2019). It states that context and local conditions – the enabling environment – hugely influence success.

A scoping review on incentives for adoption of sustainable agricultural practices and their outcomes (Piñeiro et al. 2020), part of the Ceres2030 project, also found evidence demonstrating the importance of contextual factors, in the case of a farmer deciding whether to adopt a particular new production practice promoted by a public program: the conditions of the program, the incentives offered, beliefs about the program, degree of risk aversion, experience and education levels of the farmer, economic characteristics of the farmer’s household, institutional and policy context, biophysical characteristics of a land plot, and agricultural market trends were among factors affecting a producer’s decision to adopt new agricultural practices. They note that “the variety of factors that contribute to the adoption of sustainable agricultural practices necessitates the consideration of context in policy design and the use of differentiated policy instruments.”

The research behind *Transforming Agriculture in Africa & Asia: What are the policy priorities?* (Laborde et al. 2019) was designed with context at the forefront. It provides analysis relevant to MCC’s agricultural investment strategy at the country level, so we examine it here in depth. Although it focuses on policy rather than investment by external donors such as MCC, it is highly relevant since policy and investment, as demonstrated through the typology in Section 2.2, have a lot of overlap and are closely integrated.

Laborde et al. cluster 117 countries by initial land and population context in 1970, map each country’s agricultural transformation trajectory from 1970 to 2015, then examine differences in trajectories between countries with similar initial contexts to understand what might account for these differences. The clustering of countries in 1970 is based on variables for birth rate, land

availability, and land fertility. The agricultural transformation phases are based on Timmer's framework (Timmer 1988), which describes non-linear phases using an indicator of the resources allocated to agriculture (Laborde et al. use share of agricultural employment) and a food security outcome indicator (Laborde et al. use prevalence of undernourishment). The six phases described by Laborde et al. are (1) industrialized economies; (2) agricultural integrated into the macro economy; (3) agriculture as a contributor to growth; (4) moving labor out of agriculture; (5) getting agriculture moving; and (6) subsistence agriculture. The land and population context and these phases both describe the current status of agriculture in a country and may point towards insight into its production possibilities and long-term comparative advantages.

How countries move across these phases of transformation depends on their land and population context, socioeconomic conditions, and policy strategy. The authors identify two basic strategies for transformation based on land and population context – a push strategy, emphasizing agriculture pushing growth of the national economy, and a pull strategy, where growth elsewhere in the economy pulls people out of agriculture. The decision about what strategy to take, or how to mix or sequence these strategies, depends on the land and population context. If a country has plentiful and fertile land, a push strategy may be a better option; while if a country has infertile land, high population density, and high birth rates, a pull strategy is likely the best bet. Brazil and Colombia are good examples of the push strategy, while China, Malaysia, and Vietnam, having high birth rates and limited agricultural land and water, typify the pull strategy.

Controlling for land and population context, the research can be used as follows: a country can identify its land and population context cluster, match this context cluster to historical analogues, and then consider the policy and investment strategies used by these analogue countries to understand how it might transform its agriculture. But the authors note that modern context requires additional considerations: the global economy, environmental situation, and trends in urbanization, diets, and food distribution and processing mean today's strategy cannot simply copy that of the Green Revolution.

The authors flesh out their theory by applying it to focus countries. First, they diagnosed the focus countries' current agricultural transformation phase and land and population contexts through literature review. Then, they use policy and investment strategies pursued by analogous transformed countries to identify policy and investment priorities for the focus countries. Table 2: A Matrix for Policy and Investment Options is a policy matrix of priority reforms summarizing their results. Notably, the policy and investment options categorization they use (columns: public investment, price interventions, macroeconomic policies, and land and other institutional reforms), shares similarities with the typology presented in Section 2.2, since it is related to the Baliño et al. work on which our typology is based.

Ethiopia, Kenya, Rwanda, in which MCC has Threshold Programs, fall into the "High Birth Rates and Scarce Land" land and population context, and Laborde et al. have identified heterogeneous priorities among them based depending on country-specific challenges. Burkina Faso, Malawi, Tanzania, Togo, Uganda, and Zambia, all countries in which MCC is developing or has conducted work, fall into the "High Birth Rates and Scarce but Fertile Land" land and population context. Especially important priorities for these countries include R&D and extension, Rural infrastructure, and Removing anti-agricultural bias. MCC potential partner country Mozambique

has “Abundant and Fertile Land,” and further examination of its context yielded Rural infrastructure, Rural health and education, and Land reform as the highest policy and investment priorities. An interactive version of this table with notes explaining each policy/investment option for each country and links to additional information is available on the website for the project, [here](#).

Table 2: A Matrix for Policy and Investment Options

Transformation context (2015)	Transformed countries (1970)	Matching focus countries (2015)	Public investment			Price interventions		Macroeconomic policies		Land and other institutional reforms	
			R&D and extension	Rural infrastructure	Rural health and education	Remove anti-agricultural bias	Trade policy reform ^a	Monetary and exchange rate policy	Economic diversification	Land reform	Credit
High Birth Rates and Scarce Land	China, Indonesia, Malaysia, South Korea and Vietnam	Ethiopia	●●●	●●	●●	●●●	●●●	●●●	●●	●	●●
		India	●●	●●●	●	●●	●●●	●	●●	●●	●●●
		Kenya	●●	●●●	●●	●●	●●●	●	●●●	●	●●
		Rwanda	●●●	●●	●●●	●●	●●	●	●●●	●	●
High Birth Rates and Scarce but Fertile Land	Ghana and Thailand	Burkina Faso	●●●	●●●	●●	●●●	●●	●●	●●	●●	●
		Malawi	●●●	●●●	●●	●●●	●●	●	●●	●	●●
		Tanzania	●●●	●●●	●	●●	●●	●	●●●	●●	●
		Togo	●●●	●●●	●	●●●	●	●	●●●	●	●
		Uganda	●●●	●●●	●●	●●●	●	●	●●	●●	●
		Zambia	●●●	●●●	●	●●●	●●	●	●●	●●	●●
Abundant and Fertile Land	Brazil, Colombia	Mali	●●	●●	●●	●●●	●●	●	●●●	●	●●
		Mozambique	●●	●●●	●●●	●●	●	●	●●	●●●	●
		Zimbabwe	●●●	●●●	●	●●●	●	●	●●	●●●	●●

●: lower priority ●●: medium priority ●●●: higher priority

^a The two sub-categories for price interventions are interrelated. Trade policy reform refers to the use of trade measures such as tariffs, export taxes, export promotion and sectoral policies. The anti-agricultural bias refers to the relative rate of assistance to agriculture compared to other sectors of the economy. It includes trade measures such as tariffs and subsidies but also other government policies that affect prices, such as input subsidies and direct price controls. It is expressed as positive, negative or neutral, relative to other sectors. This table shows that removing the negative relative rate of assistance (the anti-agricultural bias) was key in the agricultural transformation process.

Source: (Laborde et al. 2019). For an interactive version, see the website for the project, [here](#).

Price policies – related to “Removing anti-agricultural bias” in Table 2 – are an especially important contextual factor to account for in an agricultural transformation strategy. They can provide positive or negative assistance to farmers relative to the rest of the economy. When the assistance relative to the rest of the economy is negative, it is referred to as “anti-agricultural bias.” As a historical lesson, agricultural transformation took off when countries removed anti-agricultural bias in all the successful countries studied, including Brazil, Indonesia, South Korea, and Vietnam. On the other hand, Ethiopia, Malawi, Togo, and Uganda – countries that have struggled to transform agriculture – have maintained an anti-agricultural bias for the entire 45-year period. For a detailed explanation of anti-agricultural bias, see (Baliño et al. 2019b). Stable macroeconomic policies have also been important, as all sectors including agriculture depend on stable currency.

The IFPRI Tool for Agricultural Constraints Analysis, presented in Section 0, builds on this idea of the importance of context in drafting an overall investment strategy, while the IFPRI Tools for Cost-Benefit Analysis described in Section 3 account for high-level, economic context when evaluating particular potential investments.

Message 2: Investment complementarity – The need for a portfolio approach

A natural extension of the idea that context matters in determining the effectiveness of an agricultural investment is that other investments also matter. Bizikova et al. note that food security is often achieved using multiple, well-designed interventions (Bizikova et al. 2017). Illustrating the case of input subsidies, they write that access to land, machinery, irrigation, and other complementary inputs is necessary to make input subsidies effective in their goal.

The essentiality of complementarity is a key finding of Laborde et al. (Laborde et al. 2019). They state clearly, “No single measure on its own is sufficient to make progress. No country succeeds without a combination of complementary policies and public investments appropriate for its context.” In the group of 117 countries that they studied from 1970 to 2015, they found that R&D and extension services, an especially important area of investment, were more impactful when complemented by other measures. Similarly, rural electrification and irrigation were more successful with combined with investment in rural roads.

The Ceres2030 project conceptualizes leveraging complementarity as building an integrated “portfolio” of interventions (Laborde Debuquet et al. 2020). This finding is supported both by the Nature collection emerging from the project, *Sustainable solutions to end hunger* (“Sustainable Solutions to End Hunger” 2020), and by the team’s related work on an economic model to estimate the cost of ending hunger sustainably through investment and recurrent expenditures (Laborde, Parent, and Smaller 2020). The articles comprising the Nature collection describe how complementarities, when considered, enable the success of interventions, while the model accounts for these complementarities in a complex system of equations representing economic relationships. The modeling is able to capture both direct interactions between interventions, such as the result of a grant to promote a production practice increasing rice yields, and indirect interactions, such as the grant’s effect on greenhouse gasses via a reduced demand for the conversion of natural land to farmland.

The Ceres2030 cost model work highlights the importance of investing in capital, the economic essence of MCC’s mission. It describes the importance of complementarity here, and how the model can uniquely capture it: “The portfolio of interventions relies on the interdependence of many kinds of capital: human, social, financial, and knowledge. While the evidence shows a significant lack of detailed information on complex outcomes, especially those involving such capital..., the modeling approach captures some of the interlinkages between access to different forms of capital at the household level and

its impact on the broader economy.” These sort of interlinkages can also be captured by IFPRI’s Tools for Cost-Benefit Analysis presented in Section 3, as some of the tools used here are closely related to the modeling work done for Ceres2030.

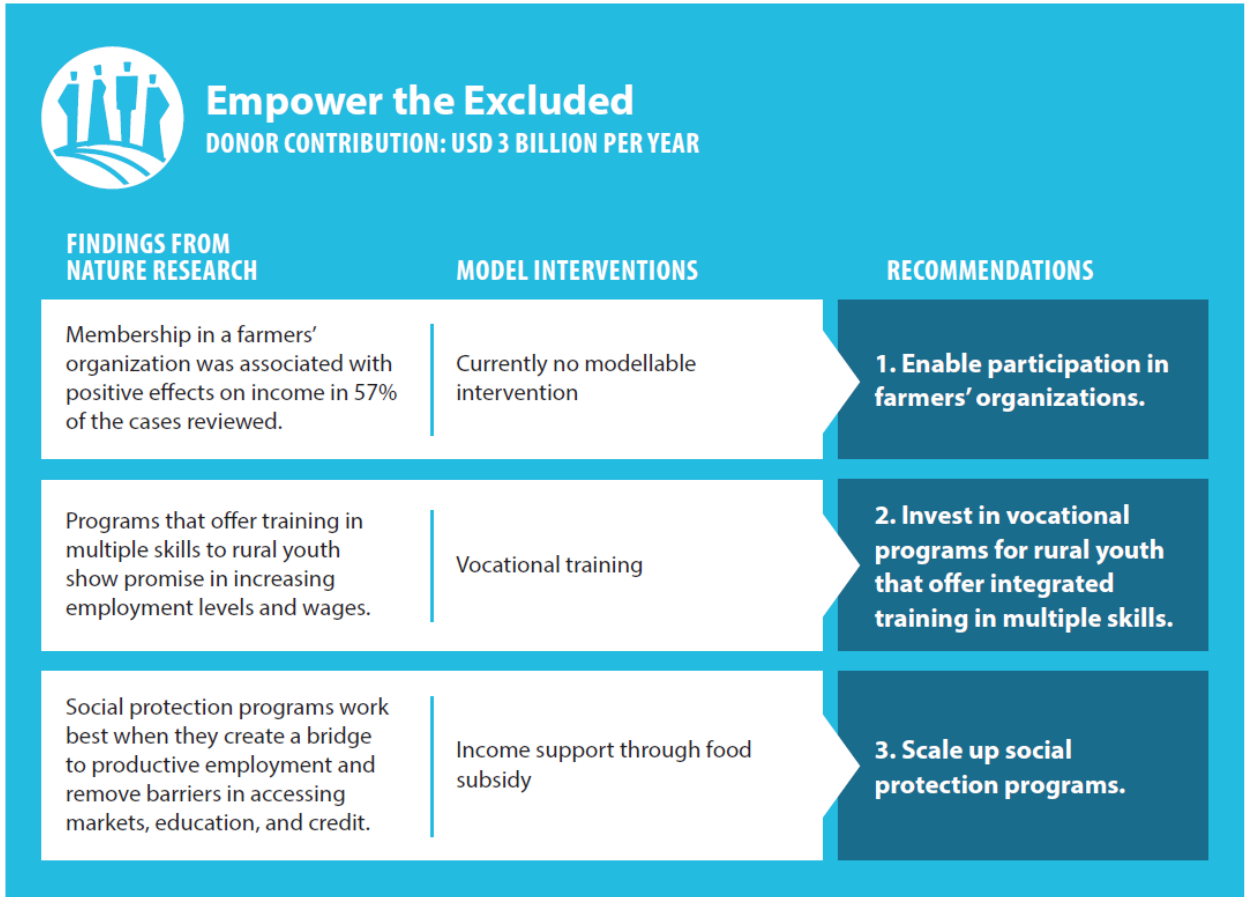
Message 3: Documented evidence sometimes falls short of answering donors’ questions

The Ceres2030 project found large gaps in the academic and grey literature in terms of the type of evidence needed to answer donor and government questions (Laborde Debucquet et al. 2020). Assessing the impact of a potential investment is complicated, and the specific data to quantify these investments, such as cost-benefit information, or evaluation of investments in particular country or regional contexts, is often thin. The 3ie Food Systems and Nutrition Evidence Gap Map (available interactively [online](#)) is dedicated to identifying and documenting the gaps in evidence for interventions (Moore et al. 2021). Bizikova et al. also identify a shortfall in documentation on the cost-efficiency of interventions in particular (Bizikova et al. 2017). This means that, while high-level recommendations on investments can be made, it is not always possible, given data gaps, to quantify an investment option in a specific context with a high degree of certainty.

Evidence by types of investment

The Ceres2030 Summary Report provides a good starting point for evidence-based recommendations by category of intervention. Ceres2030 groups interventions into 3 categories: Empower the Excluded, On the Farm, and Food on the Move. Figure 7 is the ten recommendations from the Ceres2030 Summary Report, directly reproduced.

Figure 7: Ten Recommendations from Ceres2030





On the Farm

DONOR CONTRIBUTION: USD 9 BILLION PER YEAR

FINDINGS FROM NATURE RESEARCH

MODEL INTERVENTIONS

RECOMMENDATIONS

The most important determinants of adoption of climate-resilient crops were the availability and effectiveness of extension services.

Extension services

4. Investment in extension services, particularly for women, must accompany research and development (R&D) programs.

Market and non-market regulations and cross-compliance incentives that include short-term economic benefits are more successful than measures that only provide an ecological service.

Agroforestry subsidy
Capital endowment
Extension services
Investment subsidy
Production subsidy
R&D National Agricultural Systems (NARS) & Consultative Group on International Agricultural Research (CGIAR)

5. Agricultural interventions to support sustainable practices must be economically viable for farmers.

Successful adoption is positively correlated with inclusive extension services, access to inputs, and crop varieties that are commercially viable.

Extension services combined with input, production, and investment subsidies
R&D National Agricultural Systems (NARS) & CGIAR

6. Support adoption of climate-resilient crops.

Nearly 80% of small-scale farms in developing countries are in water-scarce regions. Underexplored solutions include digital applications and adding livestock to mixed farming systems.

Capital endowment
Extension services
Rural infrastructure (irrigation)

7. Increase research on water-scarce regions to scale up effective farm-level interventions to assist small-scale producers.

Obvious and useful options to improve the quantity and quality feed are being overlooked, such as better support for the use of crop residues.

Capital endowment
Extension services
Improved forage subsidy
Production subsidy
R&D National Agricultural Systems (NARS) & CGIAR

8. Improve the quantity and quality of livestock feed, especially for small and medium-scale commercial farms.



Food on the Move

DONOR CONTRIBUTION: USD 2 BILLION PER YEAR

FINDINGS FROM NATURE RESEARCH

Storage interventions are effective, but other interventions are also needed, such as better handling, improved packaging, and careful timing of the harvest.

MODEL INTERVENTIONS

Extension services
Storage (post-harvest losses)

RECOMMENDATIONS

9. Reduce post-harvest losses by expanding the focus of interventions beyond the storage of cereals, to include more links in the value chain, and more food crops.

SMEs are successfully serving farmers in low and middle-income countries, particularly in Africa, and are correlated with technology adoption and higher productivity.

Rural infrastructure (roads)
Storage (post-harvest losses)

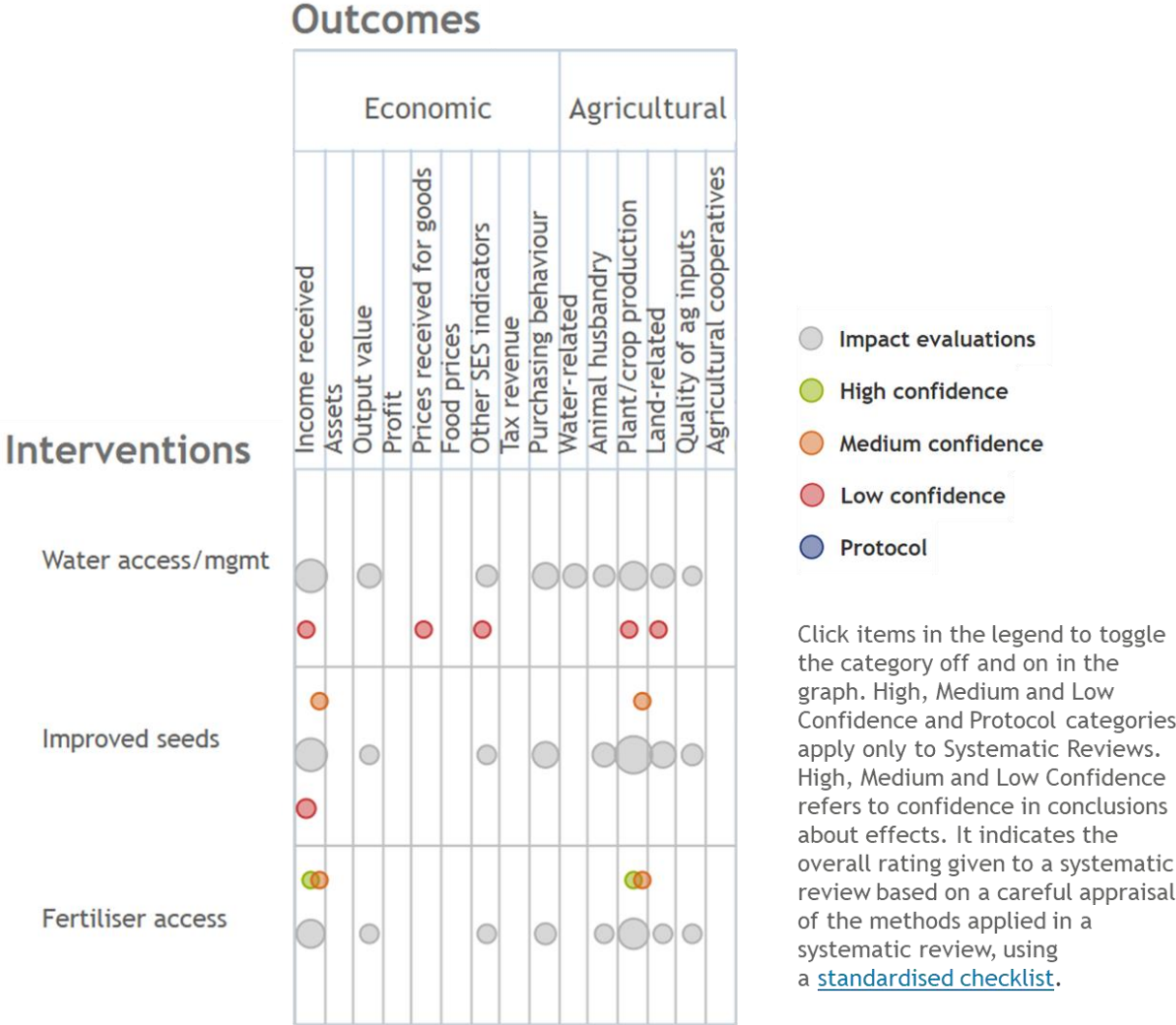
10. Invest in the infrastructure, regulations, services and technical assistance needed to support SMEs in the value chain.

Source: (Laborde Debucquet et al. 2020), reproduced with the authors' permission.

Bernstein and coauthors also provide a useful summary table of the evidence about interventions' impacts, including on poverty, nutrition security, and productivity. The table includes 19 categories of intervention: organizations and groups, tenure security, landscape-scale natural resource management, improved access to financial products, job creation programs, social protection programs, ICT, improved infrastructure, multisectoral interventions and WASH, and agriculture technology and practice, plus 9 subcategories of agricultural technology and practice. It indicates the size of the body of evidence, the strength of the evaluation methodologies, and whether the intervention has been proven to have a positive effect on a particular outcome. Agricultural technology and practice interventions – irrigation among these – are generally beneficial in a variety of ways, although sometimes the evidence base is small for subcategories and the methodology imperfect. Social protection programs are well-studied with sound methodology and show positive effects on reducing poverty and improving food and nutrition security. Improved infrastructure – while the synthesized literature base on this topic is relatively small – shows sufficient evidence of being beneficial. The table can be found on pages 16 and 17 of the report (it is not reproduced here, due to copyright restrictions) (Bernstein, Johnson, and Arslan 2019).

The 3ie Food Systems and Nutrition Evidence Gap Map is a valuable source for identifying systematic reviews on a particular intervention-outcome link of interest (Moore et al. 2021). We provide a snapshot of a small part the interactive table in Figure 8 to show what kind of information it contains. The actual table is large, including 52 interventions and 17 categories of outcome, and is filterable, including by country.

Figure 8: Sample of 3ie’s Food Systems and Nutrition Evidence Gap Map



On the impact of infrastructure on productivity: Infrastructure is an especially important type of investment, both in the MCC portfolio and in general, and both for agricultural development and for development in general. Appendix **Error! Reference source not found.** gives it special treatment, including information on the existing quantifications of its impact.

3 IFPRI TOOLS FOR EXPLORATORY AND EX-ANTE EVALUATIVE ANALYSIS

Over the years, IFPRI has developed and used a large variety of tools that can provide exploratory analysis or ex-ante analysis on what mix of investments is best suited to particular goals. They can complement the MCC tool suite by providing quantitative analysis to identify areas with high-return projects; incorporate multiple outcomes of interest to paint a more complete picture of project impact; provide deeper analysis of impacts at household, village, or regional levels; and capture effects that CBAs alone cannot. IFPRI’s expertise in agricultural development and the review of past evidence discussed above will be helpful to inform forward-looking analytical tools.

Which tool is appropriate depends on what information we want from the analysis and the nature and context of the potential investment. Tool choice is also constrained by data availability. Here, we go into detail on these three aspects and present a few types of tools that are likely to be relevant for MCC. We note that the tool types are general and that any must be customized to the particular investment(s) being analyzed. For this reason, we illustrate customized tools in action with the case studies presented in the following sections.

3.1 Ex-Ante Evaluative Analysis: Limitations of the ERR

MCC’s mission is “to reduce poverty through economic growth.” More specifically, MCC “seek[s] programs with both high poverty reduction impact and high economic returns at the same time, rather than one or the other, and this approach excludes projects that promise high returns but do not benefit the poor” (“Guidelines for Economic and Beneficiary Analysis” 2017).

MCC has an efficient and refined system to help it select the best partner countries and projects to fulfill this mission, using country scorecards, constraints analysis, and cost-benefit analysis (CBA). A key metric from the CBA is the Economic Rate of Return (ERR). An ERR of at least 10 percent, representing the minimum return to compensate for the time value of money, is the standard that is used to decide whether a project can be greenlighted. The original⁴ ERR is useful in that it provides a yes/no decision rule that is comparable across all projects, and the closeout ERR provides a valuable metric to understand the relative success of a project. (Note that the closeout ERR is still considered an ex-ante analysis by MCC: it typically contains updates to cost and target beneficiaries parameters but not to benefit parameters. Nonetheless, these updates make it a useful comparative data point).

However, there are some things that the ERR and MCC’s other analytical tools cannot capture, in this section, an illustration of complementary analytical tools is done.

A first key challenge that ERR analyses face is that they do not directly address the target outcome of reducing poverty. While the ERR is philosophically not too far removed from the outcome of economic growth, the ERR by nature is not designed to provide information on poverty. This outcome requires a bit more complexity in analysis, often relating to distributional impacts of investments. Clearly, a project could have an excellent ERR, but if it benefits farmers that are somewhat poor while leaving out the poorest, leaving them even further behind than before the project, it may not serve MCC’s mission well.

Second, ERR analyses by nature provide a one-dimensional view of outcomes. In reality, MCC considers more than the ERR in evaluating a project, and it may want to include some of this information quantitatively at this point in its process without lumping it directly into the ERR. For example, effects on greenhouse gas emissions are not currently included as a primary feature of decision-making. Ex-ante estimation of emissions effects may be useful, and their inclusion in decision-making is validated by the fact that the U.S. defines a non-zero social cost of carbon (Interagency Working Group on Social Cost of Greenhouse Gases, United States Government 2021; “EPA Fact Sheet: Social Cost of Carbon” 2016).⁵ Poverty, our first challenge, is actually included in this need for a multidimensional view of outcomes, since it would be an additional dimension by which a project could be evaluated.

⁴ The “original” ERR refers to that used by MCC before the project is executed, in contrast with the “closeout” or “revised” ERR conducted at the end of the project.

⁵ While using a social cost of carbon actually enables inclusion of emissions directly into the ERR, MCC may prefer to have it broken out as a separate dimension.

Third, ERR analyses may leave out second-order effects when estimating costs or benefits. Second-order effects are indirect effects that occur if an intervention shifts a supply or demand curve in the market in question or in linked markets. Section 0, “Capture of Second-Order Effects” provides a deeper explanation and examples from MCC’s work. If second-order effects are not accounted for, the estimations used for benefits and costs in the ERR may be over- or under-estimated.

3.2 What Can IFPRI Tools Do?

Here, we give an overview of what sorts of questions we might answer with IFPRI’s suite of tools, particularly from the viewpoint of how IFPRI’s capabilities complement the existing MCC tool suite. We organize these tools into two major purposes. Exploratory analysis tools help identify opportunities for or constraints to agricultural development. They are appropriate for the early program-planning phase, such as in conjunction with MCC’s Constraints Analysis procedure. Ex-ante evaluative analysis tools are useful for estimating the impacts of a particular investment, and are appropriate at a later stage, such as in conjunction with MCC’s CBA procedure and original ERR estimation. Some tools can be used for both exploratory and evaluative analysis.

Exploratory Analysis to Identify High-Return Investment Areas: The level of success of projects – to the degree that it can be estimated by MCC’s closeout ERRs – varies widely. Exploratory analysis by IFPRI could help identify the best areas for investment, capturing more of the projects at the top end of performance. As evident from the ERR Database (see Annex 0) created for this report, MCC and its partner countries seem to have been relatively successful in finding high-return investments: 67 percent of projects report a closeout ERR that meets or exceeds the 10 percent threshold. However, a third of the projects fall short. Furthermore, return on successful projects varies widely; the top decile of projects with closeout ERRs come in at an impressive 35 percent and higher. This suggests that there is potential for more high-return projects, if investment areas likely to have high return can be better identified. IFPRI can offer exploratory analysis to augment partner countries’ constraints analysis, offering identification of the areas of investment that are most crucial as well as some metrics for comparing these areas.

Ex-Ante Evaluative Analysis: Mission-Critical Poverty Analysis: IFPRI models may also be able to capture more detailed impacts than are captured by a CBA, allowing for a deeper understanding of the impacts of the proposed investment in the country. In particular, IFPRI models can provide insight into the effect on poverty of a particular potential investment, filling a critical gap in MCC’s decision-making toolset and delivering analysis on a key element of its mission. As an example, household-level microsimulations can offer an understanding of how a project may change the welfare of a household. Household-level behavior models can even simulate production, consumption, and labor allocation decisions. Such household-level models can further be nested into larger village-, country-, or regional-level models to analyze wider and indirect impacts on these economies.

Ex-Ante Evaluative Analysis: Multi-Outcome Analysis for Wider Understanding of Impacts: ERR analyses often do not account for social or environmental costs and benefits, and if they do, the impacts are collapsed into a one-dimensional measurement, the economic rate of return. While pragmatic for yes/no decisions and cross-project comparison, IFPRI can paint a more complex picture of what to expect from a project using multi-dimensional analysis. Such analysis can include social and environmental indicators to shed light on other important impacts of MCC projects, which can be useful to avoid projects with large unwanted impacts, to communicate to partner countries and communities how they should expect a project to affect them, and potentially to improve upon existing project plans

or make a marginal decision on whether to greenlight a project. Such analysis can also augment MCC’s ability to communicate about its results to taxpayers and decision-makers back home. Furthermore, such analysis can account for complementarity of interventions.

Ex-Ante Evaluative Analysis: Capture of Second-Order Effects to Expand CBA and Improve Accuracy: Crucially, CBAs cannot capture indirect, “second-order” effects on an economy; IFPRI offers equilibrium modeling tools that can build such effects into MCC’s analysis. Second-order effects are indirect effects that occur if an intervention shifts a supply or demand curve in the market in question or in linked markets. These effects are likely to occur if MCC’s project is large, relative to the size of the economy (village, country economy, multi-country economic region, district economy, etc.), a particular sector (e.g. agriculture or tourism), commodity market (e.g. the cassava market), or factor market (e.g., rural labor or farm equipment). If significant second-order effects occur due to an investment, an ERR analysis may under- or over-estimate the ERR.

Table 3 below summarizes which tools can be used for which type of analysis. More information about the tools can be found in Section 4, **Error! Reference source not found.**

Table 3: Types of Analysis Enabled by IFPRI Tools

		Exploratory Analysis	Ex-Ante Evaluative Analysis		
			Poverty Analysis	Multi-Outcome Analysis	Capture of Indirect Effects
IFPRI Tool	Agricultural Constraints Analysis	Yes			
	Household-level microsimulation		Yes		
	Household-level behavioral model		Yes		
	Agricultural Typology with SFA	Yes	Yes		
	Multimarket PE		Yes	Yes	Yes
	Village CGE with nested households		Yes	Yes	Yes
	Single-region CGE with nested households	Yes	Yes	Yes	Yes
	Global CGE with nested households	Yes	Yes	Yes	Yes

3.3 Types of Tools at IFPRI

So far in Section 3, we have evaluated what the ERR does and doesn’t capture and explained use cases where IFPRI tools might come into play. In this section, we will present a quick categorization of existing instruments, while in the following section, we explore the features that are common to many of them and make them useful. Note that all tools listed here, apart from the agricultural constraints analysis, are quantitative economic models.

The agricultural constraints analysis is the application of the typology presented in Section 2.2. It is a primarily qualitative tool that could extend the Constraints Analysis methodology already used by MCC into the agricultural sector. Quantitative indicators can augment the constraints analysis as relevant and desired. Such a tool could dovetail onto a constraints analysis when agriculture is identified as a particular industry of interest. We present this tool in more detail and provide an example in Section 4.

Household-level microsimulations capture the role of the farm household as both a buyer and seller of food, and they have been used to calculate the effects of food price changes on net real incomes, accounting for impacts on both farm revenues and consumption expenditure (Filipski, 2012; Zezza, 2008). However, these exercises do not account for behavioral responses at the household level or for market-level effects, focusing only on direct economic impacts.

The Agricultural Typology with Stochastic Frontier Analysis (SFA), a GIS-based model developed by IFPRI (see Maruyama 2021), utilizes SFA to estimate average household gains in agricultural potential and efficiency by comparing smallholders' performance under current conditions and under separate scenarios of new investments to improve production or market access conditions. It relies on detailed spatial and household information. To assess the impact of investments in irrigation and roads, for instance, they assume that this type of infrastructure investment expands smallholders' profit frontier, which has an immediate effect on their profits even when holding their efficiency levels constant. They then calculate what would be the additional gain from the higher-profit frontier values once efficiency levels rise. For the case of irrigation, they also include GIS information on water availability and topography (slope) in the frontier specification to account for access to water sources for irrigation. This approach does not take into account second-order effects in terms of price responses but capture some features of agent behavior through the shape of the profit frontier.

Household-level behavioral models have been used to depict the farm household's production, consumption, and labor allocation decisions. When markets are missing or failing, those decisions are made jointly, which has important ramifications for household response to market incentives and policies. Some agricultural household models (Singh, et al., 1986; de Janvry and Sadoulet, 2006; Taylor and Adelman, 2003) incorporate missing markets at the household level but treat autarkic households in isolation from the wider village or rural economy. Representing specific household constraints could be included in such models. Households isolated from markets by prohibitive transaction costs may see no benefits from market price supports, while factor-constrained households may not be as responsive to production incentives as households that can purchase or rent production factors.

Multimarket PE models considers the effects of a given policy action or investment only in the market(s) that are directly affected, maintaining all other parts of the economy constant. This limits their use case to some degree because the analysis does not account for the economic interactions between the various markets in a given economy and either ignores the effects on other industries in the economy or assumes that the sector in question is very small and therefore has little if any impact on other sectors of the economy. One example of this type of models is [IMPACT](#) model, which has been used to study future global supply, demand, and trade in the agriculture and food sector Robinson et al. (2015).

Village CGE models with nested households include such farm household models within a model of the local (village) economy (Taylor and Adelman, 1996). Farm household models and extended village economy models reveal complex linkages between functioning and failing markets, in which the impacts of policy or investment shocks may be transmitted in unexpected ways and produce unexpected or seemingly perverse outcomes. For instance, Dyer et al. (2006) show how a decrease in the price of maize may induce subsistence farmers to increase their maize production through the indirect effect on

rural wages. Löfgren and Robinson (1999) use a stylized CGE model in which household market participation decisions are endogenous to demonstrate how production responses to price policies may be discontinuous when farmers face transaction costs. In village economy models, the world outside of the village is fixed, unchanged by anything that happens within the village economy.

Single-region CGE models are a class of model that use actual economic data to estimate how an economy might react to changes in policy, technology, or other external factors. They provide aggregated representations of the entire economy in equilibrium in the baseline and under a regulatory or policy scenario (Dervis et al, 1982) (Burfisher 2017). These models, like the [IFPRI Standard CGE](#) model or [RIAPA](#) model, include many features that facilitate the use of these kinds of model in developing countries, like household own consumption, explicit treatment of transaction costs, and a separation between production activities and commodities, allowing the possibility of one activity producing multiple commodities and any commodity being produced by multiple activities. Single-region CGEs are written for application at the national level but can be modified to represent a regional analysis (geographical regions or villages, for example). In comparison to a global CGE model, a single-region CGE model is appropriate when the rest of the world can be considered as unaffected by what goes on in the country, region, or village being modelled.

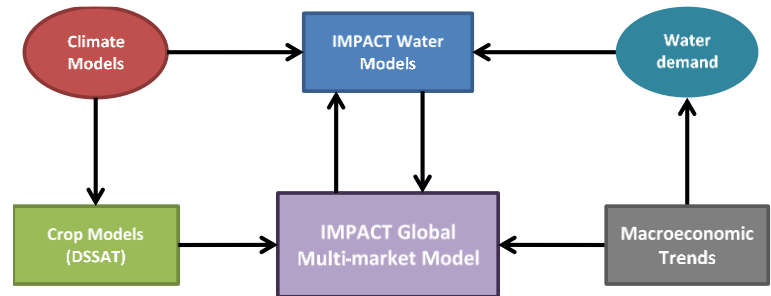
Global CGE models allow for a detailed and consistent representation of rest of the world. In this way, international economic linkages are captured through the international trade of goods, as well as through the movement of people and capital, especially foreign direct investment (FDI). One example of a multi-country CGE is [MIRAGRODEP](#), which allows us to measure the impact of any policy changes on economic indicators such as changes in production, production factor uses, real wages, value added by sector, real GDP, real income, exports, imports, and terms of trade. This type of models is especially useful in dealing with shocks, policies, or other interventions (e.g. infrastructure project) that affect more than one country, or when a change in the country being studied is expected to affect other countries, such that we cannot assume the rest of the world is unaffected.

In some cases, **microsimulations** have been appended to or **nested within CGE models**, in order to capture economy-wide interactions, for example through labor and other factor markets (Cockburn, 2001; Thurlow et al., 2007; Vos and De Jong, 2003; Annabi et al., 2005; de Souza Ferreira Filho and Horridge, 2005; Cororaton and Cockburn, 2007). Recently, such models (Thurlow and al. with the RIAPA model (IFPRI), STAGE_DEV MODEL from EC-JRC (Boulanger and al, 2017) and Laborde and al. (2017, 2020)) have used these frameworks to assess different mixes of policies and investments in the context of SDG2 strategy or the agricultural transformation agenda. Nested microsimulations of households are integral in the Ceres2030 model, illustrated below in Box 2. However, household disaggregation in these models is often obtained at the expense of commodity and activity details.

While these various types of models can help looking at cost and benefits of various investments, they vary in terms of scale, data requirements, and requirements in human capital, we will mainly propose to MCC instruments belonging to the first two categories.

Box 1: IFPRI Modeling Tools – Economy wide models

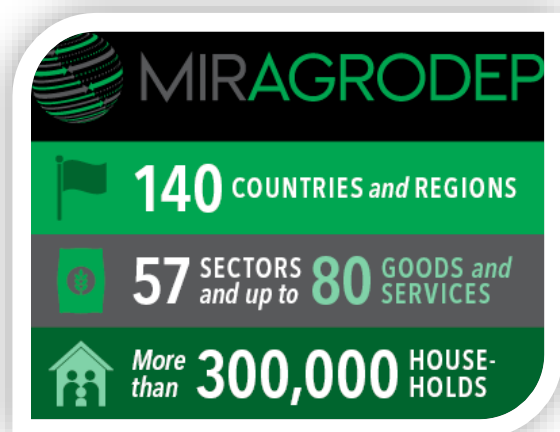
IMPACT is a multimarket and partial equilibrium model that solves for global prices that equate supply and demand for every year and commodity in the model. Production is computed at the level of IMPACT's FPU (food production units), which are the intersection of regions (which are in most cases countries) and major water basins. IMPACT has 159 regions and 154 water basins, which combine



for 320 FPUs. IMPACT has 62 commodities, including 39 crops, 6 types of livestock, and 17 processed foods. IMPACT solves annual for 2005 through 2050. IMPACT draws on inputs from other models, as shown in Figure 1. Underlying the analysis are climate models that are taken from the CMIP5 models used by the IPCC (Intergovernmental Panel on Climate Change) in their Fifth Assessment Reports (AR5). The climate models feed into the crop simulation models (for this study and for IMPACT in general, the Decision Support System for Agrotechnology Transfer [DSSAT] software package is used) and water models (hydrology, water basin management, and water stress models). DSSAT relies on demographic and GDP projections used as part of the IPCC AR5 report. For this report, we use the projections associated with the SSP2 (the baseline or “middle of the road” shared socioeconomic pathway of the AR5) and results are shown for the period 2010 through 2030.

RIAPA is a computable general equilibrium (CGE) model that simulates the functioning of a market economy, including markets for products and factors (i.e., land, labor, and capital). RIAPA measures how impacts are mediated through prices and resource reallocations, and ensures that resource and macroeconomic constraints are respected, such as when inputs or foreign exchange are limited. RIAPA provides a consistent “simulation laboratory” for quantitatively examining the policy impacts at national, sub-national and household levels. RIAPA divides the economy into sectors and household groups that act as individual economic agents. Producers maximize profits and supply output to national markets, where it may be exported and/or combined with imports depending on relative prices, with foreign prices affected by exchange rate movements. Producers combine factors and intermediate inputs using sector-specific technologies. Wheat farmers, for example, use a unique combination of land, labor, machinery, fertilizer, purchased seeds, etc. Workers in RIAPA are divided by education levels, and agricultural capital is separated into crop and livestock categories. Labor and capital are in fixed supply, but less-educated workers are treated as underemployed. Producers and households pay taxes to the government, who uses these and other revenues to finance public services and social transfers. Remaining revenues are added to private savings and foreign capital inflows to finance investment, i.e., investment is driven by levels of savings. RIAPA is dynamic, with past investment determining current capital availability. Finally, RIAPA

tracks changes in incomes and expenditures for different household groups, including changes in food and nonfood consumption across the income distribution and in different regions of the country.



MIRAGRODEP is a Computable General Equilibrium (CGE) model based on the MIRAGE (Modelling International Relationships under Applied General Equilibrium) model. In its standard version, MIRAGRODEP is a recursive, dynamic multiregional, multisector model. In MIRAGRODEP, the government is explicitly modeled as different from private agents. Government income consists of taxes collected on production, on factors of production, on exports, on imports, on consumption, and on households' income.

For this study, the main source of data comes from GTAP 10 version with 25 sectors and 30 regions (23 individual countries or subregions in LAC).

The Armington assumption (Armington 1969) allows us to capture product differentiation, including varying levels of substitution of products by origin and destination, and it is a robust way to represent bilateral and intersectoral trade flows. In this study, Armington elasticities are drawn from the GTAP 10 database (GTAP 2018) and follows three levels of nesting varying across regions depending on the product mix of each sector (based on ESI- see Box 2).

The model includes three important assumptions: the external account closure (Current account surplus/deficit is constant, and the real exchange rate is endogenous), the government account closure (government surplus/deficit is constant in terms of domestic GDP adjusting through domestic consumption tax), and the private account closure.

Box 2: The Ceres2030 Project: Using MIRAGRODEP for Optimizing Investment Decisions while Considering Multidimensional Outcomes

As part of the project **Ceres2030: Sustainable Solutions to End Hunger**, IFPRI and partners used an adaptation of the MIRAGRODEP CGE model to answer the following question: What will it cost governments to end hunger, double the incomes of small-scale producers, and protect the climate by 2030?

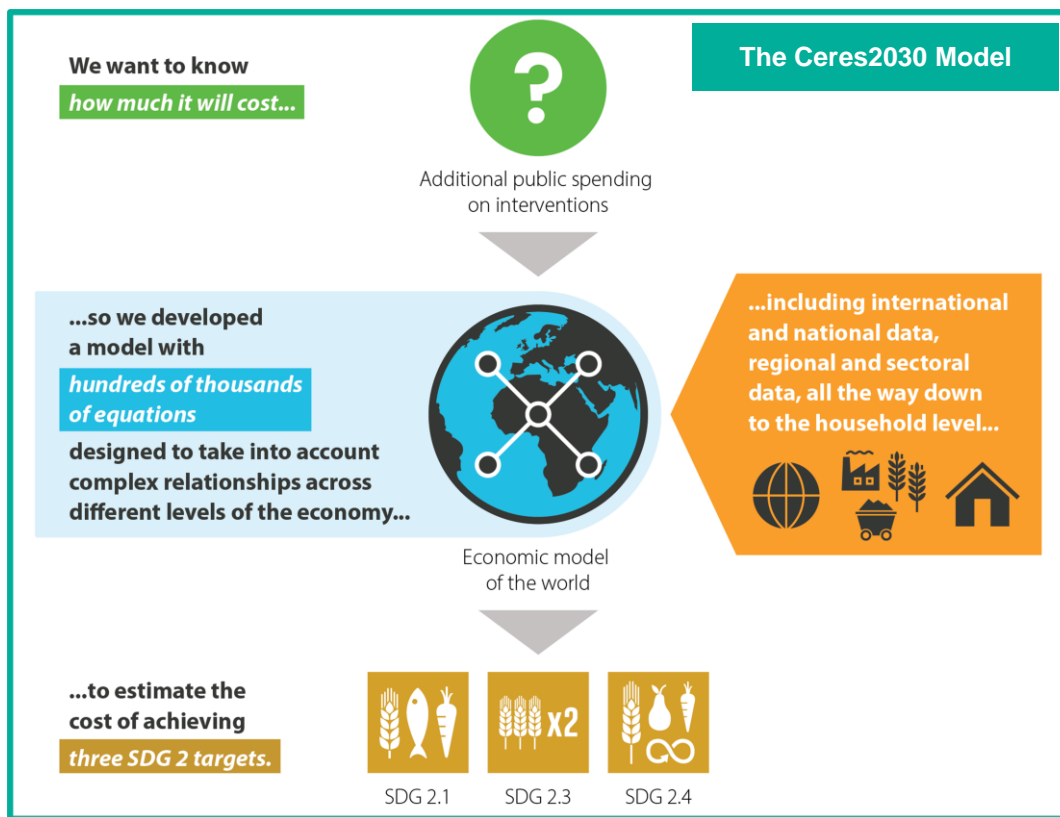
A solution to **three problems**, mapped to 3 of the 5 the targets in Sustainable Development Goal 2 (SDG 2), Zero Hunger, was simulated by the modeling:

SDG 2.1 Today 690 million people are hungry, and 95 million more people are at risk due to COVID-19.

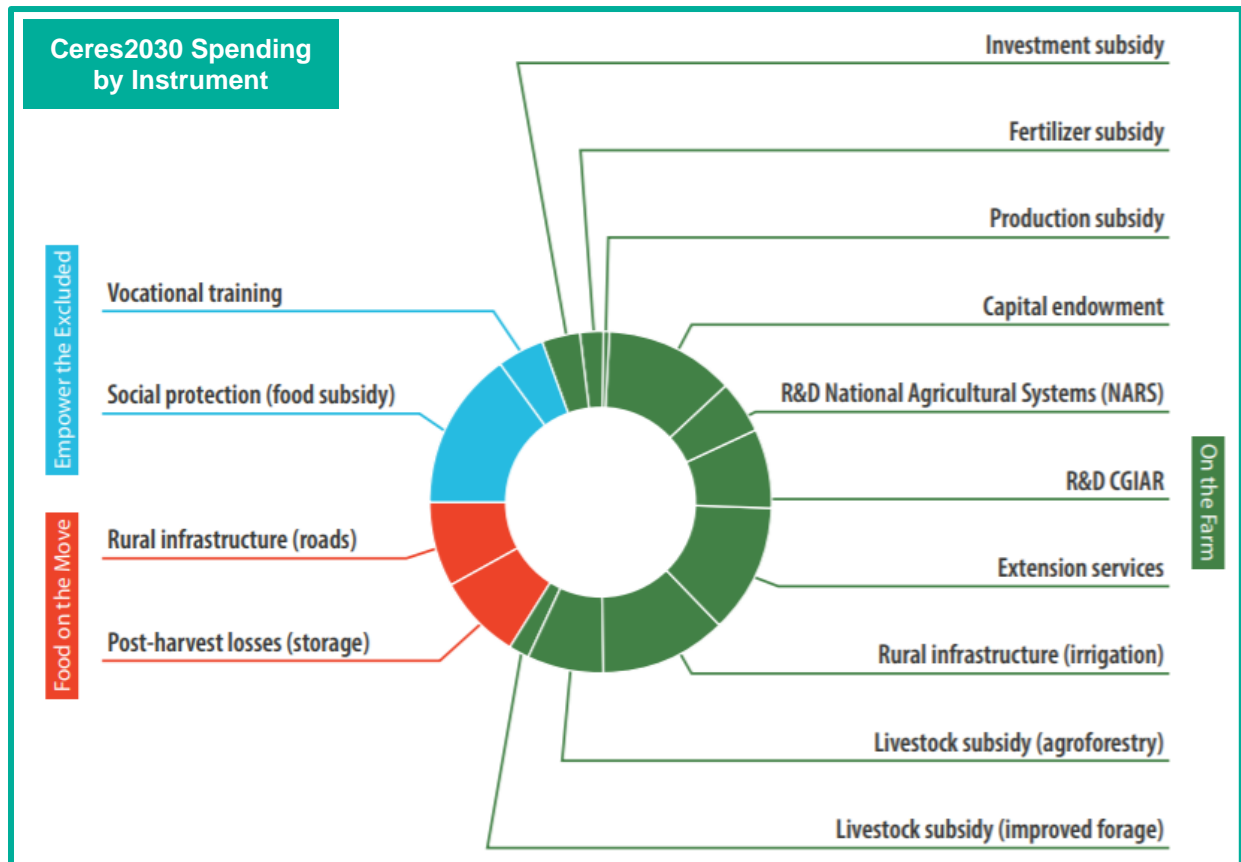
SDG 2.3 The people whose livelihoods depend on food and agriculture – small-scale producer households, especially in Africa – are among the most likely to experience hunger.

SDG 2.4 Food systems are a central driver of deteriorating environmental conditions, while at the same time being one of the sectors put most at risk by the climate crisis.

Compared to the base MIRAGRODEP model, **the Ceres2030 model** included household-level modelling and cost and impact data for specific intervention instruments, such as extension services. It simulated reaching SDG targets 2.1, 2.3, and 2.4 at minimum cost by using a portfolio of instruments, as illustrated in the diagram below.



The modeling exercise yielded a solution for amount of spending needed by geography, by instrument, and over time that is being used in dialogue on SDG investment strategy by major donors. Overall, Ceres2030 estimated that an additional USD 33 billion per year until 2030 in public spending is needed to reach the three targets. Spending is broken down by instrument below.



The cost modeling research yielded **five key findings** at the global level:

1. **Donors** need to contribute an **additional USD 14 billion per year** until 2030 to end hunger and double the incomes of small-scale producers while maintaining greenhouse gas emissions for agriculture below the commitments made in the Paris Agreement.
2. Aid will not be enough. Additional efforts of **USD 19 billion per year on average** will have to be provided by **low- and middle-income countries** through increased taxation.
3. The additional public spending will **prevent 490 million people from experiencing hunger** and **double**, on average, **the incomes of 545 million small-scale producers**.
4. Any delay in spending will not only have human costs but will also increase the total monetary costs. **Early spending**, on the other hand, allows investment in interventions that take more time—like research and development (R&D)—but have a bigger payoff.
5. **A portfolio of complementary interventions** is needed to achieve the multiple SDG 2 targets. Ceres2030 estimated the optimal investment using 14 policy instruments lumped into three categories: (1) empower the excluded, (2) on the farm, and (3) food on the move.

The material in this box is adapted from Laborde, Parent, and Smaller (2020). To learn more, see the report *Ending Hunger, Increasing Incomes, and Protecting the Climate: What would it cost donors?* available at DOI: <https://hdl.handle.net/1813/72864>.

3.4 Considerations for Models Built to Prioritize Investment

The modeling space is diverse, and models differ greatly in features and accordingly appropriate use. Here, we highlight some key features that come into play in IFPRI's suite of tools. The effects of agricultural investments shocks are complex, involving numerous and interrelated behavioral adjustments within the economy. No single model can capture all these effects, but some models are better at describing specific effects than others. Trade-offs in features are inevitable. Moreover, availability of data can be a limiting factor, and complexity can make a model infeasible or uninterpretable. So, the challenge is to include the most important features for the problem at stake and leave behind those that are less crucial, making sure a consistent framework is used and all caveats are explained.

Capture of second-order effects

Earlier, we mentioned that ERR analysis does not capture second-order effects. First-order effects are the direct effects of a project and do not capture behavioral responses of economic agents. They are the only effects when there is no change in the equilibrium price and quantity of any market, that is, the project does not shift the supply or demand curve of the market of interest or any of its linked markets. For example, MCC may account for first-order effects when planning an irrigation project by calculating the expected increase in yields for all farmers who they expect to use irrigation and subtracting their expected additional costs to produce now that they are using irrigation (based on current costs to produce). (See, for example, [Ghana: Development of Agriculture and Value Added Project](#)). This yields the first-order net benefit. The production changes are directly driven by the productivity increase, and the area subject to the irrigation investment, but the "value", i.e. the price, of this additional production is not changed.

However, in the case of a large-scale irrigation project, there is likely to be a change in the equilibrium price and quantity of the market for the produced agricultural goods, meaning that it would not be enough to account for the first-order effect. A publicly funded irrigation project causes an outward shift in the supply curve – a second-order effect. While quantity rises, price falls. For a farmer who irrigates, this means that they are able to produce more, but the price they receive for each unit falls. So, the net benefit for irrigating farmers is mitigated. It might also need to be considered that farmers who do not have access to irrigation but must sell at the same price as those that do are negatively affected. This second-order effect when considering producers in a disaggregated way may also be taken into account by equilibrium modeling. Similarly, the price reduction will benefit to various consumers, or downstream industries, and could generate much larger gains to a wider community.

Beyond a more realistic assessment of long-term impacts of investments, equilibrium models can also identify the distributional impacts in a better way (among producers or between producers and consumers) and capture the possibilities of winners and losers.

Second-order effects can occur outside the market of direct interest, too. For example, irrigation may increase the returns to fertilizer, causing a shift in the demand curve in the fertilizer market.

The Burkina Faso Roads project can illustrate a useful case to measure second-order effects. MCC's CBA used the World Bank's Roads Economic Decision (RED) model to measure benefits generated by the road project. The model calculates benefits in terms of consumer surplus taking into account road length, condition, geometry, type, accidents, and days per year when the passage of vehicles is further disrupted by a highly deteriorated road condition (wet season). It does this for four categories of traffic:

normal traffic (traffic that would pass along a road regardless of any upgrade), generated traffic (additional use by existing users of the road), induced traffic (new use by new users of the road), and diverted traffic (use that shifts from a different road to the new road). The generated, induced, and diverted traffic estimates are highly dependent on user input; for example, the user must input a price elasticity of demand for road use for the generated traffic, or define it as a percent of the normal traffic, and induced traffic is entered freely by the user. This kind of model requires very detail information in order to make the necessary assumptions for running the model and it limited in its scope of modelled effects on the economy. CGE models, on the other hand, reduce detail but capture direct and indirect effects in the agricultural sector and beyond.

Multidimensionality

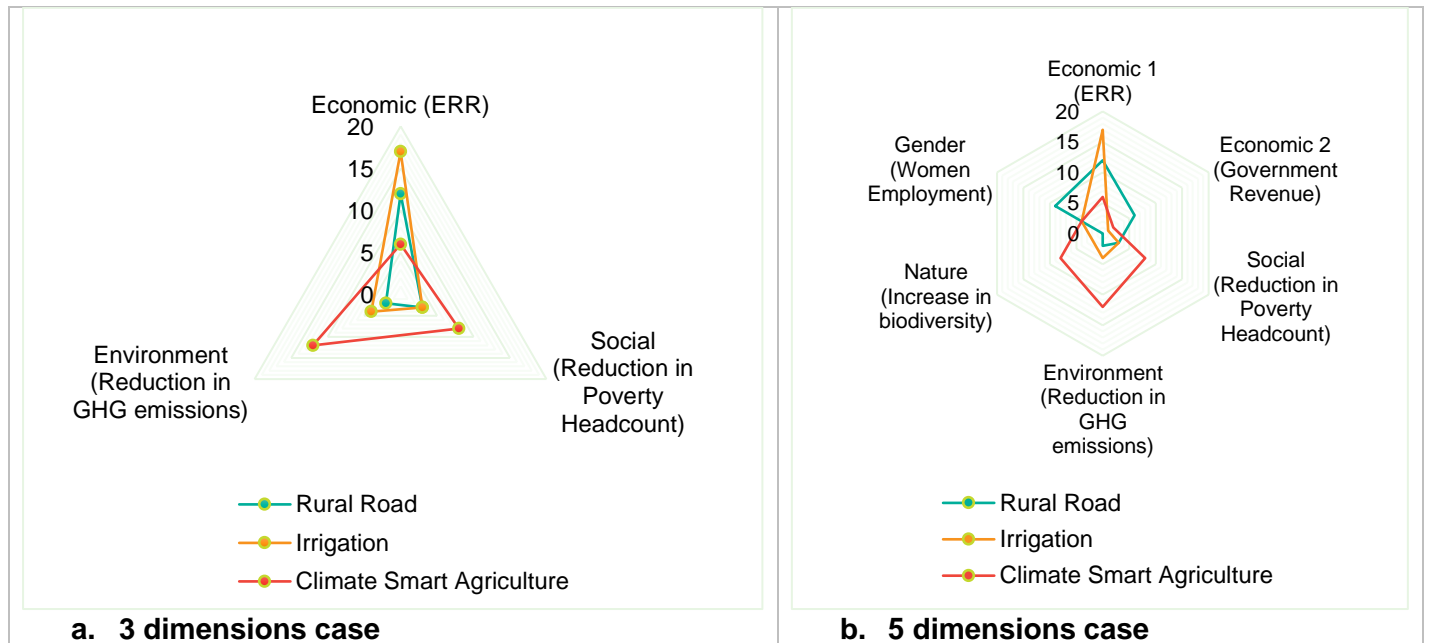
IFPRI tools can be equipped to track multiple “dimensions” of outcomes. We can ask the model how an investment or investments will affect these multiple outcomes, or we can flip the question and ask the model how much money would be required to reach a multidimensional goal (as was done with the Ceres2030 model, see Box 2).

In the first case, model results can be put into radar charts, as in **Error! Reference source not found.**, to illustrate the multidimensional impacts of an investment. They enable visual comparison to assess potential trade-offs and synergies. Of course, no single investment is expected to achieve all dimensions of reducing poverty, food security, and environmental objectives of a sustainable development agenda at once. Moreover, some investments could be beneficial in some dimensions but detrimental in others. This may not be a reason to not do such interventions, but it may be a reason to consider complementary investments.

Panel a uses a three-dimensional space focusing on one economic indicator (ERR), one social indicator (reduction in poverty headcount), and one environmental indicator (reduction in GHG emissions), applied to three different investments: one on irrigation, one on rural roads, and one on smart agricultural practices. It could be used to prioritize among projects. However, because the units on each axis are indicator-specific, cross-dimensional comparison is not possible.

Panel b shows how we can extend this framework to more indicators, to capture other aspects such as gender and biodiversity or pursue economic impacts with public revenue indicators. Versions with more indicators focusing on SDGs are available on page 10 of Laborde and al. (2019).

Figure 9: Illustrating Multidimensional Outcomes



Source: Authors' illustration.

Scaling across projects is an outstanding challenge when considering prioritizing projects of different sizes. While an ERR is neutral to project size, other dimensions may be more challenging to standardize. Poverty or environmental impacts will be associated with a level of expenditure, the project size. For example, an investment of 1 million USD leads to an x percent reduction in poverty, or the removal of y people from poverty. In this situation, either we compare investments of the same value or we re-scale investments to compare outcomes for the same cost. While a proportional adjustment to obtain impacts measured per \$1 of spending is straightforward, it may not be practically relevant. In some cases, we cannot build a “half” factory, or some projects may face strongly decreasing marginal impacts as the amount of investment increases. In such situations, a scaled indicator could be highly misleading. In addition, it may lead to favor small projects that appear to have good performance per dollar but will never be scalable or achieve systemic change. The issue of non-linearity could be examined by simulating various investments levels in the models used, but the models themselves have strong assumptions embedded about linearity, and a circular justification could occur.

This type of representation turns out to be very useful at the time of comparing projects and ranking them in specific situations. In the case of panel a, we can see that the rural road project performs lower in dimension than the irrigation project.⁶ However, this does not allow us to compare the climate-smart agriculture project and the irrigation project. The irrigation project performs better in the economic dimension but lower in both the social and environmental dimensions. As shown in the second panel, adding more dimensions complicates the comparison.

So, a quantitative framework for guiding investment prioritization may require two different elements:

⁶ This is known as Pareto domination. If we call the irrigation project P^1 , and the rural road P^2 , we will prioritize, or prefer, P^1 compared to P^2 , i.e. $P^1 \succcurlyeq P^2$ since all elements of the impact vector of P^1 called $i_1 = \{17, 3, 4\}$ are superior or equal to the elements of the impact vector of P^2 , $i_2 = \{3, 3, 2\}$

- The capacity to track and measure all the relevant dimensions with an appropriate number of indicators. We can use various models to quantify these dimensions and build charts like those in **Error! Reference source not found.**;
- A decision-making rule used to combine these different dimensions to deliver a hierarchical ranking.

These two parts will be kept distinct since various models could be actually be combined with various decision rules, and there is no unique mapping between these two aspects (Christian Henning and Hedtrich n.d.).⁷ We will discuss in the following paragraphs some issues related to the later point: the decision rule.

Beyond economic growth as captured by the ERR analyses, reducing poverty and inequality, empowering women, promoting food and nutrition security, and addressing environmental sustainability are increasingly recognized as important for stakeholders and decision making. To ease the decision process, it is convenient to collapse all the dimensions into one metric, or put it differently, to associate to each project a score S . From a theoretical point, this process is equivalent to defining a function $U()$, applied on the vector of impacts i of dimension n , n being the number of dimensions we want to consider in our decision making. So, $S = U(i)$ and $U: \mathbb{R}^n \rightarrow \mathbb{R}$. U is supposed to be continuous and strictly increasing on all of its elements. By ranking project by the value of S , we can prioritize them.⁸ The general interpretation is to assume that $U()$ is the utility function of the decision maker, and therefore projects could be ranked. For a public entity, it can be understood as a social utility function, or the “policy preferences” chosen by the decision-maker on behalf of the stakeholders. Determining the exact shape of this utility function entails choosing the “weights” of each dimension in our radar chart. It is a non-trivial task and will determine the outcome of any ranking. Using a standard microeconomic framework, we illustrate this discussion in Appendix 0 for a two-dimensional case.

Because social values and local preferences vary by partner country, the decision rule should also vary by country. Experimental economics could be used to let decision makers and local stakeholders rank various theoretical investment choices in order to identify their preferences.

If MCC desired to move away from a purely ordinal metric to a cardinal metric, monetary values could be assigned to the impacts. This would allow us to use utility scores as ratings rather than just rankings and move from an ERR to an “ERR+.” While outcomes such as the social cost of carbon may have external sources for monetary information, other outcomes like gender and poverty may not. So, this approach may introduce challenges in assigning ethical and economically sound monetary valuation.

Two approaches could be taken, with significant differences in their implementation. A first approach would be to compute the “equivalent economic rate of return”, or “ERR+” denoted as \bar{e} , that leads to no change in the decision maker’s utility between the actual project impact $i(e, y, z)$ and a project $\bar{i}(\bar{e}, 0, 0)$, such that $U(e, y, z) = \bar{U} = U(\bar{e}, 0, 0)$. Here, e = the estimated ERR, y = the estimated poverty impact, and z = the estimated carbon impact. This is the theoretically preferable approach but requires properly identifying the function $U()$. In this approach, an “adjusted” ERR+ is calculated for each project, and the adjustment properly reflects the preferences of the decision maker for each dimension. The shape of $U()$ is ignored.

⁷ We can indicate that some authors, like Henning and al. 2018, proposes an integrated approach based on a Computable General Political Economy Equilibrium Model (CGPE), and extend it to concept of evolutionary CGPE (eCGPE) where the decision rule is not only embedded in the CGE framework but also allow to iterate adjustment of the political preferences.

⁸ We “prefer” project 1, P^1 , to project 2, P^2 , i.e. $P^1 \succ P^2$ if and only if $U(i_1) \geq U(i_2)$.

A second approach would be to associate each element of the impact vector with a price. $U()$ would then be a linear function of the prices multiplied by the quantity of the impact for each dimension: $U(e, y, z) = p_e e + p_y y + p_z z$. The primary challenge with this approach is selecting the economic value of outcomes that are not priced or not perfectly priced in the real world. For example, what value would we put on a person moving from a net income of \$1.90 (2011 PPP) per day to a net income of \$3.20 (2011 PPP) a day? The direct economic gains captured by the ERR would not require these price valuations, but all other dimensions would. Various economic approaches could be used to make these valuations for each dimension (e.g., hedonistic valuation, proxy markets, social cost valuation, abatement cost valuation), with each having its own implied assumptions about the world. Some questions that would emerge in creating these valuations include:

- What is the economic valuation of a poor person? Should we use the *average* public cost of a cash transfer needed to remove a person from poverty? Or a *marginal* cost? Or the *social* cost, through missed economic opportunities, of one person remaining poor?
- How should water be priced in countries that do not have water markets, or where markets are not operating for agriculture? How we should measure damage to water quality contaminated by pesticides – the cost of *cleaning* the water? Or the cost to the communities depending on this water source?

Once we have decided on our price vector, we can define the ERR+ as:

$ERR+ = IRR \left(\sum_{t=0}^{\infty} \left[b_t - c_t + \sum_{k=1}^{n-1} p_{k,t} x_{k,t} \right] \right)$	Eq. 1
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The IRR is the internal rate of return function as currently used by MCC, t is the time index, b_t is the flows of economic benefits (value added), c_t is the flows of direct costs of the projects (initial investments and maintenance), $x_{k,t}$ is the impacts on the $(n - 1)$ other dimensions, and $p_{k,t}$ is the prices of other impacts.

This implies that ERR+ is the solution of $\sum_{t=0}^{\infty} \frac{[b_t - c_t + \sum_{k=1}^{n-1} p_{k,t} x_{k,t}]}{(1+ERR+)^t} = 0$.

If we apply this equation to our simplified economic and social space, we could express it as the solution of $\sum_{t=0}^{\infty} \frac{b_t - c_t + p_t h_t}{(1+ERR+)^t} = 0$, where h_t is the number of people remove from extreme poverty due to the project in period t , and p_t is the cost of an additional poor person for society. We assume that $p_t h_t$ is equal to the daily average poverty gap (average per capita income of people below the poverty line) x 365 days/year x 1.2. The last number, 1.2, is an assumed mark-up on social transfer programs.

To conclude, this framework could be used both to assess individual interventions and to consider holistic scenarios combining multiple investments and policy changes. The latter use could generate investment plans with higher rates of return, especially when considering multiple outcomes, than considering individual projects one at a time.

Critical features for developing countries

Economic models typically make standard economic assumptions for simplicity, but these assumptions are often violated in developing countries in ways that make such models non-optimal. Many corre-

spond to a world in which markets operate smoothly and farmers operate as commercial, profit-maximizing producers with uniform technologies. (For partial equilibrium models that address these inappropriate assumptions, see, for instance Dewbre, J. et al., 2001; Flyod, 1965; Gardner, 1987; Hertel, T., 1989; OECD 2005; Salhofer, K. & Schmid, E., 2004; Shaik et al., 2005. For general equilibrium models, see Balistreri et al., 2009; Engida et al., 2015; Karingi, S., & Siriwardana, M., 2001; Tangermann, S., 2005; Perali, F. et al., 2012.) This approach may be reasonable for developed countries, but it is not the case for developing countries.

In developing countries, most agricultural producers face constraints of imperfect markets and households make simultaneous decisions on production, consumption, and labor allocation. They are also heterogeneous in resource endowments, technologies, access to markets, and other key variables likely to shape intervention outcomes.

These particularities of developing countries can be seen in the fact that market prices do not correspond to the household's opportunity costs, for example, because of the high costs of getting goods to market; lack of access to markets for agricultural inputs, credit, insurance, outputs, and labor; or the imperfect substitutability of hired labor for family labor on the farm. Models used for developing countries must take these circumstances into account in order to be representative and useful.

Three features of agricultural and rural markets in developing countries in particular should be taken into account:

1. **Subsistence Farming:** Most farm households consume a significant share of what they produce, and many are in fact net buyers of food (Singh et al., 1986). This means that the effect of farm policies on agricultural household incomes depends on demand-side as well as supply-side effects. For example, raising farm prices could lower real incomes for net buyers of food unless they exhibit a sufficiently elastic supply response to be transformed into net sellers.
2. **Transaction Costs:** Many farm households confront high transaction costs when selling output or purchasing inputs. In the extreme, these transaction costs may be so high that the farmer is cut off from the market altogether, producing only for home consumption and resulting in subsistence agriculture. Under these circumstances, a subsistence farm household may not benefit from higher farm prices. In fact, it could lose via induced increases in land rental rates or in the prices paid for purchased inputs.
3. **Household Heterogeneity:** Heterogeneity in rural households' income sources, expenditure patterns, and ownership of factors (particularly land) means they are affected differently by direct and indirect impacts of policies. To properly track poverty impacts, a comprehensive model of the agricultural sector in developing countries must consider the behavior of structurally diverse economic agents, including commercial farms, semi-subsistence and subsistence farms, and landless rural households.

Capturing change over time: Dynamic versus static modelling

Static models have a "before" and "after" period, while dynamic models track the evolution of variables over more periods and have intertemporal linkages. For example, in a dynamic model, the values of variables in the last year can impact variables in the current year. Furthermore, the accumulation of factors of production can be included – for example, farmers can accumulate knowledge capital or physical capital such as on-farm storage or tractor equipment. Static models do not capture such dynamics.

The differences between static and dynamic models are included in the way economic agents (such as commercial farms, semi-subsistence and subsistence farms, and landless rural households) perceive

time in the different models. Using a static model used for long-term analysis is equivalent to assuming that economic agents have perfect, rational expectations, since they are jumping from one steady state to another. If this is a fair simplification of the expectation of how MCC's investment will affect a population, then a static model is likely appropriate. Dynamic models make more complex assumptions about agent behavior. Most dynamic models used in economic assessment rely on recursive dynamics, where the present depends on past observations. However, with recursive dynamics, economic agents do not have expectations about the future that impact the present. Modelling behavior this way is necessary to resolve complex models numerically. Some dynamic models use other approaches, incorporating adaptive or rational expectations by economic agents. However, these approaches are technically, and therefore financially, costly, so they should be used only if there is a strong reason to think that some economic agents will change their behavior because they anticipate investment by MCC.

For the users, static models are useful to study the impact of either short-term, "instantaneous" shocks or long-term shocks. The latter case could appear less intuitive but is key to understanding the use of some models. If we consider that an investment is shifting a system from one steady state to another, after considering all adjustments, using a model with a static comparative feature is a reasonable choice regardless of whether the shock caused by the investment occurs in a short timeframe or a long timeframe. For instance, if we look at the post-harvest losses before and after using a new packaging system on farm, and if we assume that all farmers adopt the technology during a given year, a static model will generate reasonable results for our outcomes of interest. The results that the static model generates for the profits for the "after" period could be used for all "after" years in the ERR for the full time horizon, if we can fairly assume that the same profits will apply for all years after the investments.

On the other hand, dynamic models are useful to study the transition from one steady state to another. This may be the case if investments occur over time, if adoption or effects are gradual, or if the system studied is not in a steady state. This last case is often a reasonable assumption for most developed and developing countries, as evinced by the evolution of economies over time. When market dynamics could evolve over time, a dynamic model is likely an appropriate choice. For example, Bernstein et al. note: "Though tenure recognition improves productivity in settings where title is the dominant means for securing land rights, as is the case in much of Latin America and Asia, productivity gains may take time to become apparent, the effects may vary substantially across cases, and they likely depend on other supportive conditions, such as the performance of credit, input supply, and product markets" (Bernstein, Johnson, and Arslan 2019). This indicates that formal land tenure adoption takes time, and that for some farmers whether obtaining formal tenure is worth the time and financial costs or financially possible could change over time. Both of these situations would make modelling land tenure with a dynamic model more appropriate than modelling it with a static model.

Risk and uncertainty

Risk and uncertainty can impact the valuation of projects by ERR analyses or other cost-benefit tools. There are different ways to deal with risk and uncertainty, and the choices can impact analytical conclusions. These concepts are also important to understand the implications of discount rate choice, discussed in the following subsection.

While uncertainty and risk can have similar impacts on cost-benefit analyses, they merit differentiation. Adapting from Park and Shapira's definition, "risk is the situation under which the decision outcomes and their probabilities of occurrences [can be known by] the decision-maker, and uncertainty is the situation under which such information is not available to the decision-maker" (Park and Shapira 2017).

Risk is theoretically knowable and quantifiable, whereas uncertainty is, by definition, unknowable quantitatively. It's not a perfect distinction. For example, the actuarially estimated chance of flooding during a given year on a certain piece of land is risk, while the change in frequency and intensity of flooding on that farmland over the next two decades due to climate change is uncertainty. Furthermore, IFPRI tools may or may not assume that economic agents (such as commercial farms, semi-subsistence and subsistence farms, and landless rural households) have perfect knowledge of their risk.

Modeling Risk at the Agent Level: Most economic models assume either explicitly or implicitly that economic agents have perfect knowledge of risk and are risk-neutral. This is the case for IFPRI models discussed in this report, which by default do not model risk explicitly. Therefore, any investment changing the level of risk at the individual or systemic level would not change the behavior of economic agents in the model. So, while information- and risk-related problems are a key feature of most developing countries and the sources of many market failures and under-investments, they are scarcely represented economic models. Therefore, the benefits of addressing these particular problems, which are relevant to certain MCC investments, will not be captured by most models in an explicit way.

Accounting for Risk and Uncertainty at the Systemic Level: An example of a systemic-level source of risk and uncertainty could be a locust plague affecting the entire population of interest: we have some idea of the probability of a plague of a certain intensity in a given year (risk), but there is also uncertainty about whether that risk is changing over time due to factors such as climate change (uncertainty). Risk and uncertainty at the systemic level are generally not built into the mechanisms of the models discussed here. Rather, but rather accounted for using sensitivity analysis, by running the models with a range of parameters that make up different "scenarios."

Let us illustrate how accounting for systemic risk and uncertainty could work. In a simple economic valuation with a flow of costs and benefits, one of the parameters used could be the price of oil, which is used in the model as an input for factories, transportation, etc. Since the net value of the investment depends on the present and future prices of oil, the user could build a few scenarios, n , for instance $n=3$ with high, medium, and low prices of oil. Each scenario would be assigned a probability, and an expected ERR could be computed for each. Of course, assuming just one price of oil, rather than testing different assumptions, is equivalent to running just one scenario and assuming its probability is 100 percent. On the other end of the spectrum, one could build a full probabilistic distribution for the price of oil based on historical data and run a Monte-Carlo simulation, drawing a large number of oil prices from this distribution and computing the ERR for each of them, leading to a distribution of ERR values. This is quite similar to MCC's current approach with estimating the distribution of the ERR given uncertainty in key parameters. For a model that includes the oil market and therefore the price of oil endogenously (some partial equilibrium models and most general equilibrium models fall into this category), one would not make an assumption about the distribution of oil prices, since oil price is an endogenous variable, but rather the structural parameters impacting either demand or supply for this commodity, such as the increase or decrease of oil fields overtime, changes in the productivity of existing wells, changes in energy efficiency, changes in the efficiency of other energy technologies, and changes in overall economic growth. As before, a limited number of scenarios could be built (high demand, low demand, etc.), or more systematic sensitivity analysis could be performed on key model parameters (technological coefficients, elasticities). Of course, running Monte Carlo on all the parameters used in large models can be very time-consuming and is therefore not done. Rather, more parsimonious approach is used, both from a statistical point of view (usage of Gaussian Quadrature instead of traditional Monte Carlo draws) and from a conceptual point of view (by focusing on key elements of the model that will have the most consequential impact for the project, and variables, studied).

The lesson from this illustration is that a “simple” model with only one value for a particular parameter is actually making a strong assumption without making it explicit (e.g. any assumption about the price of oil is actually associated with assumptions about all the variables that affect oil supply and demand). Conversely, any large model must by nature make many explicit assumptions. Still, both share the need to analyze sources of uncertainty to understand how future evolution of the system studied could impact the results of the analysis.

Uncertainty: A Key Takeaway

The important sources of uncertainty are those that could lead to an alteration of the decision of whether a project should be pursued or which project should be pursued.

The important sources of uncertainty are those that could lead to an alteration of the decision of whether a project should be pursued or which should be pursued. For this reason, while performing large-scale sensitivity analysis that could yield a large range of estimated ERRs, the modeler should focus on how stable the order of recommendations is, rather than any changes in exact values. For this reason, using additional criteria like the stochastic dominance of one project compared to another could be quite useful (see (Laborde Debucquet 2011), page 29, for an implementation of this approach in the decision-making process).

Discounting

Discounting is an important aspect of cost-benefit analyses, since it allows us to take the net value of effects over time and adjust these values all back to the present, so that each option is reduced to a single value for comparison. MCC’s ERR analyses effectively use a 10 percent discount rate, and any IFPRI tool for cost-benefit analysis would need to choose a discount rate (or discount rates) as well. The choice of discount rate is key to analysis, and its value can change the conclusion of whether an option should be pursued, or which option should be pursued. Although it is just one small value, it captures many assumptions and plays a critical role in assessments, including assessments of non-economic costs. Appropriate rates of discount, the underlying assumptions that drive these rates, and empirical rates to be used for benchmarking discount rates are the subject of a rich body of economic literature, with suggestions for rates ranging from negative to double digits.

Let us ground our discussion here in a refresher on the justification for discount rates. What are we accounting for by using a discount rate? Uncertainty and risk are the main elements – the benefits we estimate may not pan out due to some unforeseen circumstances. Uncertainty, and often risk, tend to be higher in developing contexts, contributing to a higher discount rate than in developed contexts. The expectation of real income growth also contributes: for example, a poor college student would get more out of a free meal than her future self that makes a healthy salary, so the meal is worth more to the current her than the future her. This concept also applies at the macroeconomic level since real income is assumed to grow over time. Developing countries generally have faster real income growth than developed countries, contributing to a higher discount rate in developing countries.

What does the discount rate account for?

In the use appropriate for MCC's projects, it accounts for:

- Uncertainty
- Risk
- Real income growth

There are other assumptions that sometimes go into discount rates but may not apply here. First, in cases where inflation is not otherwise accounted for, a discount rate may include the rate of expected inflation. MCC uses real currency, as do IFPRI models, so the inflation rate is not a component of our discount rate. Second, impatience – defined here as the preference to have something now rather than later, assuming receiving it is guaranteed in either situation (no risk or uncertainty), there is no real income growth, and all other circumstances remain constant (no uncertainty) – is arguably not an appropriate factor for the discount rate in many policy contexts, although it may be worth accounting for at the individual level. If impatience at the societal level is accounted for, though probably irrational by our definition here, it would play much less of a role than at the individual level. To illustrate, governments may make a public investment meant to benefit a generation that is not born yet although the investment has no benefit for the currently represented society.

MCC's Discounting Assumptions: MCC calculates the economic rate of return, which is the discount rate for which the net benefits of a proposed project are 0. It then compares the ERR to a "hurdle rate" of 10 percent; if the ERR is 10 percent or more, the project may be greenlighted ("Guidelines for Economic and Beneficiary Analysis" 2017). This decision rule is equivalent to using a 10 percent discount rate to calculate the net present value of a project and greenlighting the project if the net present value of its net benefits equals 0 or more. By default, MCC accounts for costs and benefits over a 20-year time horizon, although this can vary by project as appropriate. This assumption is equivalent to using an infinite discount rate for years 21 onward. MCC does not state, to this team's knowledge, the assumptions underlying this rate, but it does note, "In the field of international development, discount rates of 10-12% are commonly used. MCC's hurdle rate of 10% is consistent with this industry standard."

Ranges of Discount Rates: Suggestions of appropriate discount rates vary widely depending on the context of investment, the origin of funds, the time horizon from which one is discounting, assumptions about the nature of risk, and other underlying assumptions. U.S. government agencies typically use discount rates in the neighborhood of 3 to 7 percent for policies affecting the U.S. population ("Chapter 6: Discounting Future Benefits and Costs" 2010, 6). However, rates may be higher or lower, and even the assumption that the discount rate should be positive in certain contexts has been called into question. While we won't address all relevant assumptions here, we'll explore a few topics that may influence the choice of appropriate discount rate for MCC projects.

Valuing Climate Impacts: For climate impacts, a discount rate lower than MCC's 10 percent is likely appropriate. Existing U.S. government guidelines are worth comparing with here: the EPA recommends a use of 5 percent ("Chapter 6: Discounting Future Benefits and Costs" 2010, 6). While uncertainty, risk, and economic growth rates may contribute to a higher discount rate being applied to impacts on populations in MCC's partner countries, the valuation of the benefit of greenhouse gas reduction requires a discount rate appropriate for a global population. So, the rate used for the impacts occurring in

developing contexts is not necessarily the correct one. Furthermore, the literature goes so far as to suggest that the discount rate for the impacts of public action on climate should even be negative (Fleurbaey and Zuber 2013).

Time Horizons: MCC usually considers a cost and benefit time horizon of 20 years, although it can be longer or shorter depending on what is appropriate for the expected impacts of the project. If only projects with a quicker payoff are considered, it is possible that the most valuable projects may be overlooked.

Time-Variant Discount Rates: MCC uses a constant discount rate of 10 percent across the time horizon. However, the literature notes that the discount rate can vary over the time horizon, declining with time for various reasons (see (Li and Pizer 2019; Fleurbaey and Zuber 2013) for detailed justification). This would be especially important to account for for MCC projects that have a longer stream of costs and benefits to consider. Li and Pizer suggest a discount rate of 2.1–3.8 percent after 50 years under certain assumptions, for example.

Public, Private, and Public-Private Partnership Projects: It has been argued that public projects should face a lower discount rate than private projects due to factors including the structure of risk and market imperfections (see, for instance, (Jensen and Bailey 1972; Grout 2003)). Furthermore, the discount rate for public-private partnerships may differ from public projects due to time considerations (see (Grout 2003; Moszoro 2016)).

Equity: The choice of discount rate for public projects by its nature relies on ethical choices. Fleurbaey and Zuber provide discussion of this as it relates to equity across generations. They describe how the intergenerational discount rate, assuming all people equal and with the risk component removed, can be conceptualized as a matter of aversion to inequality after some minimum level of consumption (Fleurbaey and Zuber 2013).

Discount Rates: A Key Takeaway

The discount rate embodies many assumptions and is highly influential on the ultimate decision of whether a project should be pursued or which project should be pursued. Discount rates can differ by context. Thus, selection of discount rates is a key choice in IFPRI tools for cost-benefit analysis.

3.5 Picking the Right Tool

Selection of the right tool for a particular situation comes down to (1) suitability, which depends on the questions we wish to answer with the analysis, the desired level of detail for the analysis, and the nature and context of the investments we are evaluating, and (2) feasibility, which includes time, human capital, and financial cost considerations. Typically, there is a tradeoff between the two criteria: more advanced tools allow us to capture more effects, direct or indirect, track multiple outcomes, and perform more rigorous assessments, but they face more limitations from a feasibility standpoint.

In this section, we will provide some general guidelines to help decide which tool is appropriate for which job, although a modeler will always be needed to finalize the decision. Often, there is not one right answer, as tools may have overlaps in capabilities, or the set of appropriate assumptions may not be black and white. In these cases, specific functionalities within the model or feasibility considerations will contribute to the final “best” choice. Reducing variety of tools used is desirable where suitability is

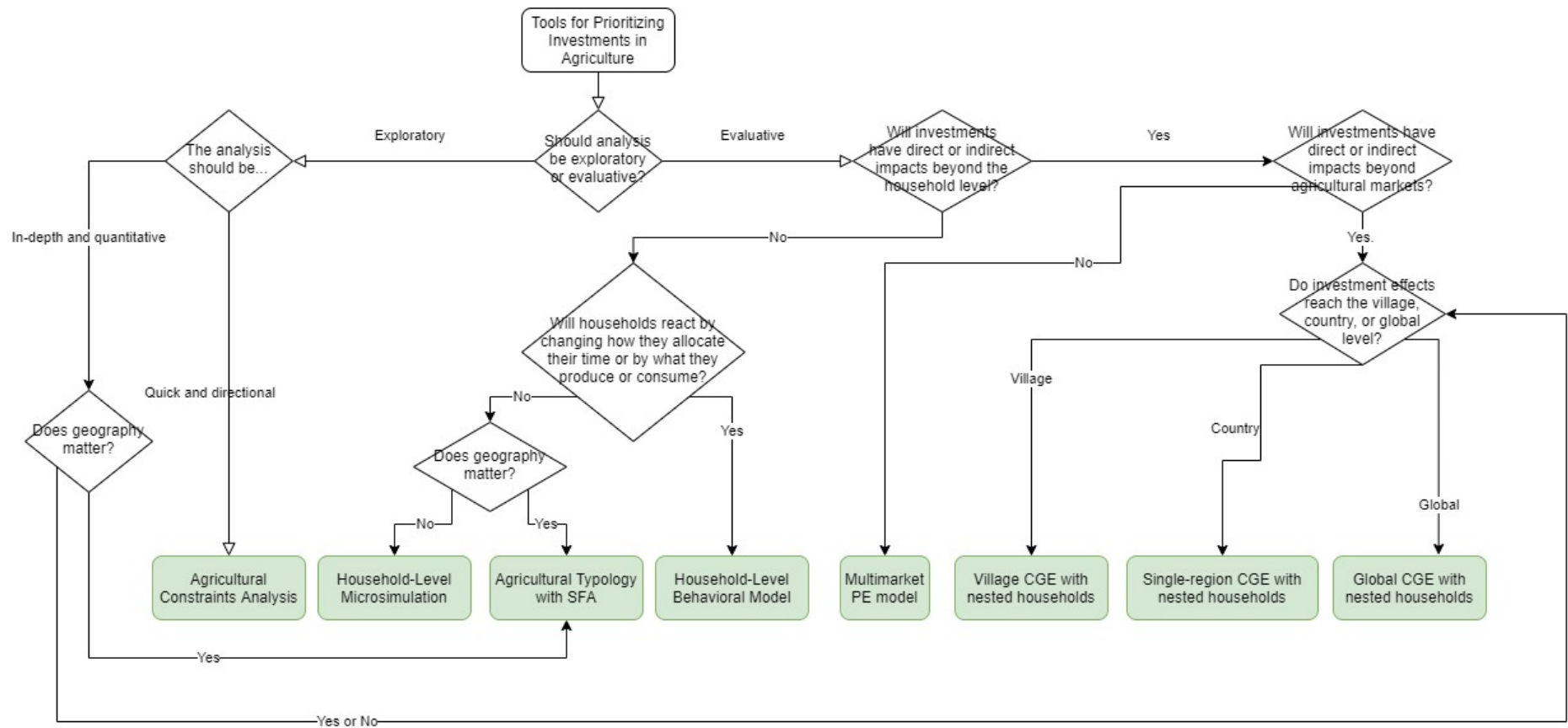
not compromised, since a wide set of tools may lead to inconsistent answers, undermining the decision-making process.

We also provide a summary of general feasibility considerations by tool and discuss specific requirements based on the investments to be modeled.

Suitability

Figure 10 below is a decision tree to guide selecting the best tool based on suitability. It is organized into two main branches: tools for exploratory analysis and tools for ex-ante evaluative analysis.

Figure 10: Picking the Right Tool: Suitability Decision Tree



For **exploratory analysis**, the choice of the best tool among IFPRI's available kit is relatively straightforward. The agricultural constraints analysis is ideal for a quick, qualitative, country-level assessment, with the option to augment it with widely available quantitative indicators. For more in-depth and rigorous assessment of promising investment options, CGE models can be highly useful. The CGEs can be especially useful to determine which investments – or portfolios of investments – have the highest return, given one or more development goals, such as reducing national poverty, increasing farmers' wealth, and limiting greenhouse gasses (see Box 2 for an example of this kind of analysis as done in the Ceres2030 project). If transportation or irrigation is of particular interest, the Agricultural Typology with SFA is well-suited to determine where in a country transportation or irrigation investments are likely to be most impactful on farm production and poverty outcomes.

For **ex-ante evaluative analysis**, the choice of model is more difficult. Generally, a more complex model comes with greater functionality, but it can be less feasible. Thus, a user must know when the added complexity is important to paint an accurate picture of "the real world." These three questions guide our understanding of when additional complexity is needed:⁹

1. Which markets need to be represented? / Will price change on a directly affected market?
2. Should we consider indirect ("second-order") effects or behavioral responses of households or other economic agents? / Are other markets indirectly affected?
3. Should changes in opportunity costs be accounted for? / Especially in the case that factor markets are affected, is there an opportunity cost? In other words, are the factors of production being pulled away from other economic activities?

Markets. First, a major difference across the different models is which markets are represented. That is, some models model how a market works, while others may not (instead, for example, assuming the price is fixed and the quantity available is infinite). Modeling a market means prices are endogenous in the model and can therefore change when the investment is simulated. Assuming price will not change is acceptable in situations including short-term analyses (a few months, for example). Many short-term macroeconomic assessments assume prices are "sticky," including the multiplier approach based on Input-Output tables or SAMs (see (Adelman and Robinson 1986)). For long-term investments, assuming fixed prices is likely inappropriate.

However, modeling a market is not the only means to deal with prices that could change. By building different scenarios for the model to simulate, an analyst can explore varying exogenous prices when evaluating an investment. Varying exogenous prices through scenarios implies that price changes are not driven by the investment. So, it might be appropriate when there are reasons we could expect large variation in prices due to external factors that could affect the impact of our investment: for example, we may want to design different scenarios for world cocoa prices if we are considering a local cocoa farm investment.

If we expect that the given investment, by its magnitude related to the relevant markets, will change prices, then we should ideally model those markets. Recall that a price change in a market occurs when the supply or demand curve shifts.¹⁰ One way a change in market price might happen is through a simple supply-side effect: by expanding production, for example with an investment that enhances farm productivity for tomatoes across an entire region, tomato prices are expected to go down in that

⁹ For all types of project we consider these questions are relevant and only a project level assessment of this question could deliver the proper response.

¹⁰ Assuming neither supply nor demand is perfectly elastic.

region. This will transfer some of the benefits to consumers of the tomatoes, who could be final consumers or intermediate firms. In this case, representing the output markets appears to be quite essential for assessing long-term impacts, especially in terms of redistributive outcomes. Still, there are some situations where the considered investment is “small”, for which equilibrium prices will not be changed. For example, if our investment is instead one to start vanilla farming and processing for export in a region, our investment may be considered small because the market in which the output is sold is the world vanilla market, as opposed to a more local market for tomatoes. The definition of “small” is relative; an expected market share indicator could be used to determine potential impact.

Elasticity of demand will influence how much prices might change. If demand is inelastic, we should expect a price decline. In the vanilla investment example, the product is integrated into world markets and relatively standard, so consumers of vanilla are just as happy to buy any other vanilla. In this case, the new investment represents a tiny share of existing global production and will face an infinitely elastic demand curve (in this case, the world price). We can assume that the vanilla investment won't affect world markets for vanilla (or any other related markets); we assume the vanilla producers are “price-takers” when they export. Therefore, we would not need to model markets outside the country of investment.

Input and factor markets related to the investment may need to be modeled in some cases. Inputs and factor prices can change due to change in their demand. Indeed, an agricultural project that requires a large amount of land or fertilizer or that will create large employment opportunities would push prices for land rents, fertilizer, or wages upward. This would benefit the input suppliers but create additional competition, negatively impacting input consumers. Since some of the investments considered could take place in a context where inputs and factor markets are not perfectly elastic and where bottlenecks exist, capturing these effects would be important. Inelasticity of input and factor demand or other issues would have direct feedback on the production costs of the considered investments but also on the intersectoral benefits of a given investment through the economic system, since all resources are “scarce.” As before, we can identify situations where we can expect no change in factor prices (e.g. if jobs are created in a region where many people are unemployed, we would not expect wages to go up) or where the inputs are bought on world markets (e.g. if all fertilizers are imported, then investment increasing fertilizer demand will not increase fertilizer price).

Second-Order Effects. Taking a decision on price changes is already an element for answering the second question and capturing the second-order effects in terms of economic agents' response following the investments. Indeed, if we consider “no price change”, it is obvious that producers and consumers will not react to these non-existing price changes. They will not modify their consumption or production patterns. Incidentally, having to measure, and represent, the price elasticities is irrelevant. At the opposite, as soon as we consider price changes, it is obvious that we should integrate how quantities, either of outputs, inputs, or final consumptions, adjust. As stated previously, this is quite important when we consider long-term impacts (multi-year assessments) of investments. While in the short run we can consider that economic agents have limited possibilities to adjust their behavior (e.g. fixed technologies, existing contracts with suppliers, strong preferences from consumers), after a few years, it is expected that the economic system will have adjusted to the new technology, investments, or consumption opportunities. Considering such second-order effects requires having models where these responses are captured through behavioral equations, representing how consumers and producers make their decisions, and incidentally will require a number of associated parameters. These parameters in their simpler form are supply and demand elasticities.

However, assuming that second-order effects are only triggered by price changes would be misleading. Indeed, any investment that leads to change in the production function of an economic agent, for instance by changing the productivity of some inputs or factors, will lead to quantitative adjustments even at fixed prices. For instance, increasing labor productivity at constant wages will push a firm to hire more people. Similarly, introducing new technology in terms of packing that will reduce post-harvest losses therefore reduce the per-unit cost of marketed production, leading to more production at fixed prices.

So, as soon as we consider either price changes or productivity changes,¹¹ second-order effects should be captured in the model considered.

Opportunity Costs. Finally, the second-order effect, and a holistic representation of markets, is also a channel to consider opportunity costs of some investments for the economy. Without any market-mediated response, it will be impossible to track the opportunity cost of an investment for the economy, or some economic agents (either firms or households). We exclude from the opportunity cost the value of the MCC investment. Indeed, we do not assume that the economy considered needs to give up another investment to benefit from the MCC investments (except specific cases of co-funding etc). We focus in this category on opportunity costs triggered by the investment: labor that should be removed from other activities (with lower productive) to be used in the project, electricity that should be allocated in priority to the new factory etc. In many cases, it means that the gross value added created by the project will largely exceed the net value added for the sector or the economy as a whole. Resources will be reallocated but not always expanded. It actually requires understanding if “new jobs” are created, or if we just create “better jobs” but overall employment will not change. In many cases, when focusing on factors of production, the main question will be to know if we consider an inelastic or an elastic supply for labor, land etc. This is actually a mirror assumption than to consider fixed factor prices when addressing the first question. Having a “fixed wage” assumption means that we have a large reserve of workers ready to work at this price, and we do not have to use people currently employed in other activities for the new project.

In the last part of this report, we illustrate the consequences of limiting the quantity and price responses when assessing the impacts of an investment.

¹¹ To be precise, any investments changing the marginal conditions, either for producers or consumers, i.e. marginal productivity of an input/factor, or marginal utility, triggers second-order effects to consider. For consumers, we do not expand this issue in this document, but food safety related investment could be a perfect illustration. While improving the actual utility of a food item for consumers, it increases its marginal utility, and more people are eager to consumer the safer product (and could pay a higher price for it).

Feasibility

While an ambitious agenda in terms of developing a suite of models is attractive, it can be a logistical and implementation nightmare. Doing detailed economic modeling requires data, software, expertise, and time, leading to a high cost. Tools with higher complexity tend to have higher costs for development, usage, and maintenance.

General Requirements

Table 4 summarizes the main general requirements for each tool, including software and data, as well as providing an indication of data availability. General data requirements refer mainly to what datasets are needed to “build” the model, while specific data requirements – what data is needed to assess a particular investment – are discussed later. The rows follow the same order in our decision tree, so they are roughly in order of theoretical complexity.

Table 4: Model Feasibility Summary

Tool	Software Requirements	Data Requirements	Data Availability
Agricultural Constraints Analysis	Optional: Excel, Tableau	Indicators that are consistent by country, e.g. based on WDI, FAOSTAT and previous studies	Extremely high.
Household-level microsimulation	Excel, R, Stata	Household surveys. IFPRI has an online inventory.	High. Available for most countries
Agricultural Typology with SFA	Stata, ArcGIS	Household surveys; GIS data on land use, topography, and transportation networks	Limited. Main challenge: Input and output prices and geo-referenced locations of surveyed households.
Household-level behavioral model	Excel, R, Stata	Household Survey, e.g. LSMS, Several years if possible	Limited. Main challenge: Behavioral responses need econometric estimates, which are difficult to get with one survey.
Multimarket PE	GAMS	IMPACT model datasets	High.
Village CGE with nested households	GAMS	Village level SAM	Limited. Main challenge: These must be designed on a case-by-case basis.
Single-region CGE with nested households	GAMS	National SAM Household survey	High. Available for most countries.
Global CGE with nested households	GAMS	GTAP dataset country household surveys	High. Available for most countries

Source: authors' design.

Issues MCC may consider when determining feasibility may include:

- What are the time and cost requirements of the tool?
- Can the tool be used internally and independently by MCC, or will requests need to be outsourced to other experts (e.g. IFPRI staff)?
- Does MCC subscribe to or would it be worthwhile to subscribe to the required software?
- Does MCC have the resources to maintain the tool, or will external experts need to maintain it (e.g. with data updates)?

MCC may also consider fixed start-up costs (for development of a reusable tool) and costs over time (for repeated use and maintenance of the tool).

As a note, additional data may be needed for any model that we want to use to capture water, land, and carbon stock effects.

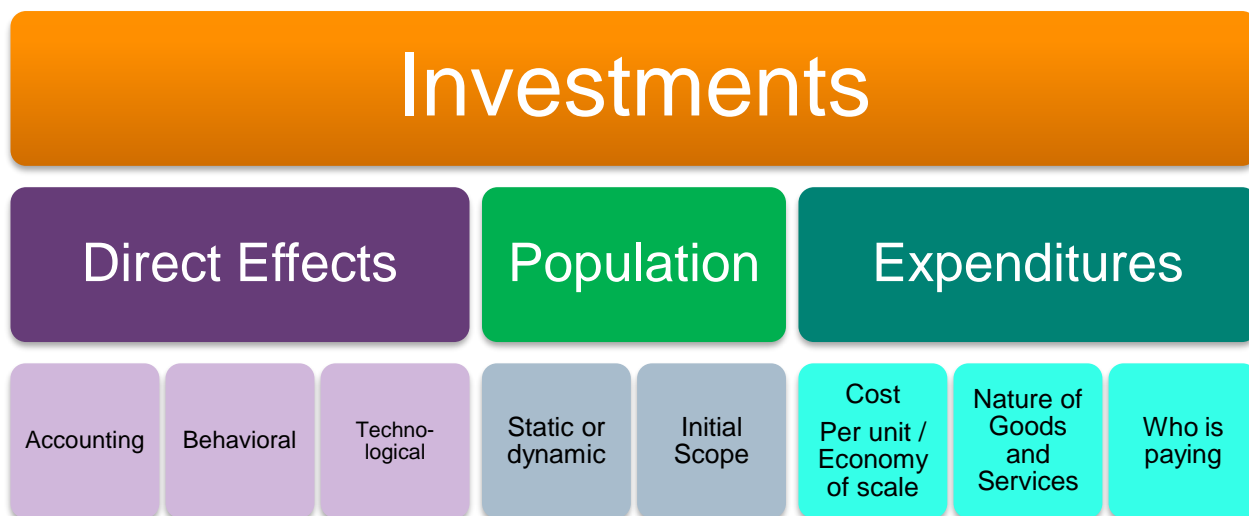
Specific Data Requirements

Depending on the investment being considered and some contextual factors, investment-specific data may be needed. MCC already uses investment-specific data for its projects, so this type of data would not necessarily impose additional costs compared to MCC's standard practice. Focusing primarily on the CGE suite of tools, and following the approach introduced by Laborde, Bizikova, and Smaller (Laborde, Bizikova, and Smaller 2019), information on three aspects of the investment is required to model it:

- the direct effects of the investment,
- the population (firms, farms, and/or households) directly impacted by the investment, and
- the nature and value of the expenditures needed to deliver the investment.

These requirements are summarized in Figure 11 below.

Figure 11: Specific Data Requirements - Elements used to define investments in a model



Source: authors' design

Direct Effects: The direct effects captured could be “accounting” effects (e.g., more money available to invest or more area under irrigation), behavioral effects (e.g., the investments change agent behavior and practices), or technological effects (changes in the relationship between inputs and outputs). More specifically, the direct effects the model can represent include:

- i. A modification of production capacity via new endowments (additional factor of production, e.g., investment in goods or land, changing the supply of a production factor for a household).
- ii. A change in technology through a change of input-output coefficients in a specific production function (e.g., wheat technology used by smallholders).
- iii. A wider shift in factors of production (e.g., labor, land, or total factor productivity) or input (e.g., fertilizer) productivity. This category can be seen as subcases of cases i and ii, but we keep it separated for the sake of clarity. This can involve behavioral change triggered by a new environment (see below the example of the land reform in Burkina Faso).
- iv. Shifts in environmental outcome parameters when technological changes are implemented: for example, GHG emissions for soil emissions when new practices are introduced (e.g., no tillage) or water use by unit of output (e.g., drip irrigation).
- v. A shift in the output or input prices faced by some economic agents (due to price incentives, e.g. subsidies, or due to changes in mark-up by economic agents upstream or downstream)

Sometimes, for case iii especially, parameters may not be directly observable. In this case, we would need to rely on existing literature or new econometric estimates to properly calibrate the direct effect.

Population: The second category is simple. Modeling requires a description of the population targeted by the investment that can be mapped to households or firms in the model, its “initial scope.” Furthermore, information is needed on if this population changes over time – whether it is static or dynamic – and if it changes, its dynamic profile.

Expenditures: Finally, information is needed about the cost of the investment, including for its maintenance. Except in exceptional circumstances, we exclude opportunity costs from the data requirement, since the model itself opportunity costs built in. Tracking the “nature” of the expenditures – which goods and services spending goes to – allows us to track the demand-side effects of any investment: the Keynesian, pro-growth effects of new spending. But it also allows us to track the absorption capacity of the economy and the potential displacement, or “crowding-out,” effects of large investments. Additional information may include the linearity of the cost (is the cost per “unit” of the investment good the same regardless of the number units produced?) and the distribution of costs across agents.

Illustration with a previous MCC project: We illustrate how MCC’s current standard practice of information collection can cover the information required for modelling, using the [Burkina Faso: Rural Land Governance project](#) as our example. We rely chiefly on the ERR analysis (Millennium Challenge Corporation 2016).

The “DiD estimates” and “Common Assumptions” tabs, displayed in Figure 12, show **direct effects** of the investment: a reduction in number of land-related conflicts (frequency, percentage of reduction), a reduction in the per-unit cost of conflicts, and a long-term productivity enhancement effect due to improved institutional environment. The first two of these could be translated into accounting effects in the model, while the last would be a behavioral effect. As MCC references in the ERR analysis, additional econometric research may be needed to provide reasonable estimates of behavioral effects.

Figure 12: Illustration of Direct Effects Data, MCC Project

Conflict Prevalence and Reduction Parameters	Used
% of HHs under conflict, 2007	4.12%
exog. % increase in conflict incidence, annual	3.65%
Incremental change in Perceptions (serious concerns)...	
...Arrival of new migrants for cultivation increases land conflict for household	-2.00%
...Arrival of new investors increases land conflict for household	-1.35%
... Returnees reclaiming land increases land conflict for household	-3.16%
... Inheritance disputes among villagers increases land conflict for household	0.54%
... Property damage caused by animals increases land conflict for household	-6.54%
... Water access restrictions for livestock increases land conflict for household	-1.46%
% decrease in conflicts due to dispute res. yr 1	0.00%
% decrease in conflicts due to dispute res. yr 2	6.05%
% decrease in conflicts due to dispute res. yr 3+	12.10%
Costs of Conflict	
Incremental change in Productivity (serious concerns)...	
...Arrival of new migrants for cultivation increases land conflict for household	-45.50%
...Arrival of new investors increases land conflict for household	0.00%
... Returnees reclaiming land increases land conflict for household	-42.20%
... Inheritance disputes among villagers increases land conflict for household	0.00%
... Property damage caused by animals increases land conflict for household	0.00%
... Water access restrictions for livestock increases land conflict for household	-22.90%
Incremental increase in Productivity from perceptions change...	2.58%
Property damage/loss cost per dispute	\$ 200.00
Resolution cost per dispute	\$ 28.00

From "Perceptions of Land Tenure Insecurity: Survey Evidence from Burkina Faso" Linkov, 2015. Calculated using 2010 survey data.

Table 5. Regressions of Agricultural Productivity on Single Tenure Insecurity Measures

	For your household		In the village today		In the village in the near future		In the village in the far future	
	Somewhat	Serious	Somewhat	Serious	Somewhat	Serious	Somewhat	Serious
Arrival of new migrants	-0.002	-0.455**	0.068	-0.443***	0.191***	-0.379***	0.194**	-0.231**
Outsiders seeking land for non-agricultural purposes	-0.084	-0.181	-0.075	-0.148	-0.067	-0.126	-0.069	-0.102
Former residents returning	-0.155	-0.036	0.018	-0.073	0.093	-0.147	0.119	-0.087
Inheritance	-0.084	-0.162	-0.077	-0.144	-0.071	-0.123	-0.065	-0.108
Livestock damage	-0.025	-0.422***	0.078	-0.355**	0.101	-0.356***	0.148**	-0.314***
Access to water for livestock	-0.075	-0.137	-0.069	-0.132	-0.069	-0.115	-0.066	-0.094
Conflicts in general	0.013	-0.044	0.094	-0.098	0.108	-0.071	0.115	-0.119
Expropriation by state	-0.079	-0.134	-0.065	-0.119	-0.072	-0.117	-0.067	-0.098
Expropriation by villager	-0.117	-0.077	-0.181**	-0.165	-0.067	-0.092	-0.035	-0.058
	-0.068	-0.091	-0.075	-0.094	-0.077	-0.09	-0.074	-0.084
	-0.032	-0.229*	-0.021	-0.265**	0.005	-0.328***	0.025	-0.313***
	-0.078	-0.117	-0.073	-0.115	-0.071	-0.098	-0.07	-0.102
	0.004	-0.015	0.071	-0.001	0.097	-0.078	0.017	-0.061
	-0.066	-0.09	-0.062	-0.091	-0.07	-0.09	-0.072	-0.083
	0.063	0.002	0.083	0.002				
	-0.081	-0.085	0.099	-0.083				
	-0.072	-0.097						

Coefficients in bold, robust clustered standard errors below
Control variables results omitted
*** p<0.01, ** p<0.05, * p<0.1

Source: Adapted from MCC ERR analysis.

Tabs "DiD estimates" and "Common Assumptions." Excel document: "Analysis, Economic Rate of Return: Burkina Faso's Rural Land Governance Project." 2016. Millennium Challenge Corporation. Available at <https://www.mcc.gov/content/uploads/2017/05/mcc-err-burkina-landgov-close.xlsx>.

The ERR analysis also provides information on the size of the **targeted population**, as indicated in Figure 13, which would be mapped to rural households in the model.

Figure 13: Illustration of Population Data, MCC Project

Total Population in 46 communes in 2007	count =	48 (one commune is missing)	1,880,367
Estimated population in 2027 at 3.07% annual population growth			3,444,617
Percentage of households experiencing conflict in Year 20, Without Project			8.14%
Percentage of households experiencing conflict in Year 20, With Project			7.16%
Population of 47 communes experiencing conflict in Year 20, Without Project			280,450
Population of 47 communes experiencing conflict in Year 20, With Project			246,515
Population experiencing increased income as a result of reduced land conflict due to the			33,934

Source: Adapted from MCC ERR analysis.

Tab "Commune Level Assumptions." Excel document: "Analysis, Economic Rate of Return: Burkina Faso's Rural Land Governance Project." 2016. Millennium Challenge Corporation. Available at <https://www.mcc.gov/content/uploads/2017/05/mcc-err-burkina-landgov-close.xlsx>.

Finally, the ERR analysis gives the amount of the **expenditures** and how they are spent (see Figure 14 below). This project mainly requires spending on services, which would be translated into the model as payment to households providing high-skilled labor, and production of buildings, which could be modeled as the purchase of various building material commodities and payment to households providing low-skilled labor.

Figure 14: Illustration of Expenditure Data, MCC Project

Quarterly Disbursements by MCC					
	FY 2008	2008	2009	2009	
	QTR Q3	Q4	Q1	Q2	
Dev & Dissemination of Policy and Legislation Activity	\$ -	\$ -	\$ -	\$ -	-
Institutional Development & Capacity Building Activity	\$ -	\$ -	\$ -	\$ -	-
Targeted Land Registration Interventions Activity	\$ 49,237.32	\$ 1,733.00	\$ (50,970.32)	\$ -	-
Legal and Procedural Change and Communication Activity	\$ -	\$ -	\$ 113,029.42	\$ (11,211.00)	-
Site-Specific Land Tenure Interventions Activity	\$ -	\$ -	\$ -	\$ -	-
M&E Related Activities	\$ -	\$ 5,967.00	\$ 3,688.48	\$ (4,199.00)	
Program Administration & Oversight	\$ 1,005,664.69	\$ 1,270,948.92	\$ 813,247.21	\$ 862,533.24	
RLG-Related Activities, Total Quarterly	\$ 49,237.32	\$ 1,733.00	\$ 62,059.10	\$ (11,211.00)	
RLG-Related Activities, Total YoY					
Compact Overhead and M&E, Total Quarterly	\$ 1,005,664.69	\$ 1,276,915.92	\$ 816,935.69	\$ 858,334.24	
Compact Overhead and M&E, Total YoY					

Source: Adapted from MCC ERR analysis.

Tab "Quarterly Costs." Excel document: "Analysis, Economic Rate of Return: Burkina Faso's Rural Land Governance Project." 2016. Millennium Challenge Corporation. Available at <https://www.mcc.gov/content/uploads/2017/05/mcc-err-burkina-landgov-close.xlsx>.

4 CASE STUDY: EXPLORATORY ANALYSIS

In this section, we present the typology introduced in Section 2.2 as a primarily qualitative tool that could extend the Constraints Analysis methodology already used by MCC into the agricultural sector. Such a tool could dovetail onto a constraints analysis when agriculture is identified as a particular industry of interest.

The constraints analysis used by MCC is based on Hausmann et al. (Hausmann, Rodrick, and Velasco 2005) (hereafter HRV), where they developed a methodology to identify the range of issues constraining economic growth in a country and prioritize among them. Constraints analyses for MCC country programs include adaptations and applications from this paper, including usage of HRV's decision tree and diagnostic economic indicators. Table 5 below is MCC's illustration of how economy-wide constraints (columns) identified by HRV's framework can be contextualized by industry (rows). The point of analysis with the HRV framework is to identify those economy-wide constraints that are most binding to private investment and entrepreneurship.

Table 5: MCC’s Illustration of Constraints Analysis by Industry

Industry	Constraint										
	High Cost of Finance	Low Returns to Economic Activity									
		Natural Capital	Human Capital	Physical Capital (Infrastructure)				Innovation	Low Appropriability		
				Energy	Transport	Water / Sanitation	Market Failures		Macro Risks	Micro Risks	
Light Mfg			Mechanic	Costly	Costly					Reg. Red tape	
Agricult.			Agronomy	Ltd access	Costly			Value chain gaps			
IT			IT Spec.	Costly							
Tourism			Hospitality								
Etc.											

Note: MCC’s illustration of how economy-wide constraints (columns) identified by HRV’s framework can be contextualized by industry (rows). MCC notes, “[This table] provides some examples of how an industry-level lens (rows) can help contextualize economy-wide constraints (columns). Teams can use this lens to better understand how constraints identified by the diagnostic tests are experienced and constrain specific industries.”

Source: MCC. <https://www.mcc.gov/resources/story/story-cdg-chapter-3-guidelines-for-constraints-to-economic-growth-analysis>

While MCC’s constraints analysis methodology encourages targeted analysis at the industry level, the agricultural sector is of particular interest for many MCC countries, often meriting its own analysis. So, a tool that enables holistic consideration of constraints from the agricultural point-of-view may often be a useful analytical entry point for partner country teams conducting a constraints analysis.

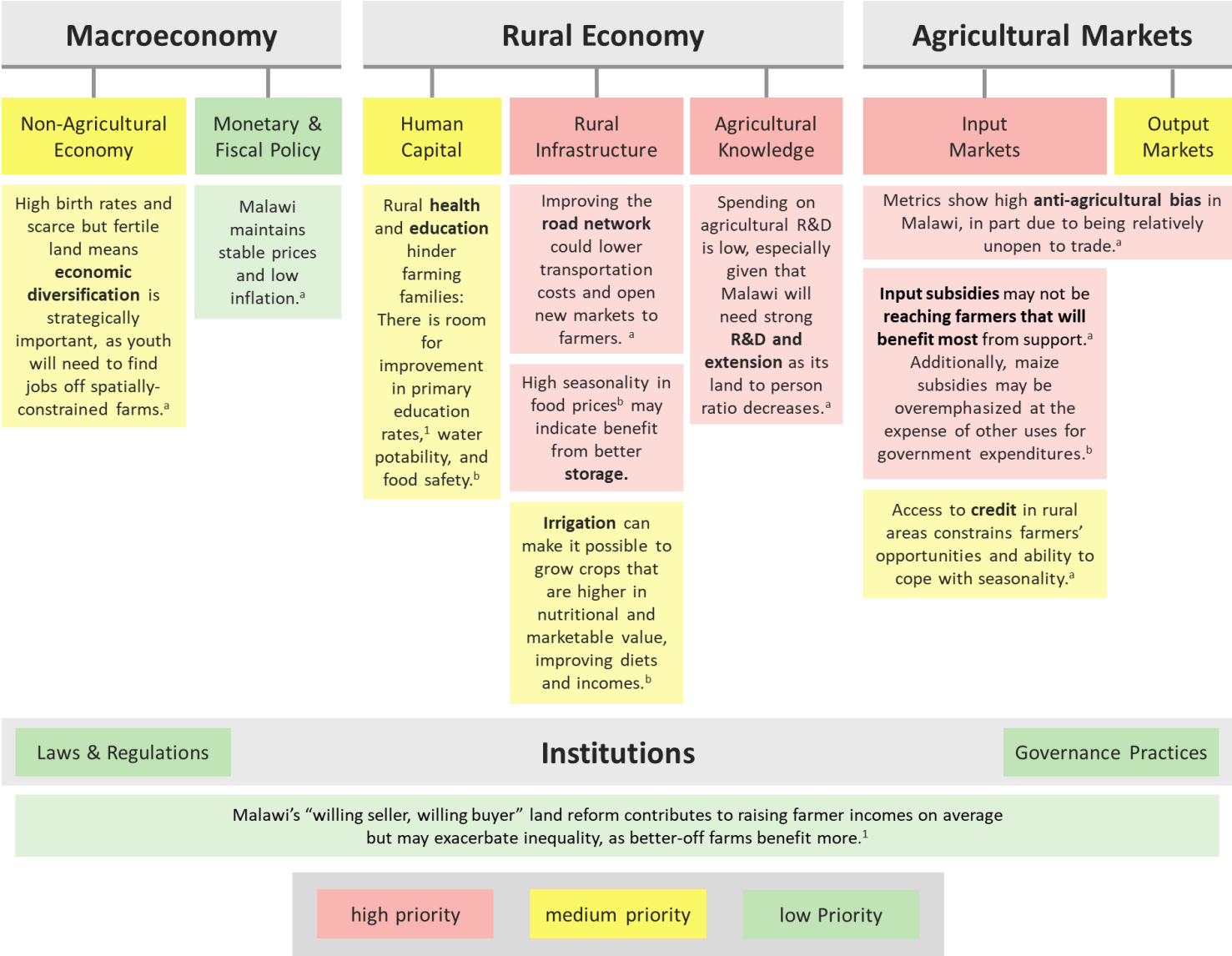
By considering the situation in the country of interest for each category and subcategory of the typology, a user can use the typology to brainstorm constraints and opportunities for growth in the agricultural sector. While the typology does not provide the answers itself, it does provide a framework that broadens considerations past a narrow definition of the agricultural sector, provides a holistic set of potential factors, and facilitates understanding of how factors relate to the agricultural sector. Analysis using the typology can serve as a quick overview of a country’s agricultural situation to begin discussions and be returned to, tested, and deepened through further analysis. This typology tool is similar to MCC’s Constraints Analysis in that it builds a broad, holistic picture and facilitates understanding of linkages. It differs in that we do not yet prescribe a universal data-based analysis as MCC’s Constraints Analysis does, serving instead as a starting point for further hypothesis testing and data-based analysis. Indicator sets that are consistent across countries could be added to the tool, based on data from the World Development Indicators, FAOSTAT, and previous studies, for example.

Figure 15 below is an illustration of what an application of the typology to a particular country may look like. Here, the authors have briefly considered the case of Malawi for illustration, at the Domain and Category level. Subcategories are not pictured here, although they could be in a more detailed analysis. The boxes below the Categories indicate various constraints to, opportunities for, or factors in

growth of the agricultural sector. Categories are color-coded based on the users' evaluation of how important a factor is to *agricultural* development outcomes in Malawi. Red indicates that a category or factor is an especially high priority, that is, that the constraint is especially binding or the opportunity to promote growth and reduce poverty especially large. Yellow indicates a medium priority, while green indicates that potential for improvement is relatively low.

Note that identified constraints may or may not present appropriate areas for investment for MCC – some may be a matter of country policy rather than MCC projects. Still, these are factors that MCC would need to understand to make effective investments, and their identification may inform the policy debate in the partner country.

Figure 15: An Illustration of the Typology for Agricultural Constraints Analysis: Malawi



Source: Author's illustration.

Note: This is an illustrative, rather than rigorous, analysis using the typology, pulling from the following sources:

^a See "Policy Options for Focus Countries," *Transforming Agriculture in Africa and Asia*. <https://www.iisd.org/agricultural-transformation/looking-forward-to-policy-options/#close>

^b See *Agriculture, Food Security, and Nutrition in Malawi: Leveraging the Links*. 2018.

In this illustrative application of the typology to Malawi, we have identified rural infrastructure, agricultural knowledge, and input markets as particularly important constraints/opportunities for Malawi's agricultural sector. In the category of Rural Infrastructure, the road network and storage facilities may be especially important areas of investment, while electrification (not pictured) was addressed in a previous project by MCC. In the category of Agricultural Knowledge, both R&D and extension to help disseminate the R&D are identified as important by (Laborde et al. 2019), given Malawi's land and population context. Within Agricultural Markets, anti-agricultural bias (see (Baliño et al. 2019b) for more) constrains both input and output markets. In Input Markets in particular, subsidies may not be being used in a way that gives a high return in terms of sectoral growth and poverty reduction. These last two factors within agricultural markets are examples of areas that may or may not present a clear investment case for MCC: similar to how MCC has supported land reform by building physical office infrastructure, for example, there may be investments that can be made to support the application of policy or best practices in these areas. If not, there may still exist opportunities for policy reform that can be explored in other parts of MCC's process or by the partner country teams in their non-MCC work.

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APPENDIX

Review of Economic Rates of Return in MCC Projects

ERRs at closeout are available for 58 projects over 112, so a little more than half (52 percent) and the average value is 15.3 percent. 4 projects (7 percent of available data) 15 projects have an ERR between 0 and 10 percent, 13 projects an ERR between 10 and 15 percent, 26 projects an ERR at 15 percent or higher. So, among those with ERR reported, 67 percent met MCC's threshold ERR of 10 percent or higher.

Table A.1 shows the average ERR for each of the three levels of agricultural targeting, among those 58 projects that had ERRs reported. Targets Agriculture, Includes Agriculture, and Does Not Target Agriculture had 19, 20, and 19 projects with ERRs reported (see last row), respectively. Projects targeting agriculture has the highest average ERR, at 19 percent. Includes Agriculture and Does Not Target Agriculture have average ERRs at 14 and 13 percent, respectively. It is interesting to note that projects targeting the agricultural sector or that includes the agricultural sector had reported higher ERR than projects not targeting the agricultural sector. However, it is likely not possible to say that projects targeting agriculture will have a higher average ERR than others, since the sample size is so small, and variation is so high. Nonetheless, it may be interesting to consider what about the completed agriculturally focused projects has made them successful.

Table A.1 ERR range (Closeout) by Agricultural Sector Targeting

ERR Range	Targets Agriculture			Includes Agriculture			Does Not Target Agriculture		
	Number of projects	Breakdown of projects	Range Average	Number of projects	Breakdown of projects	Range Average	Number of projects	Breakdown of projects	Range Average
<0%	1	5%	-1%	1	5%	-8%	2	11%	-2%
0-10%	3	16%	3%	5	25%	7%	7	37%	4%
10-15%	3	16%	11%	7	35%	13%	3	16%	13%
15% +	12	63%	27%	7	35%	23%	7	37%	26%
No ERR reported	17			17			20		
All	36		19%	37		14%	39		13%

Source: Author's calculations, based on their database of publicly available MCC ERR analyses.

Other rows in Table A.1 shows the distribution of projects across ranges of closeout ERR values: negative, 0-10 percent, 10-15 percent, 15 percent and greater, and projects for which no closeout ERR has yet been reported. Columns show the number of projects that fall into each range, the percentage breakdown of projects into each range, and the average value for the range. Targets Agriculture has the highest percentage of projects in the 15%+ range, with 63 percent of projects falling into this category.

Table A.2 shows the difference between closeout ERRs and original ERRs, among the 26 projects that had both measurements and where both used the same time horizon for estimation. On average, original ERRs overestimated the rate of return by 7 percentage points versus closeout. There is large variation in the differences; they range from an 11 percentage-point underestimation to a 67 percentage-

point overestimation. However, this wide range is driven by an outlier, the 67 percentage-point overestimation of the rate of return for “Morocco's Small Scale Fisheries Project, Port Facilities.”¹² There may have been conditions around the ex-ante analysis for this project making the ERR especially optimistic and setting the original ERR apart from the “typical” ex-ante analysis. If so, and if these conditions were recognized by the ERR team beforehand, it could be worth reconsidering the below table with the relevant project excluded.

Table A.2 Closeout ERR vs Original ERR

	Difference between Closeout & Original ERR	Number of Comparable Projects
Targets Agriculture	-7%	12
Includes Agriculture	-4%	6
Does Not Target Agriculture	-7%	8
Weighted Average	-7%	26
Max	11%	
Min	-67%	

Decision Making in a Multidimensional Setting: A Simplified Illustration

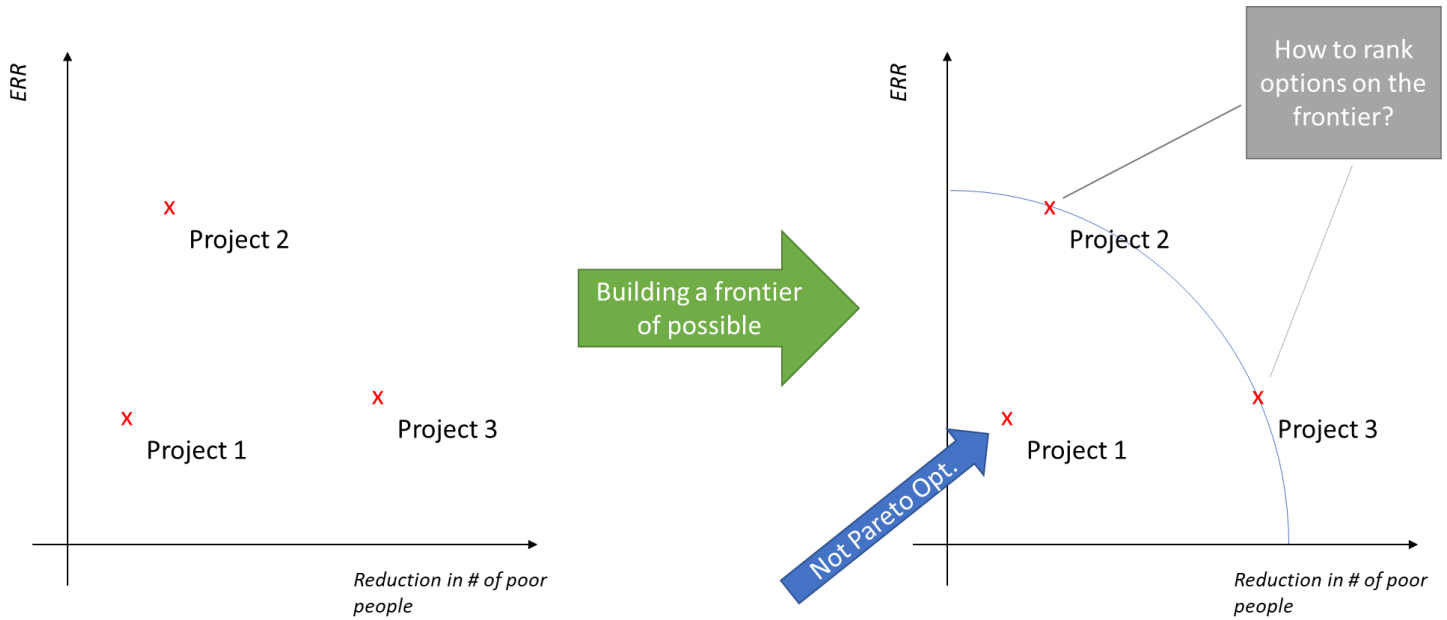
In this appendix, we illustrate the discussions initiated in Section 3.4, “Multidimensionality,” about decision in a multi-dimensional space. For the sake of simplicity, and to use “flat” visual representation, we focus on two dimensions only: economic performance, captured by the ERR, and social outcome, i.e. poverty reduction. This approach is highly compatible with the initial mandate of MCC.

Our starting point is described by Figure A.1. On the right panel, and using a model, that can capture both economic performance and poverty impacts, but being agnostic about its exact nature, we have performed an ex-ante assessment of 3 projects. These three projects have a similar cost, or their outcomes have been rescaled properly to allow a comparison at “equivalent costs”. Some projects, like project 1, are Pareto-inferior and could be discarded (other projects outperform them in two dimensions at once). At the opposite, some projects are on the “frontier” about what is possible to achieve through various investments: some will deliver larger economic impacts and limited poverty outcomes, while other will do the reverse. If we assess a large number of projects, we may be able to build a quasi-continuous frontier of possible reachable outcomes. Moving along this frontier is associated with trade-offs decision: in our case it will show how much economic performance we need to sacrifice to deliver more inclusiveness. From a micro-economic point of view, it is a marginal rate of transformation (MRT) between our efficiency and equity objectives. It is defined by a set of investment technologies and our economic structure. This frontier in itself could be modified through new “technologies”, in their mundane sense, i.e. new investment opportunities, new agricultural practices, or in their social sense, e.g. better institution or social practices could lead to different economic consequences for the same physical investments (e.g. labor rights will impact the value addition/poverty reduction of a given factory project). Our goal is to see how

¹² Furthermore, the second largest misestimation, at a 26 percentage-point overestimation, was for a related project, “Morocco's Small-Scale Fisheries Project, Wholesale Fish Markets.” Note that these two entries in the database comprise one of the rare instances in which the ERRs may violate the mutually exclusive principle that they are assumed to follow for analysis purposes.

we can actually rank options on the frontier and it is equivalent to be explicit about the decision rule used by decision makers.

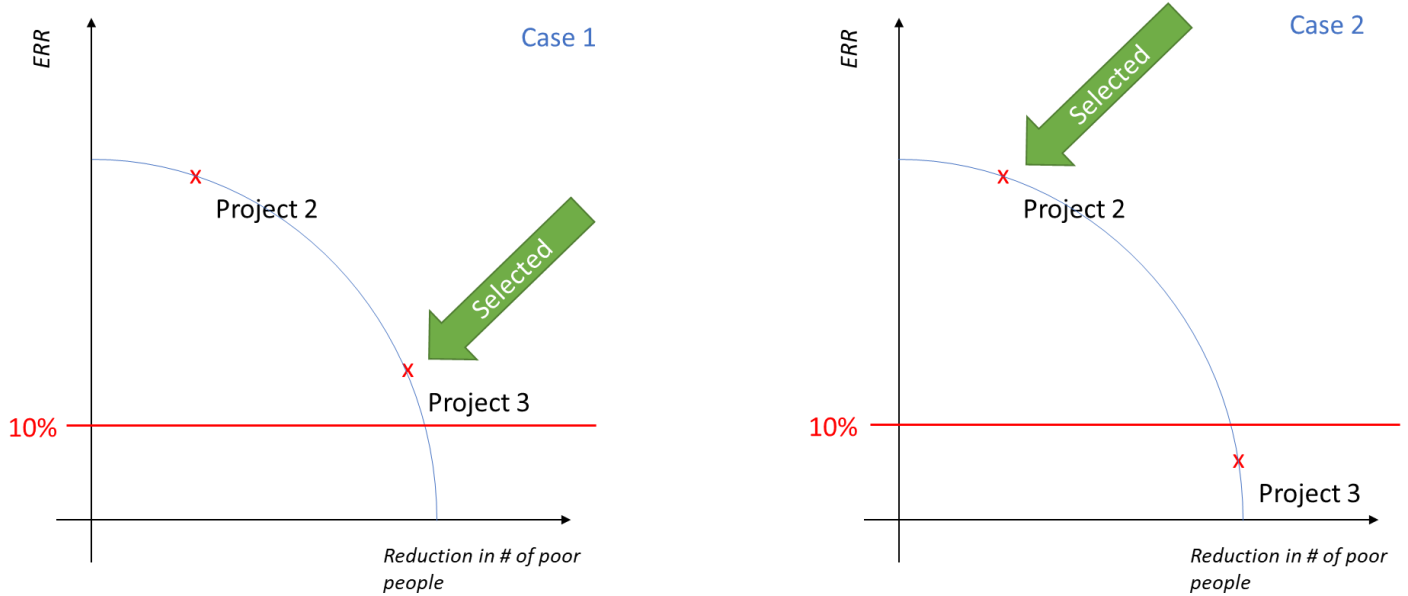
Figure A.1 Step 1: Projects performance in a two-dimensional space



Source: Authors' Elaboration

The first case will be a literal interpretation of the MCC guideline regarding the ERR requirements of 10 percent and is illustrated by Figure A.2. The 10 percent requirement is indicated by the red line. It separates the project outcome space, between the “acceptable” space, above the 10 percent line, and the discarded project below the 10 percent line. In case 2, right panel, only project 2 is valid and will be selected by default of relevant competition, keeping in mind that project 1 is not represented since projects 2 and 3 are better of both dimensions, project 2 will always be preferred to project 1. In the case 1, left panel, two projects are eligible, but since there is no “value” of exceeding the economic requirement threshold, we select the project with the highest rate of return in terms poverty reduction, i.e. project 3.

Figure A.2 10% ERR requirement rule.



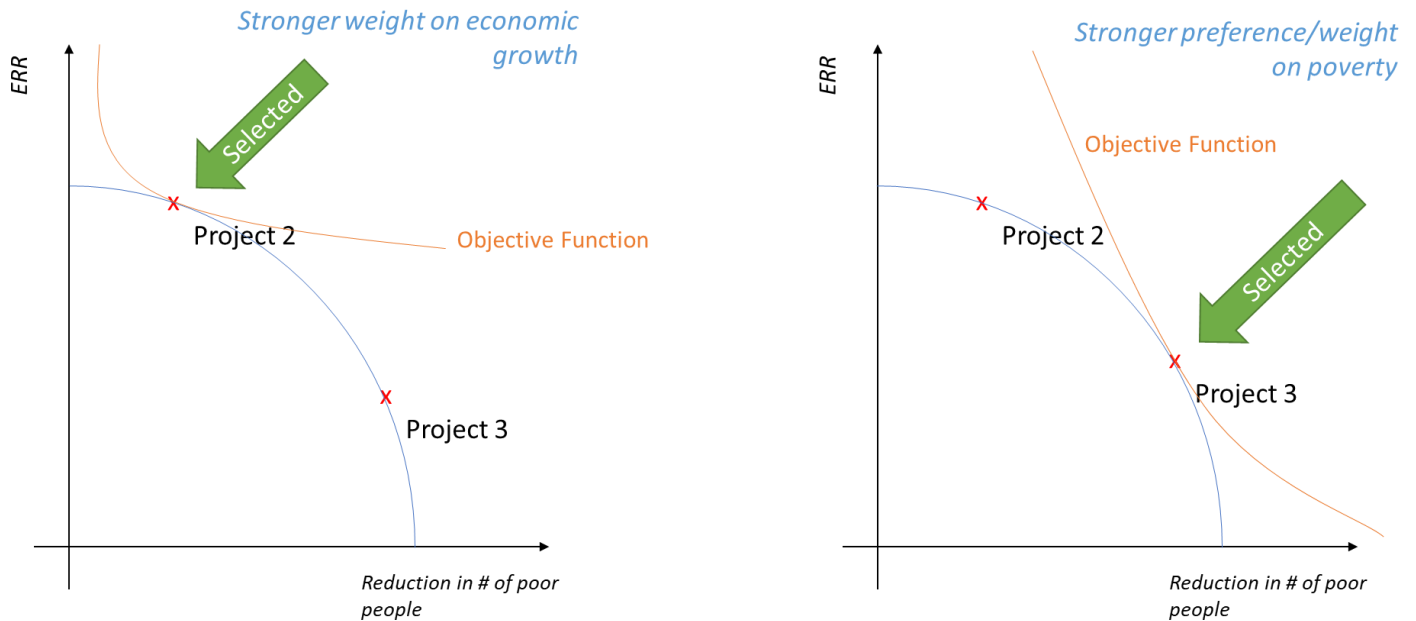
Source: Authors' Elaboration

This rule could be expressed as “we select the project with the highest performance in terms of poverty reduction, given it has at least a 10 percent ERR”. In this setting, one dimension is a strict constraint, and leads to a pass/fail check, while the other is used to do a continuous and hierarchical ranking. This approach does not involve trade-offs, and for all eligible projects, only their projection on the horizontal axis matter, moving along the frontier, and the shape of this frontier, in the two dimensions space, is actually irrelevant. This leads to two remarks and limits of this approach:

- While making a choice in a n -dimension space requires to always keep $n-1$ dimensions as constraints (lower or upper bound) and use the remaining dimension as the ranking criteria;
- The marginal cost in terms of economic growth of poverty reduction is totally neglected and we can comparing a project with a (+10.1 percent ERR and a -20 percent poverty reduction) and a project with a (+40 percent ERR and a -19.9 percent poverty reduction) will lead to select the former and not the later. Such decision could be easily challenged by various stakeholders, including traditional investors, but will also show that the due to uncertainty in terms of impact achievements, one project, the second one, could appear has a better bet.

In this context, we can argue in favor of improved decision-making rule, reflected by a continuous behavior. As discussed in section 0, we can use a function to translate the n -elements vector, describing the impact of each investment, into one number, either a monetary metric, leading to an ERR+, or a utility value, through the decision maker utility function, or political preferences. In this appendix, we focus on illustrating the later. The example is given by Figure A.3 where we show two potential utility function for the decision, either biased in favor of economic growth, on the left side, or on poverty reduction on the right side. The optimal solution involves that the marginal rate of substitution between poverty and ERR for the decision maker is equal to the marginal rate of transformation between economic performance and social performance, as defined by our two indicators.

Figure A.3 Optimizing a social utility function



Source: Authors' Elaboration

Last but not least, we should not neglect the fact even for a given set of investments projects, by introducing new policy instruments, or modalities, we can change the final outcomes in terms of redistribution. In particular, we can disconnect the market outcome of investments, as captured by our initial assessment, from the final social outcomes by using taxation and redistribution, or by having specific investment modalities (e.g. providing health services to the workers of a factory, or specific contract farming options for linking small producers to a new dairy plant, see Bernard and al., 2017¹³ for an example). In such cases, as shown in Figure A.4, the combination of the investment decision, with some “social” packages will lead to redistribute the economic growth outcome toward vulnerable population and could lead to a much better outcome, from the decision maker point of view, than any existing investment projects alone.

¹³ Bernard, Tanguy; Hidrobo, Melissa; Le Port, Agnès; and Rawat, Rahul. 2017. Nutrition incentives in dairy contract farming in northern Senegal. IFPRI Discussion Paper 1629. Washington, D.C.: International Food Policy Research Institute (IFPRI). <http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/131128>

Figure A.4 Combining investment decisions and additional modalities



Source: Authors' Elaboration

We conclude by saying that we discuss here some very specific investment related policies/regulations and that any large scale, or systemic, changes in institutions or laws will actually transform the frontier for all projects as stated earlier.

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