Assessing the Performance of Agricultural Development Investments

A Practical Guide using the SIPmath™ Standard

Working Paper No. 414

CGIAR Research Program on Climate Change,
Agriculture and Food Security (CCAFS)

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Titles in this Working Paper series aim to disseminate interim climate change, agriculture and food security research and practices and stimulate feedback from the scientific community.

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Photos:

Abstract

The global community must make significant investments to address climate change and build resilience in agricultural systems. Within climate-smart agriculture investment portfolios, all sizable projects face uncertainty and risk and must be adaptively managed to achieve success.[1]–[4]. This paper presents notes for calibrating a user-friendly tool to screen and compare investment options: The Climate-Smart Agriculture Investment Plan (CSAIP) Cost Benefit-Analysis (CBA) Tool. The CSAIP-CBA models a 20-year period following investment implementation and uses a probabilistic approach to account for uncertainty in project costs and benefits subject to risks and adoption barriers. The model includes measures for number of beneficiaries, adoption rates, estimated impacts, and budget and costs while also considering risks and GHG emissions. Implementation examples of the CSAIP-CBA tool are drawn from investment portfolios prepared for Ghana and Burkina Faso; these suggest that carbon pricing and adoption rate assumptions should be considered when prioritizing investments.

Keywords

investment; climate-smart agriculture; cost-benefit analysis; resilience, uncertainty

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Contents

Acronyms

CBA	Cost-Benefit Analysis
CSAIP	Climate-Smart Agriculture Investment Plan
GHGs	Greenhouse Gases
USD	United States Dollar

Introduction

The global community must make significant financial investments to address climate change. National governments, international finance institutions, and private sector players all currently provide funding for a variety of climate related projects. At the 24th United Nations Framework Convention on Climate Change Conference of Parties, the World Bank pledged 200 billion United States Dollars (USD) to fund climate resilience efforts in the next five years. Because agriculture and food production are substantial drivers of climate change, accounting for up to 29% of greenhouse gas (GHGs) emissions, they receive some of this funding [5].

Monitoring and evaluation efforts show that agricultural development projects often have a poor track record of success. All sizable projects face uncertainty and risk and must be adaptively managed to achieve success [1]–[4]. An analysis of 86 World Bank project evaluations produced between 2000 and 2009 found that 41% had non-positive outcomes [6]. The implications of this rate are significant: when projects financed on borrowed funding fall short of expectations, the country's standard of living declines. A variety of highly uncertain and interrelated political, environmental, and financial factors can affect investment outcomes. Data capable of predicting outcomes *ex-ante* are scarce; even when available, they are often relevant to only one of the many potential factors in play. The complexity and data scarcity that characterize agricultural development and climate change projects increase uncertainty when prioritizing investments, frustrating interest among financiers.

Ex-ante predictions are typically based on a cost-benefit analysis (CBA). However, over the past several decades, the number of World Bank projects that have been justified using this basic project assessment tool has declined. This decline creates a feedback loop of overreliance on predetermined standards, which in turns creates a higher barrier to applying cost-benefit analysis [7]. Moreover, economic returns are not always the sole interest, and CBAs do not capture other outcomes, such as changes to GHG emissions, or account for other risks in the modelling framework. A user-friendly tool to rapidly screen and compare investment options is needed.

This paper presents notes for calibrating such a tool: The Climate-Smart Agriculture Investment Plan Cost-Benefit Analysis Tool (CSAIP-CBA), including use examples drawn from investment portfolios prepared for Burkina Faso, Ghana, Mali, and Côte d'Ivoire. The CSAIP-CBA models investment costs and benefits using a standard cost-benefit analysis based on methods proposed by Yet *et al.* using Monte Carlo techniques and the SIPmath Standard[4]. This standard has two important benefits with regard to portfolio models such as described here.

1) It allows for modular simulation, in which projects may be simulated individually and then rolled up into a simulation of the portfolio.

2) The models at all levels may be run in native Excel without macros or add-ins as they use the built in Data Table function to perform simulation.

The Models rely on an economic and financial analysis of expected inputs and outputs. A project's impact is monetized, discounted, and calculated annually, considering the gradual adoption of project interventions by the target beneficiaries, which is subject to the implementation risks and benefits. The model assumes that benefits accrue for 20 years while investment costs are principally used in the first five years.

CSAIP-CBA uses a probabilistic approach to account for uncertainty in project costs and benefits that are subject to risks and adoption barriers. Accurate estimates for these parameters are a major challenge in *ex-ante* impact assessments. The parameter uncertainty of these variables is modelled in the CSAIP-CBA using a probability distribution, specified as a metalog, that represents the degree of confidence around estimates, which are then considered when calculating common CBA indicators. This approach is consistent with best practice for *ex-ante* impact assessments.

In the following sections, we describe model running and parameterization. The model has been implemented using Microsoft Excel by World Agroforestry (ICRAF) and Probability Management Group. The model requires six categories of data for each investment: (1) number of beneficiaries; (2) rates of adoption; (3) estimated project impacts; (4) project budget and costs; (5) risk frequency and severity; (6) greenhouse gas impacts. Values for model parameters are defined based on available sources and the preferences of the stakeholders and modelling team. A combination of expert knowledge and external data sources may be used where available (Table 1). Examples of sources and approaches for each category are described below.

Table 1. Sources of information for model parameters used to estimate investment performance in terms of productivity, resilience, and mitigation in the Climate-Smart Agriculture Investment Plans of Burkina Faso, Ghana, Mali, and Côte d'Ivoire.

Parameter	Expert Knowledge	External Data
Number of beneficiaries	x	x
Adoption rates	x	
Change in benefits project		x
Project costs	x	
Risk frequency		x
Risk impact on project	x	

Methods

Number of Beneficiaries

Investment benefit projections are based on the number of beneficiaries reached during the 20-year project cycle. The number of beneficiaries in any given year of that cycle is derived from the total number projected and the functional form selected in the rate of adoption. Then, the number of beneficiaries in each respective year is multiplied by the relative change in benefits for that investment. The benefits derived is a direct function of the number of beneficiaries.

Depending on the investment, there are two estimated beneficiary groups: those that are already producing the target product and those that are not currently producing the target product but, due to the investment project, will begin new agricultural activities. Data can be combined using the following equation to estimate the number of farming households that an investment may reach:

$$\left[\begin{pmatrix} households \\ currently \\ producing \end{pmatrix} \times \begin{pmatrix} proportion \\ program \\ will\ reach \end{pmatrix} \times \begin{pmatrix} proportion \\ reached\ that \\ adopt \\ CSA \end{pmatrix}\right] + \left[\begin{pmatrix} households \\ not \\ producing \end{pmatrix} \times \begin{pmatrix} proportion \\ program \\ will\ reach \end{pmatrix} \times \begin{pmatrix} proportion \\ reached\ that \\ adopt \\ CSA \end{pmatrix}\right]$$

The first three variables of the equation estimate the number of households currently producing the target crop or livestock that will be reached by the investment. The second three estimate the number of new farmers that might start producing as a direct result of the investment.

Both expert opinion and secondary data may be used to set the number of beneficiaries. Census data, which often describes the number of farmers and rural households in regions targeted for investment, was primarily used for CSAIPs for Ghana, Burkina Faso, Mali, and Côte d'Ivoire. Oftentimes, however, concrete data is not used to set the number of beneficiaries during project development. Instead, experts and project developers simply *decide* how many beneficiaries should be targeted. This aspirational number can also be used in the CSAIP-CBA model without problem.

Due to the high level of subjectivity used when deciding the number of beneficiaries, an investment boundary was created for the CSAIP-CBA based on the cost per beneficiary. According to previous World Bank Project Appraisal Documents [8], the cost per beneficiary ranged between approximately 200 and 2,000 USD. When examining other donor-funded programs, costs per beneficiary were 150-450 USD. Therefore, the investment boundary in CSAIP-CBA should be between 200 and 600 USD. Below 200 USD, proposed investments are unrealistically cost effective; above 600 USD they are non-competitive with other options.

Adoption Rate

The project scope is defined by the total number of targeted beneficiaries. Project benefits, in any given year, are determined by the adoption rates and the relative increment of increase. Because the total project benefits are accrued over the investment timeframe, the number of beneficiaries for each year is estimated. The percentage of target beneficiaries that adopt the project intervention is modelled using the Bass model [9]. Our formula is shown below:

$$AR_t = \frac{1 - e^{-(p+q)t}}{1 + \left(\frac{q}{p}\right) e^{-(p+q)t}}$$

where AR is the adoption rate, p is the rate of innovation, and q is the rate of imitation over a specified period of time represented by t. Broadly speaking, the rate of innovation represents the number of beneficiaries directly interacting with the project while the rate of imitation touches on indirect beneficiaries.

Parameters *p* and *q* were estimated based on expert opinion of the likely and relative trajectory of implementation for each investment under the investment plan. Experts were asked to select which of nine curves they thought best fit the likely trajectory of adoption for each investment and then come to consensus (Figure 1). Each curve differs in slope and time to maximum adoption, with the greatest difference between the top left and bottom right panels. Factors that might cause slower or faster adoption rates include whether a project relies on establishing physical infrastructure (e.g., weather stations) or human capacity (e.g., reconstructing an extension system), or it builds on existing infrastructure (e.g., digital agriculture).

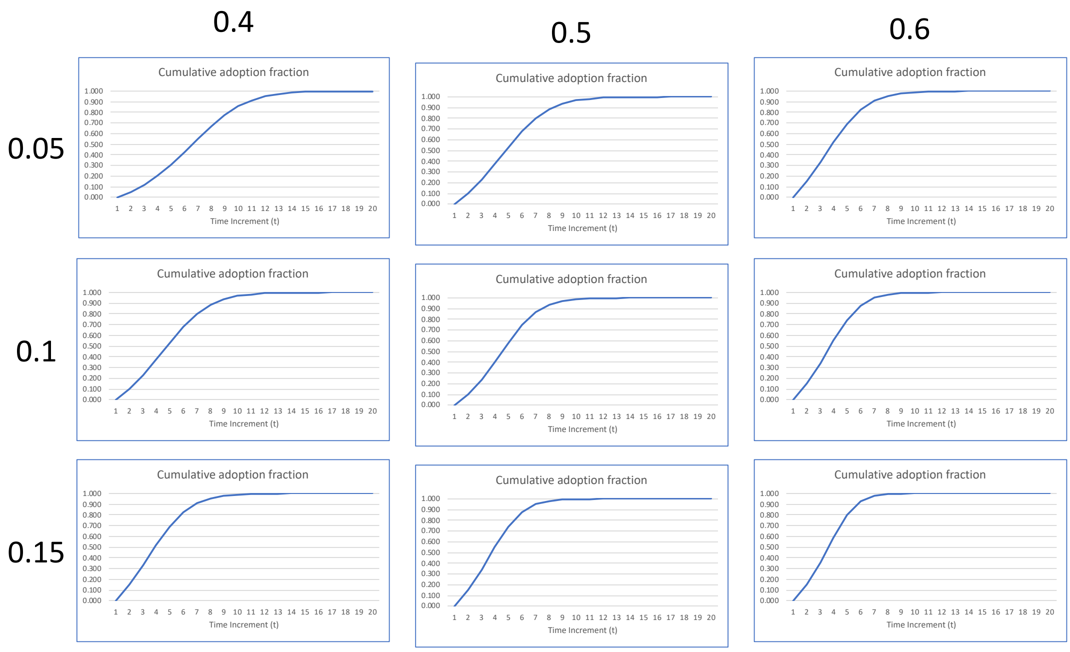

Figure 1. Functional forms of adoption curves for different parameter values in the Bass model

The mapping of investments to likely adoption curves is an indirect way of attaining the parameter values for *p* and *q* needed in the model (Table 2). It should be noted that innovation and investment values are only indicative; it is entirely possible that other functional forms will be preferred by in-country teams. Such examples can be generated by changing the values of *p* and *q* in the model of the existing spreadsheet (v6.1.3) to show stakeholders or experts other functional forms that match expectations. Additionally, adoption-versus-time curves that best match predictions of the adoption b could be used to discover which *p* and *q* values match that functional form by trial and error.

Table 2. Parameter values used for the Bass model to estimate annual adoption rates [10]

		Rates of Imitation (q)		
		0.4	**0.5**	**0.6**
Rates of Innovation (p)	0.05	Water harvesting and irrigation	Aquaculture	Cocoa; diversified tree crops
	0.1	Small ruminants, tubers, livestock	Poultry	Cereal-legume integration
	0.15			Advisory services

Budget and Costs

It is necessary to estimate a project budget—the amount of funding and costs—for each investment against which to evaluate project benefits. Estimated budgets can be either abstract or detailed, although it can be assumed that the more detailed a budget is, the better an approximation it will be. Both detailed and abstract budgets were used in this paper.

A detailed template was created for estimating budgets, including a consideration of personnel and infrastructure (See Spreadsheet attached to the Working Paper). This template was then populated in collaboration with specialists knowledgeable about the institutions and infrastructure. Notably, there is a trade-off between the accuracy of a projected budget and time: the creation detailed budgets took several days each and may not always be appropriate. Alternatively, project budgets can be estimated by experts or using secondary literature. These will provide an initial estimation to calculate costs and benefits but, by definition, they are poorly constrained.

It is also possible to generate abstract project budgets based on the number of beneficiaries. Project costs were based on the average costs per beneficiary following a typology of investment cost effectiveness derived by expert opinion. Agricultural investments typically range between 200-600 USD/beneficiary. Each investment was prescribed to one of three pathways: cost-efficient, moderate, or expensive, with corresponding costs 200, 400, and 600 USD/beneficiary. These values were then multiplied by the target number of beneficiaries in the regions identified in the investments based on census data. This method provided an estimate of total budget.

After a total budget is determined, annual costs are determined. The simplest assumption is to distribute costs equally each year. Of course, if knowledge about differential costs per year is available this can also be used. In previous CSAIPs, costs for Years 6-20 received 10% of annual budgets.

Estimated Impacts of Projects

Investment benefits can be directly assessed through the evaluation of estimated project impacts. These are pre-defined, high-level objectives for each project, often identified by stakeholders during the development of corresponding investment plans. They are modelled against the counterfactual scenario of no investment project. This scenario is developed by generating the baseline values of key indicators before projects from existing agricultural census data and standardizing them across the country to represent all beneficiaries. Projected returns and indicator changes over the project period without the project are then adjusted for predicted climate impacts, based on estimated changes in agricultural productivity predicted with the IMPACT model [11]. The investment project impacts are estimated by conducting a financial analysis of the relevant management practices and technologies to generate post-implementation indicator changes. Data for this financial analysis can be derived from the Evidence for Resilient Agriculture Database, which includes nearly 1,500 studies of farm-level management practices and technologies in Africa; it can be supplemented with additional sources as needed [12].

Climate-smartness indicates improvements to three main aspects of agriculture: productivity, resilience, and climate-change mitigation. In addition to project-specific objectives, it is important to assess these core components of climate-smart agriculture in each priority investment. Changes in productivity can be directly measured, by the change in percent productivity. The resilience of projects is demonstrated by assessing the risks and using the probability of a positive Net Present Value (NPV). In cases where NVP probability is lower, it is important to consider the downside risks of investments, as there is a possibility that they may not perform as hoped or planned and may not produce positive results when implemented. Mitigation can be assessed in terms of greenhouse gas emissions based on project activities; investments can have direct impact on emission levels, either by producing GHGs or by sequestering carbon dioxide and reducing GHG production.

Methodologically, variation in predicted results is produced by considering the joint effects of multiple, uncertain parameters. CSAIP models are based on the best available information at the time of development, information about costs, benefits, and performance can be scarce and uncertain. The CSAIP-CBA modelling approach attempts to account for that reality and make it explicit, to achieve a better, more informed decision-making process. The economic analyses in CSAIPs allow investments to directly target resilience against productivity and growth risks, including climate, pest, and social factors. CSAIPs are thus guarded against the excessive optimism that occurs when risks are excluded from economic analyses.

Risk Frequency and Severity

Investment benefits are constrained by climate and social risks. Climate risks affect a project's expected relative impact. For example, pests or disease outbreaks can reduce yields from an irrigation project. However, risks do not always depress benefits. Investments such as climate information services may have no impact under normal conditions but positive impacts under adverse conditions such as drought or late onset of rains. The CSAIP-CBA model includes three climate risk factors. By default, they are droughts, floods, and pests and diseases. However, any risk factors deemed important to likelihood of investment success could be substituted.

Social risks affect the rate of adoption and relative benefits. The number of beneficiaries in any given year is determined by the rate at which interventions are adopted in a project area; modifying adoption rates thus changes expected benefits. As in the case of climate risks, social risks vary across investments. The default in the model counts governance, conflict, and political instability as social risks.

For each climate and social risk, the model requires a frequency of occurrence and severity of impact input. These values can be derived from secondary literature, raw data, or expert opinion. Examples of secondary literature include Choudhary and D'Alessandro's *Ghana: Agriculture Risk Assessment*, Murkin *et al.*'s *Climate Risk Analysis* and USAID's *Mali Climate Vulnerability Mapping* reports as well as published, peer-reviewed literature (Table 1) [13]–[15]. Raw data may be derived from sources such as the World Bank Open Data

Portal or FAOSTAT [16], [17]. Finally, experts with sufficient domain knowledge can be used to define additional values.

The following sections describes how risk values are estimated. These estimated values are not a comprehensive guide but provide the authors' approach as an example. The appropriate approach for each team using the CSAIP-CBA model will depend on the data and time available.

Climate Risks

The impacts of climate risks were estimated for beneficiaries and non-beneficiaries separately because climate change impacts may vary significantly with and without project interventions. In some cases, peer-reviewed literature may yield this information, but we found that in almost all cases, it contained insufficient data to answer for an investment's many interventions and potential impacts. Thus, we typically needed to supplement the modelling effort with expert opinion. Experts provided an idea of expected impacts, from minor to catastrophic, that attend the occurrence of a particular risk. The range of answers helped to develop a distribution of impacts, from 0% damage to 100% damage, or complete destruction.

Drought

The likelihood of drought is derived from the frequency of droughts between 1991-2010 as drawn from secondary data [18]. Drought events are based on globally gridded precipitation data and defined as periods of rainfall that fall below the average of the preceding 12 months by more than one standard deviation (Standardized Precipitation Index SPI-12 < -1). A drought period begins in a month where the SPI-12 reached -1 and ends in a month where the SPI-12 reached 0, representing a return to average rainfall conditions. The number of such events between 1991-2010 is the reported drought frequency. Mean and variance are calculated by dividing the country into 16 grid cells and calculating the mean number of droughts per cell. Drought likelihood is defined as the average number of drought events per year. For example, if an area averaged one drought per decade, then the estimated risk of drought is 10% in any given year.

Floods

Flood likelihood is estimated from historic flood data based on the United Nation's Office for Disaster Risk Reduction's knowledge platform *PreventionWeb* between 2005-2014 [19]. Although some flooding occurs annually during the rainy season, flood events are defined as those which are recorded in *PreventionWeb* as internationally reported losses and are potentially disruptive to project activities. Previous analysis by the World Bank based on the Ghana Meteorological Office (Table 3) illustrates the information potentially available in other sources. Flood likelihood is defined as the average number of droughts expected annually, based on the number of observed floods in the historical period.

Table 3. Number of severe and catastrophic rainfall events by region in Ghana (1980-2010) recorded by the Ghana Meteorological Office [10]

Region	Severe	Catastrophic
Upper West	4	0
Upper East	5	1
Northern	3	2
Brong-Ahafo	2	1
Volta	5	0
Ashanti	5	0
Eastern	5	0
Western	4	1
Central	4	0
Greater Accra	0	1

Pests

Data on the frequency of major, project-disrupting pest outbreaks in Africa is difficult to find. We assessed the likelihood of pest outbreaks using data sources appropriate to each country. For example, Côte d'Ivoire and Mali are susceptible to desert locusts invasions such as those that occurred on 5 occasions between 1900-2000 [20]. Because outbreaks may span multiple years, this data yields an estimated 5% likelihood of desert locusts in any given year for these two countries. Additionally, novel or "shock" pest and disease outbreaks have occurred in sub-Saharan Africa approximately 5 times over the past 20 years, including the most recent outbreak of fall armyworms across the continent [21]. This gives a conservative, upper-limit estimate of a 25% likelihood of a significant pest outbreak in any given year. Local and regional estimates were combined to yield the final likelihood of a disruptive pest outbreak in any given year.

Social Risks

Political Instability

We used the World Bank's Worldwide Governance Indicator platform *political stability and absence of violence* indicator to estimate the likelihood of political instability [22]. We converted derived scores to likelihood by establishing a linear scale ranging from -3, which indicates the 100% political instability of a country in active conflict or without a functioning government, to +2, the highest level of stability, correlated to 0% political instability. Based on the available data, we computed the mean and standard deviation (SD) in across a range of years and converted this to a mean likelihood of political instability using our linear scale.

Poor Governance

We used the Worldwide Governance Indicator platform *government effectiveness* indicator to estimate the likelihood of poor governance affecting project implementation [22]. GE Scores were converted to likelihood of poor governance using a linear scale where -2.5, the lowest score, corresponded to a 100% chance of poor governance and +2.5, the highest score, corresponded to a 0% chance of poor governance. We computed the mean and standard deviation in GE score using the available data and converted this to a mean and standard deviation in likelihood of poor governance using our linear scale.

Community Conflict

Community conflict, particularly between different ethnic groups or between agriculturalists and pastoralists, is frequently identified as a potential project risk by in-country stakeholders. We estimated likelihood of community conflict using the Institutional Profiles Database indicators of social conflict (A203) [23]. Social conflict variables include estimations of ethnic and religious conflict, conflict over land in rural areas, and other types of social conflict. We converted these scores to a likelihood of conflict using a linear scale, where a score of 0 corresponded to a 100% chance of conflict and a score of 4 indicated a 0% chance of social conflict. We used the SD of a country's scores across the five variables to estimate the uncertainty around the likelihood of conflict.

Implementation

We implemented the CSAIP-CBA framework in a series of investment portfolios for countries in Sub-Saharan Africa. The following examples are drawn from the CSAIP reports for Ghana and Burkina Faso [10], [24].

CSAIP Ghana

Investment Beneficiaries

Ghana's priority investments intended to reach a total of 1,690,000 beneficiaries (Table 4). Investments ranged from 500,000 beneficiaries for knowledge and advisory services to 70,000 for fisheries and aquaculture projects.

Table 4. Number of beneficiaries in each project [10]

Investment	Targeted Beneficiaries
Knowledge and advisory services	500,000
Ruminant production	150,000
Root-tubers-livestock	200,000
Cereal-legume integration	200,000
Poultry production	160,000
Cocoa production	150,000
Tree crop production	120,000
Water management	140,000
Sustainable fisheries, aquaculture	70,000
Total beneficiaries	1,690,000

Productivity

All of Ghana's identified CSA priority investments were found to increase productivity by at least 20%. Sustainable fisheries and aquaculture showed the highest yield increase, nearly 60%; water management and cereal-legume integration showed yield increases over 40%. Knowledge and advisory investments led to a smaller change, as their impacts are less direct, and tree crop production had similarly low yield gains of 20% (Table 5).

Table 5. Percentage change in yield, expressed as percentages with the standard deviation of the difference between beneficiaries and non-beneficiaries in parentheses [10]

Investment	Change in Yield (SD)
Sustainable fisheries and aquaculture	59% (30%)
Water management	44% (4%)
Cereal-legume integration	40% (31%)
Cocoa production	32% (20%)
Poultry production	27% (52%)
Ruminant production	27% (19%)
Root-tuber-livestock	27% (14%)
Knowledge and advisory services	21% (40%)
Tree crop production	20% (20%)

Resilience and Risk

All nine investments showed a good resilience, with the chance of a positive NPV greater than 50% for each investment in Ghana's portfolio (Table 6). This suggests that the investment plan is generally well positioned for future environmental conditions. The tree crops, cocoa, water management, and cereal-legume integration investments appeared especially robust, with an 85% or higher chance of a positive NPV, even when risks are included. Projects with lower probabilities for a positive NPV showed greater sensitivity to potential risks. The *with risks* scenario is likely more realistic, since uncertainty in performance is inherent to investments in agricultural development.

Table 6. Chance of a positive NPV with and without climate and pest risks [10]

Investment	Chance Positive NVP (%)	
	With Risks	Without Risks
Tree crop production	92%	94%
Cocoa production	89%	93%
Water management	89%	90%
Cereal-legume integration	85%	89%
Poultry production	71%	77%
Knowledge and advisory services	58%	61%
Root-tuber-livestock	54%	77%
Ruminant production	51%	65%
Fisheries and aquaculture	50%	63%

Mitigation

Five of the investments, focused on meeting Ghana's future protein needs with livestock, poultry, and fisheries and aquaculture, were projected to produce low levels of additional emissions (Table 7). Improving livestock productivity typically leads to GHG production, from enteric fermentation and methane or increased amounts of manure, for example. The entire investment portfolio, however, was projected to reduce Ghana's overall emissions by sequestering 7.31 Mt CO_2 if all the priority investments were implemented FAO's EXACT GHG calculator [25].

Table 7. Emissions from priority investments (MT CO_2) [10]

Mt CO_2			
Emitted		**Sequestered**	
Cereal-legume integration	-0.02	**Tree crop production**	3.4
Fisheries and aquaculture	-0.35	**Cocoa production**	3.2
Poultry production	-0.39	**Water management**	2.35
Root-tuber-livestock	-0.39	**Knowledge and advisory services**	0.23
Ruminant production	-0.72	-	
Subtotals	-1.87	**Subtotals**	9.18

Economic and Financial Performance

The nine investments in Ghana's portfolio were predicted to provide significant benefits for Ghanaian farmers by improving their productivity and income. The CBA, presented both with and without risks, sheds light on the potential magnitude of foreseeable risks (Table 8).

Table 8. CBA for the economic and financial performance of the nine priority investments with and without climate and pest risks (million US$). Notes: NPV = Net Present Value, ROI = Return on Investment, BCR = Benefit Cost Ratio, SD = standard deviations. NVP and ROI represent the average of 100 model runs [10]

CSA Investment	Estimated Budget	Mean NVP		Mean ROI		Mean BCR (SD)	
		WITH	WITHOUT	WITH	WITHOUT	WITH	WITHOUT
Cereal-Legume Integration	32.00	109.0	208.8	4.04	7.77	2.63 (5.54)	5.04 (6.96)
Cocoa Production	54.00	188.8	231.3	4.15	5.10	2.72 (3.96)	3.33 (4.33)
Poultry Production	32.00	81.6	119.3	3.19	4.63	1.97 (4.90)	2.88 (5.70)
Ruminant Production	37.50	38.1	88.5	1.43	3.07	0.77 (7.26)	1.78 (7.74)
Fisheries & Aquaculture	35.00	9.6	28.5	0.29	0.93	0.21 (0.92)	0.62 (1.24)

Water Management	70.00	143.7	171.1	2.32	2.78	1.54 (2.36)	1.84 (2.47)
Knowledge & Advisory	50.00	198.1	331	4.74	7.90	2.99 (14.31)	4.99 (17.12)
Root-Tuber-Livestock	50.00	24.2	75.9	0.52	1.74	0.36 (2.39)	1.15 (2.76)
Tree Crop Production	29.04	204.2	217.6	8.24	8.79	5.30 (7.85)	5.64 (8.00)

CSAIP Burkina Faso

Investment Beneficiaries

The recommended investments for Burkina Faso were projected to reach nearly 1.7 million people (Table 9). Organic farming and on-farm biogas projects were projected to reach fewer, while the investment in capacity building was projected to reach 500,000 beneficiaries. While all the projects were likely to reach poor Burkinabe farmers, some were more likely to benefit women and the youth, including agroforestry and water management.

Table 9. Beneficiaries for each project [24]

Proposed Investment	Beneficiaries
Organic farming	60,000
On-farm biogas	65,000
Water resources and irrigation	100,000
Sustainable livestock intensification	150,000
Forest, agroforest, and garden	180,000
Finance and insurance	200,000
Integrated soil management	200,000
Oil-protein crops	240,000
Capacity building	500,000
Total	1,695,000

Productivity

Water resources and irrigation showed the highest yield increase per beneficiary at 56%, with organic farming close behind; projects such as biogas and forest and garden also performing over 40% (Table 10).

Table 10. Change in yield, expressed as percentages with the standard deviation of the difference between beneficiaries and non-beneficiaries in parentheses [24]

Investment	Change in Yield (SD)
Water resources and irrigation	56% (41%)
Organic farming	54% (45%)
On-farm biogas	45% (28%)
Forest, agroforest, and garden	40% (21%)
Oil-protein crops	39% (9%)
Sustainable livestock intensification	38% (28%)
Integrated soil management	29% (34%)
Finance and insurance	19% (10%)
Capacity building	18% (8%)

Resilience and Risk

Overall, the chances of a positive NPV were good for most of the investments. Without risks, all priority investments had a better than 50% chance of a positive NPV, with some reaching a 90% chance. Projects with a higher chance of positive NPV showed little difference when risks were included (Table 11).

Table 11. Chance of a positive NPV with and without climate and social risks; average of 100 model runs [24]

Investment	Chance Positive NVP (%)	
	With Risk	Without Risk
Forest, agroforest, and garden	89%	92%
Integrated soil management	71%	83%
Capacity building	62%	80%
Oil-protein crops	60%	90%
Finance and insurance	45%	63%
Sustainable livestock intensification	43%	65%
On-farm biogas	32%	51%
Organic farming	29%	54%
Water resources and irrigation	21%	54%

Mitigation

Burkina Faso's investment portfolio was projected to overall emissions by sequestering 4.31 MT CO_2 if all investments were implemented. Only one, sustainable livestock intensification, would generate GHG emissions (Table 12).

Table 12. Emissions from Priority Investments (MT CO_2) [24]

Investment	Emitted (Sequestered) (Mt CO2)
Sustainable livestock intensification	(0.69)
Water resources and irrigation	0.03
Organic farming	0.04
Oil-protein crops	0.11
Capacity building	0.21
Finance and insurance	0.25
On-farm biogas	0.53
Integrated soil management	1.25
Forest, agroforest, and garden	2.58
TOTAL	4.31

Economic and Financial Performance

Burkina Faso's CBA was calculated with and without risks. All investments were predicted to provide significant benefits. Projects with lower NVPs had high up-front investment costs but also the highest projected yield per beneficiary (Table 13).

Table 13: CBA for the economic and financial performance of the nine priority investments with and without climate and pest risks (million US$). Notes: NPV = Net Present Value, ROI = Return on Investment, BCR = Benefit Cost Ratio, SD = standard deviations. NVP and ROI represent the average of 100 model runs [24]

CSA Investment	Estimated Budget	Mean NPV		Mean ROI		Mean BCR (SD)	
		WITH	WITHOUT	WITH	WITHOUT	WITH	WITHOUT
Integrated soil management	60.00	72.0	128.9	1.35	2.46	5.30 (7.85)	5.64 (8.00)
Organic farming	50.00	-5.1	21.8	-0.15	0.48	2.99 (14.31)	4.99 (17.12)
On-farm biogas	55.00	-1.5	16.9	-0.09	0.30	2.72 (3.96)	3.33 (4.33)
Water resources and irrigation	65.00	-15.8	22.9	-0.35	0.35	2.63 (5.54)	5.04 (6.96)
Sustainable livestock	37.50	16.4	76.1	0.67	2.57	1.97 (4.90)	2.88 (5.70)
Finance and insurance	40.00	15.9	52.2	0.43	1.51	1.54 (2.36)	1.84 (2.47)
Forest, agroforest, and garden	55.00	168.2	196.1	3.47	4.06	0.77 (7.26)	1.78 (7.74)

Oil-protein crops	55.00	32.5	106.1	0.62	2.19	0.36 (2.39)	1.15 (2.76)
Capacity building	55.00	52.5	140.4	1.06	2.95	0.21 (0.92)	0.62 (1.24)

Lessons Learned

The price of carbon matters and the integration of these prices has a significant effect on projected investment performance. Carbon pricing is calculated by capturing the external costs of carbon emissions, such as damage to crops, health care costs, and property damage, and tying them to their sources by exacting a price for carbon [26]. The implementation of certain types of investment involves GHG emissions, which can increase project costs, imply up-front costs for beneficiaries, decrease adoption rates, and thus reduce net benefits investment performance. CSAIP financial and economic analyses are highly sensitive to some model assumptions. A careful and cautious analysis of future carbon pricing and risk calculations for agricultural sector investments is thus well warranted.

Adoption rates heavily inform CBA results. Differences among productivity estimates arise from variations in the cost of interventions, the number of beneficiaries, and the relative speed at which interventions reach scale [27]. In turn, these projections are used to estimate potential benefits and perform CBAs. Thus, the assumptions underlying adoption rate calculations for all investments, including how fast projects could reach scale, directly impact the results of a CBA, regardless of the extent to which they vary from observed adoption rate.

The availability and legitimacy of data are challenges, and insufficient data leads to high levels of uncertainty. Insufficiencies of literature and data on topics relevant to agricultural development can lead to skewed estimations and increased uncertainty. In this way, issues of insufficient data gathering, suboptimal data gathering methodology, outdated data, and opaque data constrain investment planning, investment implementation, and opportunities to secure additional future investments. There is a massive lack of data for the areas of the world most in need of focused investing and well-planned development programming.

Low availability of expert opinion data is particularly challenging. The Intergovernmental Panel on Climate Change recommends reporting the degree of certainty as a measure of the consensus within the scientific community [28]. This is because data that reflects a strong stakeholder consensus on the state of the beneficiary country or region help ensure that programming will meet the true needs of communities. The myriad data challenges that exist in developing regions are in part due to the very limited availability of local expert capacity.

Conclusion

Monitoring and evaluation efforts show that project outcomes often have a poor track record of success. As a result, fewer World Bank-funded programs are being justified by traditional CBA. Issues of data scarcity further increase uncertainty in prioritizing investments. The probabilistic approach of the CSAIP-CBA accounts for the uncertainty, risks, and barriers to adoption in project costs and benefits. Its CBA model includes data on (1) number of beneficiaries; (2) rates of adoption; (3) estimated impacts of projects; (4) project budget and costs; (5) risk frequency and severity; (6) greenhouse gas impacts. The comprehensive CSAIP-CBA methodology allows a clearer understanding and consideration of uncertainty while assessing the potential costs and benefits of investment projects. CSAIP-CBA considers the presence or absence of specific risks and allows their effects on project evaluation indices to be defined and quantified.

In the cases of Ghana and Burkina Faso, CSAIP-CBA models projected that overall investment portfolios would produce a positive effect. Productivity was projected to increase for all investments in both countries; in Ghana, investments also demonstrated a high degree of resilience. Both countries showed an overall reduction of GHG emissions based on investment projects. The Ghanaian investment portfolio projected significant financial benefits and increased income. In both cases, climate and pest risks had notable and varying impact on potential costs and benefits. Such findings can support informed decision-making in prioritizing investment portfolios. By assessing potential project emissions, the CSAIP-CBA tool allows a clearer understanding of the importance of carbon pricing. Considering potential GHG emissions in tandem with country-specific carbon pricing allows project benefits to be weighed against carbon pricing costs when prioritizing investments.

The CSAIP-CBA tool is robust at varying levels of uncertainty and data scarcity, and provides insight into the impact that adoption rate assumptions have on project costs, benefits, and investment viability [26]. Quantifying uncertainty is crucial to revealing areas of data scarcity and gives stakeholders the opportunity to improve data availability. Future expansion of this work can evaluate portfolios of investments may be evaluated under numerous uncertain scenarios[1]

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