INTEGRATING GENDER IN COST-BENEFIT ANALYSIS OF CLIMATE INTERVENTIONS

Training Guide for the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM)

Training Guide

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About AICCRA guides
Titles in this 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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ABOUT AICCRA

CGIAR | AICCRA Accelerating Impacts of CGIAR Climate Research for Africa

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ABSTRACT

This guide compiles the materials for the course "Integrating Gender In Cost-Benefit Analysis Of Climate Interventions" including lecture materials, links to learning videos, recommended readings, and self-check quizzes to assess your understanding.

The course aims to think critically through ways to quantify and evaluate the monetary and non-monetary costs and benefits of climate interventions for smallholder farmers, with a strong focus on gender equity and social inclusion. It covers gender aspects of evaluating an intervention using net present value, an expected utility framework to quantify welfare gains from reduced risk, changes in women's workloads and empowerment, as well as experimental and quasi-experimental impact evaluation methods.

The training materials were built on an online course conducted by the International Food Policy Research Institute (IFPRI), the Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA) program, and the CGIAR Gender Platform in November and December 2024. The materials generated during this online course were transcribed and adapted for developing a self-paced course for the platform Regional Universities Forum for Capacity Building in Agriculture (RUFORUM).

Keywords

Gender; Cost-Benefit Analysis; Climate Information Services; Social Inclusion; Evaluation; Non-Monetary Benefits

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ACRONYMS

AICCRA	Accelerating Impacts of CGIAR Climate Research for Africa.
ATE	Average Treatment Effect
CBA	Cost-Benefit Analysis
CIS	Climate Information Services
DID	Difference-in-Difference
IFPRI	International Food Policy Research Institute
IV	Instrumental Variable
NPV	Net Present Value
PSM	Propensity Score Matching
RCT	Randomized Controlled Trial
RD	Regression Discontinuity
RUFORUM	Regional Universities Forum for Capacity Building in Agriculture
TOC	Theory of Change
WEAI	Women's Empowerment in Agriculture Index

INTRODUCTION

Welcome to the training materials of the course "Integrating Gender in Cost-Benefit Analysis of Climate Interventions"! This course is a joint effort between the e-learning platform Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) and the Alliance Bioversity & CIAT under the Accelerating the Impacts of CGIAR Climate Research for Africa (AICCRA).

Background Information

RUFORUM is a network of 175 African universities in 40 countries, training the next generation of scientists for Africa. The AICCRA project, funded by the World Bank and led by CGIAR centers including the Alliance of Bioversity International and CIAT, aims to improve access to climate-smart agriculture innovations and climate information services (CIS) across sub-Saharan Africa.

This course is developed under AICCRA Theme 4: Climate Information Services, which focuses on improving the availability, use, and impact assessment of CIS. An online course in four modules over the course of five sessions was previously delivered in December 2024 to meet this aim. The present training materials are built on the previously delivered online course.

This course is designed to equip you with tools and frameworks to better assess the full value of resilience-building interventions — not just in terms of monetary gains, but also in terms of gender equity, well-being, and empowerment. In this training guide, you will find lecture materials, links to learning videos, recommended readings, and self-check quizzes to assess your understanding.

Objectives

When deciding whether to invest in an innovation, program or policy aiming to improve smallholder farmers' resilience and climate change adaptation, governments and donors typically consider the costs and benefits of doing so. However, cost-benefit analysis (CBA) frameworks typically focus on the net present value (NPV) of future cash flows arising from an investment, which do not capture important gender outcomes of these types of innovations. Benefits could include, among others, improved women's empowerment, reduced workloads and drudgery, or improved well-being from better consumption smoothing. In this course, we aim to provide participants with tools and methods to bring these types of outcomes into their cost-benefit analyses, which can strengthen resource allocation for programs with strong gender benefits.

The course aims to guide and strengthen agricultural research-for-development, ensuring it has meaningful and lasting contributions to global targets for gender equality, opportunities for youth and social inclusion. By the end of the course, you will be able to:

1. Understand and apply the basic concepts in CBA, including NPV and discount rates, to assess monetary intervention benefits.

2. Discuss how integrating gender and social aspects is relevant for resilience planning, especially in smallholder farming settings.

3. Develop a Theory of Change that identifies the desired resilience intervention benefits, including the outputs, outcomes and impacts to inform the intervention's design, monitoring and evaluation.

4. Estimate the non-monetary benefits from resilience interventions, including gender empowerment and well-being for vulnerable groups, through the expected utility framework; and identify tools for its data collection.

5. Critically analyse resilience interventions' outcomes by choosing and comparing experimental and quasi-experimental approaches to measure gendered outcomes effectively.

Prerequisites and Target Audience

This course is targeted at graduate students in economics or environmental sciences, development practitioners, and researchers looking to boost their knowledge and skills on gender in food systems.

Participants should have basic knowledge of the types of innovations to enhance climate change adaptation, including knowledge of concepts such as climate-smart agriculture and climate information services. Participants do not need to be gender experts or have prior knowledge of cost-benefit analysis methods.

Module 1: General Overview of CBA

Module Overview

Welcome! Module One will cover a general overview of cost-benefit analysis. It will primarily discuss net present value and discount rates since these are two central concepts in cost-benefit analysis. Then, it will progressively introduce an approach to a specific method that is different from traditional cost-benefit analysis, as it covers monetary and non-monetary costs. To do so, the module will also cover why gender matters in cost-benefit analysis and why we have this course specifically on integrating gender in cost-benefit analysis.

Learning Objectives

1.1 Understand the key concepts of cost-benefit analysis, net present value and discount rate.

1.2 Evaluate how NPV uses monetary values to assess the costs and benefits of an intervention.

1.3 Recognize why gender matters in cost-benefit analysis and what's missing from purely monetary calculation of benefits.

1.4 Explain how we can integrate gender in cost-benefit analysis, focusing especially on innovations that enhance smallholder farmers' resilience and climate change adaptation.

1A: Key Concepts Of CBA: Net Present Value and Discount Rate

The first half of this module is going to focus on the key concepts of cost-benefit analysis, especially looking at the concepts of net present value (NPV) and discount rates. It will go through the definitions of those concepts, and then it will cover how we can calculate the net present value and how we can determine that discount rate.

Definitions

- Cost-Benefit Analysis (CBA): a process that is used to measure the benefits of an intervention minus the cost involved in making it happen. It is used to assess the profitability of an intervention, an activity, a project or a program. Because it's used to assess profitability, the benefits are typically measured in monetary terms, focusing on the concept of net present value (NPV) of future cash flows.

- Cash flow (CF_t): the balance of cash that is moving in and out of a specific project at a specific point in time. In other words, it's the difference between the revenue and the costs at time t.

- Time value of money: when designing an intervention or a project, especially if it goes over several years, cash flows at different points in time have to be considered. This means assessing how much it is invested at the beginning of the project, and then what it will cost you and what you will get from it financially at different points in time. Money received or paid at different times has a different value. As a result, it is not possible to simply sum values over time in a CBA, unless values are converted into a common base or unit.

Aggregating cash flows

Please watch the following **video** to learn more about this topic.

Discounting, discount rate, discount factor, discounting on timeline.

Because the time value of money, a dollar spent or received now doesn't have the same value in the future. Therefore, a discount rate is needed to convert them into a common base or unit.

Discounting

Discounting cash flows moves them to the same time base. This will allow to calculate their total value, using a discount rate and a discount factor.

Discount rate

It is an estimated rate used to convert future cash flows into their value in the present time.

- Accounts for the fact that a dollar today is worth more than a dollar in the future, because of returns on investment, interest rates, inflation.
- The lower the estimated value of future cash flows, the higher the discount rate.

If the money in the future is worth a lot less, that means the discount rate is very high. If money in the future is estimated, if the value of the money in the future is more or less the same as now, that means a very low discount rate.

Discount factor

It is a multiplier used to convert future cash flows to their present value. The discount factor for converting CF in time t to time 0 would be: $\frac{1}{(1+R)^t}$ or $(1+R)^{-t}$, where R is the discount rate. Figure 1 shows an example of cash flows from year zero to year four. In order to add up these cash flows, they have to be converted into the same units (time 0) using the discount factor. That brings us to the notion of net present value.

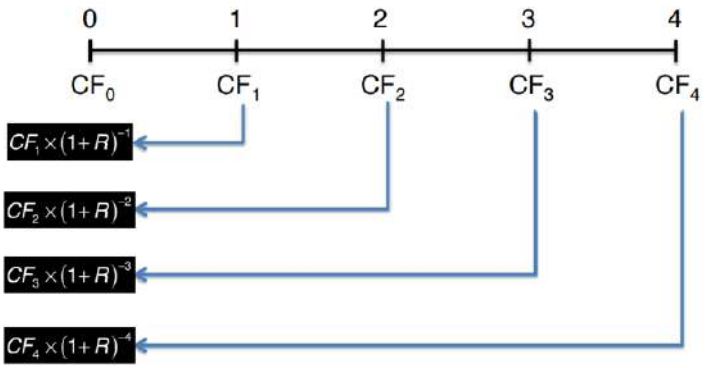

Figure 1. Discounting on timeline. Source: CBA for CIS online course, 2024.

Calculating the Net Present Value

The net present value is the metric that is used to assess the overall profitability of an investment or a project. This is done by comparing the present value of

future cash outflow, for example, an investment, and the present value of the cash inflows, which is the returns on investment, the money coming in at different points in time. Cash outflows and inflows have to be converted to present value through the following formula that uses the discount rate.

Formula:

$$NPV = \sum_{t=0}^{\infty} \frac{Cash\ Flows}{(1+R)^t}$$

where $\sum_{t=0}^{\infty}$: denotes summation of values from time 0 onwards.

t = time of the cash flow
R = discount rate

NPV > 0 : expected returns (estimated in present value) > costs
NPV < 0 : expected returns (estimated in present value) < costs

Figure 2. Formulas for Calculating the Net Present Value. Source: CBA for CIS online course, 2024.

If NPV is positive, the current value of expected returns is superior to the cost, making it a profitable investment or activity intervention. If NPV is negative, the current value of expected returns is inferior to the cost, not being a profitable investment or activity intervention.

Please watch the following **video** to learn more about this topic.

Box 1. Self-check Exercise: Calculating the NPV. Consult Annex 1 for the Answers.

Let's calculate the NPV of a crop investment over a period of 3 years with a 5% discount rate. You will invest $1000 on year 0, then you will spend $200 per year on year 1-3. You expect to generate $800 in year 1, $900 in year 2, $1000 in year 3.

1. **What would be your discounted cash flow each year?**
   a. $-952.38 for year 0; $544.22 for year 1; $604.69 for year 2; and $658.16 for year 3.
   b. $-1000 for year 0; $600 for year 1; $700 for year 2; and $800 for year 3.
   c. $-1000 for year 0; $571.43 for year 1; $634.92 for year 2; and $691.07 for year 3.
2. **What would be your NPV?**
   a. $897.42
   b. $1,100

c. $0

3. Is the investment profitable?

a. It is not profitable, it would result in a loss and should be considered.

b. It is profitable, the investment should be considered.

c. There is no difference.

Determining the discount rate

Estimating the value of future cash flows, turning those into the present value, requires having the appropriate discount rate. Discount rates depend on a lot of factors that include context, individual preferences, people's economic constraints and the type of investment.

Usually, in a smallholder farmer setting, there are discount rates higher than 10%. The discount rates are used to bring benefits accrued in the future into a common denominator to compare them with the cost of a program. Time preferences are related to how patient people are in preferring to receive money now or later. For example, an individual with a higher time preference will prefer immediate cash rather than later. They will place a reduced value on future cash flows, which is related to a higher discount rate.

The discount rate can be subjective; it may differ depending on how people value money based on several factors. For example, the type of crops that farmers grow may influence the risk faced and their liquidity constraints. Those who are growing perishable crops might not have as high a revenue as those who have better storage facilities or grow non-perishable crops that they can store until it is the right time to sell when prices are high. These aspects may reduce farmers' opportunities and thereby increase their dependence and risk, which could drive liquidity constraints.

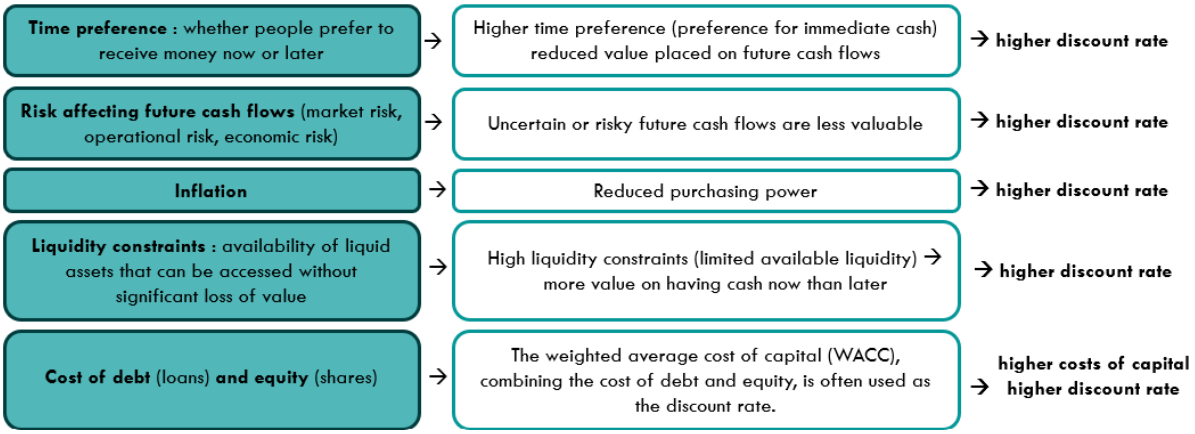

Figure 3. Factors related to high discount rates. Source: CBA for CIS online course, 2024.

It is not always possible to observe an individual's time preference or individual factors such as the extent to which somebody is facing risk or liquidity constraints. Therefore, the weighted average cost of capital (WACC), which combines the cost of debt and equity, is often used as the discount rate. The WACC looks at interest rates and returns on equity and uses that as the discount rate because it says something about the opportunity cost of money in financial markets. It assumes that the cost of capital in financial markets for debt and equity is indeed a reasonable discount rate for the people on whom we are doing these cost-benefit analyses. If people do not have access to those financial markets, then the cost of debt and equity might not be that relevant for them.

Farmers who don't have access to formal financial markets will typically face strong liquidity constraints and risks that are not necessarily reflected in the weighted average cost of capital because that's the price in financial markets. That is the challenge that the development setting faces, compared to investors in developed countries or the larger private sector who do cost-benefit analysis and investment analysis. The latter ones can use the weighted average cost of capital, but in a smallholder farmers scenario, the market's discount rate might not be the right one. If the discount rate from capital markets using the combined cost of debt and equity is used, it might be underestimated.

If farmers are integrated in financial markets, the cost of loans or the cost of debt can be considered for determining discount rates. If farmers are not integrated in financial markets, we may want to say, "But is there an informal financial market? Is there informal borrowing? What is the cost of borrowing when we're looking at those informal sources? Can we derive a percentage from there?" If that's not possible, we could also look at time preferences for smallholder farmers. There are survey tools that have been developed to elicit time preferences, such as the Global Preference Survey. It gives guidance on how to measure time preferences as precisely as possible using choice experiments. The use of choice experiments eliciting farmers', women's, and men's preferences on discount rates could provide deep insights into NPV estimations. Sensitivity analysis is also an important part of estimating these discount rates.

Want to know more about it? Access the Global Preference Survey **here**.

Box 2. Self-check Exercise: Determining the Discount Rate. Consult Annex 1 for the Answers.

1. **How does an individual with a high discount rate values money from today as compared to money from tomorrow?**

   a. The individual will have a higher time preference, meaning that they value money from today more than money from tomorrow.

b. The individual will value money from today equally than money from tomorrow.

c. The individual will have a lower time preference, meaning that they value money from today less than money from tomorrow.

2. In which of the following case can we use the weighted average cost of capital (WACC) as the discount rate?

a. A farmer who is facing strong liquidity constrains and risks.

b. A farmer from a developing country who borrows money informally from a local moneylender to buy drought-tolerant seeds.

c. A farmer from a developed country who has access to a loan from the bank to invest in drip irrigation technology.

3. If the WACC can not be used as the discount rate, how can we elicit time preferences?

a. The WACC is the only option to determine the discount rate.

b. We can use the cost of debt (loans) and equity (share) to determine the discount rate.

c. We can use choice experiments to elicit farmers' preferences on discount rates, followed by a sensitivity analysis.

1B: Why Does Gender Matter in CBA?

The second part of the module will discuss why gender matters when conducting cost-benefit analysis and, more broadly, how gender comes into play in assessing the success of an intervention. It will start with definitions to progressively build on what's missing from traditional cost-benefit analysis when it comes to gender and in what ways it may or may not be included in such analysis.

Definitions: gender and intersectionality

- Gender: Gender is "a socially defined set of roles, rights, responsibilities, entitlements, and obligations of females and males in societies. The social definitions of what it means to be female or male vary among cultures and change over time". This is distinguished from the term sex, which is a biological distinction. However, in practice, sex and gender are used interchangeably when discussing disaggregation of data and its use (source: USAID).

- Intersectionality: The complex, cumulative way in which the effects of multiple forms of discrimination (such as racism, sexism, and classism) combine, overlap, or intersect, especially in the experiences of

marginalized individuals or groups (source: Merriam-Webster dictionary).

These concepts are important as they help us understand how different aspects of someone's identity, including race, gender, sexuality and social class interact and create a very unique experience of discrimination, oppression, but also privilege in some cases.

Gender considerations in the discount rate

Most farmers face challenges with cash liquidity and credit constraints, influencing their discount rates. These challenges are often related to their socioeconomic context, such as access to resources or land ownership. Gender and intersectionality also have an impact on each person's discount rate, as it is related to their context and circumstances. Decision-making and the power dynamics between men and women within a household influence discount rates. For example, who gets to decide what crops are going to be planted this year or how much money within the household will be invested.

Research indicates that women in particular may experience greater liquidity constraints than men. They often have less access to livelihood resources, often don't own their land, often prioritise financial security for their household and tend to have more limited access to credits and extension services. As a result, the perceived value of future and immediate cash flows will vary between men and women, and that will lead to different discount rates.

Box 3. Self-check Exercise: Gender Considerations in the Discount Rate. Consult Annex 1 for the Answers.

Anna and John are each expecting to receive $1000 one year from now.

1. **Calculate the NPV for Anna considering that her discount rate is 15%**
    a. Anna values the $1,000 future cash flow at $1,150 today.
    b. Anna values the $1,000 future cash flow at $1,000 today.
    c. Anna values the $1,000 future cash flow at $869.57 today.
2. **Calculate the NPV for John considering that his discount rate is 5%**
    a. John values the $1,000 future cash flow at $1,000 today.
    b. John values the $1,000 future cash flow at $952.38 today
    c. John values the $1,000 future cash flow at $1,050 today.
3. **Why is there a difference between Anna's and John's discount rate**?

a. John has higher liquidity constraints, meaning she has limits in access to loan and needs cash now. Anna is more comfortable waiting due to fewer constraints.

b. Anna has higher liquidity constraints, meaning she has limits in access to loan and needs cash now. John is more comfortable waiting due to fewer constraints.

c. Anna has higher liquidity constraints, so she is comfortable waiting. John has limits in access to loan and needs cash now.

Limitations of NPV in valuing women's work.

Please watch the following **video** to learn more about this topic.

This module started with the Net Present Value as a tool for traditional CBA approaches. NPV allows us to evaluate the profitability of interventions based on how much money we are investing in this intervention, the money coming out, and how much money do expect to come in thanks to that intervention. Factors such as change in market shares, increased household income and change in productivity can be measured in monetary terms and integrated in that approach.

However, there are a number of things that are difficult to integrate in this analysis. There can be non-monetary benefits that would be the desired impacts of climate information services interventions. Some of these are resilience strengthening, non-tangible outcomes, empowerment outcomes, welfare, empowerment indicators, improvement of living conditions, knowledge and skills gained and the value of women's time use. The risks or uncertainties that farmers experience in their farming decisions are also difficult to integrate into traditional CBA.

What would be the desired impacts that you would want a climate information service project to achieve? And how can we go beyond just NPV, and how can we take that into consideration in cost-benefit analysis?

The next module will cover how, using a theory of change, you can think a bit more about your monetary, but also non-monetary intended benefits of your intervention and how to capture them. It will explore how those concepts of uncertainty, but also risk of version, will play a role in these analyses, and we'll also talk about the concept of expected utility and look at how it impacts decision making and how to factor this into cost-benefit analysis.

Wrap-up of Module 1

The CBA is a financial evaluation method to determine the feasibility and economic efficiency of a project by comparing its total costs and total benefits. The NPV is the main tool used for traditional CBA approaches. It provides a measure of profitability by comparing the value of future cash flows to the initial investment. In profitable projects, NPV is positive and in unprofitable projects, NPV is negative.

To calculate the value of that money received in the future into its present value, a discount rate and a discount factor are needed. The reason is that money received in the future doesn't have the same value as money received now. This discount rate is very dependent on different farmers' constraints, time preferences and circumstances such as liquidity constraints or limited access to loans. Therefore, to better estimate the cost and the benefits of an intervention, it is important to consider the specific socioeconomic constraints and situations. Gender also plays a role in time preferences and discount rates. Men and women have different socioeconomic constraints depending on their context. For example, women don't necessarily have the same access to resources, access to decision making and access to learn as men do.

The traditional cost-benefit analysis focuses on the monetary impacts of an intervention. However, there are a lot of intended or expected benefits that are not necessarily monetary. The goal is to implement interventions that have monetary benefits for the people who are part of it, but that may also make sure that both men and women have are better able to integrate information that leads to more free time and more quality of life.

Recommended Readings for Module 1

- Berk, J., & DeMarzo, P. (2020). *Corporate Finance* (5th ed., chapters 4 & 5). Pearson.

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MODULE 2: INTRODUCING RISK AVERSION AND BENEFITS BEYOND NPV IN CBA

Module Overview

Welcome! Module Two will introduce risk aversion and benefits beyond net present value in cost-benefit analysis. Because we're focused on resilience interventions or innovations that aim to reduce risk for smallholder farmers, the net present value approach to cost-benefit analysis is not always adequately reflecting those reductions in risk. Therefore, the concept of risk aversion is introduced and how to include benefits that go beyond the net present value when we conduct cost-benefit analysis.

It will explore the desired intervention benefits in resilience interventions and how we can identify those. It will introduce the theory of change as a tool to assess those desired intervention benefits, including outputs, outcomes and impacts. Then, we will be linking that to a framework that allows us to incorporate risk aversion in cost-benefit analysis. This module is also going to introduce the concept of risk aversion and the concept of utility.

Learning Objectives

2.1 Explain the limitations of traditional CBA for evaluating resilience interventions and identify benefits that go beyond NPV, including non-monetary and gender-sensitive outcomes.

2.2 Develop and apply a gender-responsive Theory of Change to identify desired outputs, outcomes, and impacts of resilience interventions for smallholder farmers.

2.3 Understand and apply key concepts in decision analysis under uncertainty, including risk aversion, certainty equivalent, risk premium, and expected utility.

2.4 Compare and apply different approaches to measure non-monetary benefits and well-being such as parametric, unconstrained preference, and revealed preference methods.

2A: What Are The Desired Intervention Benefits?

Identifying Desired Outcomes: Theory Of Change (ToC) From A Gender Perspective.

The Theory of Change (ToC) is a narrative or a way of looking at a project, typically represented as a diagram that explains the pathways by which a set of investments or interventions is expected to create measurable outputs, leading to intended (short/medium/long-term) outcomes, and then to broader impacts. It includes:

- Assumptions and preconditions: underlying factors that are not directly controlled by the program but must be true for its success.
- External factors: elements outside the program's control that may influence the outcomes. One example of an external factor is when you're running a project, and then all of a sudden, there is a pandemic. This is typically outside of the program's control, but it will definitely influence the outcomes of your program.

The ToC should be designed at the beginning of a project or program and include a monitoring and evaluation process. It will help determine what it is that you're proposing to do and how it leads to the impacts that you say it will have.

This is where it's interesting to think about what you're trying to reach with the theory of change, and through the monitoring and evaluation process, how you are going to measure those impacts or those benefits. This is where we get to the cost-benefit analysis method.

Example of Theory of Change.

Figure 4 shows an example of a Theory of Change. For this example, we are designing a project that aims at developing climate information services to improve climate resilience. The intervention is to develop short and long-term forecasts on rainfall, temperature, wind, drought, intensity, and duration (shown in the bottom blue box). It is also going to provide advisories on soil condition, crop variety selection, fertilizer application, etc.

The green boxes (left) are what would be a traditional theory of change that doesn't specifically integrate gender in its design. The outcomes of this intervention would be improved farm decision-making, early planning for severe weather conditions, increased farm investment, etc. The impacts would

be increased farm productivity, reduced losses, increased preparedness, etc. The orange boxes (right) show additional points that you may want to consider for having a gender-responsive intervention. These points include reduced need for farm labor among men and women, a reduced time allocation on domestic production, etc., as outcomes. While reduced workload, increased bargaining power, and secure income for men and women are the impacts. The overall goal would be to have smallholder farming communities that have strengthened their climate resilience from a gender-perspective approach.

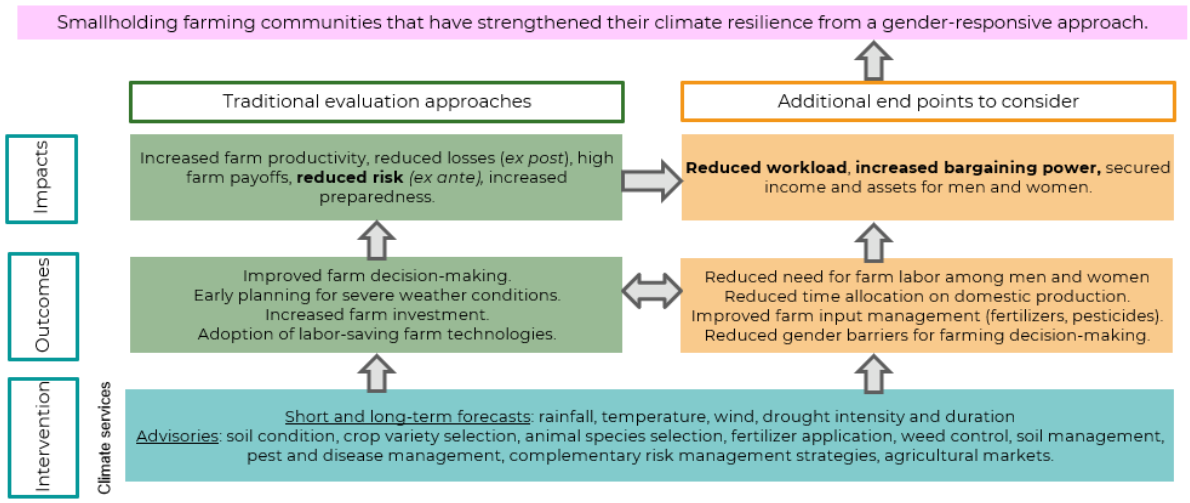


Figure 4. Example of gender-responsive Theory of Change. Source: CBA for CIS online course, 2024.

This example may come with a number of assumptions. For example, the assumption that farmers have equal access to technology, there's equal access to technology for both men and women, which is not usually the case. The second assumption is that climate information services produce information that is good quality, easy to interpret, demand-driven, localized, delivered on time and in the right format. The third assumption is that it addresses the needs of both men and women, but in this assumption, we have to recognize that men and women may have different roles and may perform different activities within the farm, and as a result, they may have different needs. The last one is equal capacity to act and to make decisions upon the given information, that people have enough knowledge, control over land or resources to be able to integrate that climate information.

There are also a number of external factors that might influence the program. For example, changes in staff in the organization, research institute, local NGOs or extension office working specifically on the project. Those changes might influence the delivery of the climate information services and also the trust-building process with farmers. If the leadership changes, it might have different priorities that might impact the project. Political unrest or changes in

government policies are also external factors that may result in changes of priorities, or in the worst-case scenario, a decision to not continue the program. The third external factor from this example is market access or market fluctuation that could impact the farm investments or access to inputs. For example, unexpected future climate conditions may require a change in the seed type, but making that change may not depend entirely on the farmer. Infrastructure and connectivity access, intermittent power, and disrupted internet connectivity are external factors that may also hinder delivery of climate information services.

Gender-responsive ToC

Unfortunately, very often, a Theory of Change does not typically mention gender. However, it is very important that gender is included from the beginning of the project to ensure inclusive outputs, outcomes and impacts. That is the way to ensure that the interventions are equitable, effective, and sustainable, and most importantly, that they address both men's and women's needs, roles, and impacts, which are very likely different.

Gender sensitive approaches will often uncover barriers and opportunities that would otherwise be overlooked and that could lead to more innovative and more comprehensive solutions. If gender aspects are overlooked or neglected, that could lead to unintended consequences that not only don't improve existing inequalities, but potentially make them worse.

For example, if a intervention is about giving better access to climate information to people in a specific community. The intervention uses smartphones as a way to disseminate that information to make sure that farmers have better access to it. But it is applied in a region where households typically have one smartphone for the entire household, it is very likely that the smartphone belongs to the husband, the head of the household. Therefore, it is very likely that he will have a lot more access to what's being sent or shared through that smartphone than his wife. His wife may be able to get information from other sources, for example, somebody coming to the community, women's groups or the radio. But if somehow the intervention replaces other channels of communication, some of the unintended consequences might be that women have less access to information than before. If women were used to getting information by radio and now it's not done anymore because it's been replaced by smartphones, at the end of the day, women could have less information because of the intervention and less ability to participate in decision-making and make money.

This means that when implementing a project, it is important to make sure that you understand the differences that exist and the situations of discrimination, oppression, and inequalities that exist for different groups, including gender.

Making sure that when you're designing an intervention, you understand the context and that all benefit from the intervention equally.

Box 4. Self-check Exercise: Gender-responsive ToC. Consult Annex 1 for the Answers.

Smallholder farmers in Trans-Nzoia County of Kenya primarily grow maize and wheat as livelihood acivity. Climate change has led to increased occurrences of droughts, dry spells, and floods, leading to crop losses and affecting their productivity. Women, who make up a large portion of the farming workforce, face unique challenges due to traditional gender roles and limited access to resources. We want to implement a Climate Information Service (CIS) that may support farmers in adapting to climate change and build resilience.

1. **Based on the Theory of Change presented in the module, which of the following is an example of a gender-responsive output from implementing climate information services (CIS) in this context?**

   a. Improved national Early Warning Systems.

   b. Delivery of tailored weather forecasts through platforms accessible to both women and men that address their differentiated information needs.

   c. Increased fertilizer subsidies for maize and wheat farmers.

2. **Which of the following is an example of an external factor that could influence whether women benefit equally from the CIS?**

   a. Whether women and men perceive the climate information as trustworthy.

   b. Policies or institutional frameworks that do not prioritize climate adaptation projects.

   c. The choice of delivery channel (e.g., SMS, radio, farmer groups).

What Is Missing From Traditional CBA Approaches: Non-Monetary Benefits.

Module One covered that the traditional cost-benefit analysis is about measuring the financial costs and benefits of an intervention using the net present value and the discount rates, which are used to calculate how much future cash inflows and outflows are worth today. We started identifying that even if traditional CBA is useful in some ways, there are a number of things that it doesn't take into account. For example, it doesn't take into account women's informal domestic work, which often invisible work and is not necessarily associated with cash inflows. It doesn't take into account the fact that women typically have much higher work burdens because of the informal domestic or reproductive role that they play. It also doesn't take into consideration an individual's level of risk aversion.

That is a problem, especially when you're designing a program that aims at reducing somebody's exposure to risk, but you don't have a way to capture how they respond to risk and what their level of risk aversion is.

In the end, these interventions are not developed just for farmers or beneficiaries to increase their income. There are a lot more benefits that we aim to achieve with those programs, and that should be highlighted or identified right from the project design stage through the theory of change. Some of those benefits include, for example, some welfare benefits that people can have from having peace of mind because the shocks are not impacting their livelihoods as much. Interventions can also lead to changes in the intra-household bargaining dynamic or the participation of women in the decision-making of their household, supporting women's empowerment. Interventions can also impact the way people use their time or manage their time for their work, impacting their free time.

This submodule will look at what's missing from traditional cost-benefit analysis approaches and how we account for those aspects to measure the impact of resilience interventions.

Want to know more about it? Consult the following document.

Timu, A. & Kramer, B. (2023). Estimating the intrahousehold costs and benefits of innovations to enhance smallholder farmers' resilience. Frontiers in Sustainable Food Systems, 7, fsufs.2023.1129419. https://doi.org/10.3389/fsufs.2023.1129419

How To Measure Those Non-Monetary Benefits? Approaches For Assessing Well-Being.

This submodule will look at different approaches for assessing well-being. The first one is the parametric approach to measure well-being through a model that will map observable indicators into a measure of well-being. Another approach is the unconstrained preferences approach, which measures well-being through how specific constraints affect preferences that people have in an environment with zero constraints. The last one is the revealed preference approach, which uses the willingness to pay as a measure of well-being.

Information for applying these approaches can be obtained from the farmers through different tools, such as surveys or games. There are different ways of getting that information from farmers; even with illiterate farmers, we can conduct data collection to run those calculations. These approaches will allow us to evaluate resilience interventions beyond the outcome level (behaviors, consumption) to the impact level (empowerment, well-being).

Parametric Approach: Measuring Well-being Through Observed Indicators.

We have seen that the theory of change is a planning and evaluation tool used to create a pathway from your intervention to your desired outcomes and impacts, considering assumptions and external factors that you're not directly responsible for.

It's very important that the theory of change includes gender and includes those non-monetary benefits from the start, because that's also going to highlight what you need to measure at the end. We have seen that there are different approaches to measuring that notion of well-being among farmers, those non-monetary aspects of well-being. The parametric approach is one of these approaches, which uses observable indicators to measure well-being.

Please watch the following **video** to learn more about this topic.

If there is information on what might change in consumption or leisure as a result of a certain resilience innovation, and there is information on preferences on how those changes are then being valued, then the parametric approach can be used.

Unconstrained Preferences Approach: Preferences Versus Constraints.

The unconstrained preference approach is used to compare people's preferences with and without constraints and how it changes.

Please watch the following **video** to learn more about this topic.

Case Study.

A lab-in-the-field experiment with 224 participants from 112 couples in Zambia, aiming at quantifying the welfare benefits of climate information services, was carried out.

People had a choice between investing in early maturing or late maturing varieties with and without access to climate information, and they were asked to decide those questions were asked to men alone, women alone and then men and women as a couple. And the study looked at how much the decisions varied in all those different circumstances.

Decisions under uncertainty, when people were told there were there was either a 0% or a 100% probability of rain, were considered the preferred behavior. This means that when people knew exactly with certainty how much rain there was going to be and made decisions based on that, it was considered to be their preferred behavior.

The study found that when people had access to forecasts and advisories, they tended to invest more closely to their preference without risk. Now, how did those preferences and behavior differ by gender? It was considered that an individual's decision, when not influenced by their spouse, was considered their preferred allocation. Their preference is the decision that they make with no influence from their spouse.

The study found that when people did not have access to climate information, the decisions that they made as a couple were closer to the decisions that the man would make on his own or the man's preference rather than the woman's preference. They were asked separately, but when asked together, their decisions as a couple were closer to the man's preferences. But when climate information was provided, then their decisions made as a couple became closer to what both men and women chose individually. This experiment used the unconstrained preference approach, where you first look at what people's preferences are when there are no constraints and then how that changes when you introduce a constraint.

Want to know more about it? Consult the following document.

Kramer B, Trachtman C, Zuze L. 2023. Information as a Source of Empowerment: The Role of Climate Information Services. AICCRA Working Paper no.17. Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA). https://hdl.handle.net/10568/135668

Revealed Preference Approach: Willingness To Pay As A Measure Of Well-being.

Traditional cost-benefit analysis approaches that are based on net present value do not capture risk and do not capture non-monetary benefits, such as welfare benefits, changes in intra-household bargaining dynamics, the decision-making power of each member of the house and the change in time use and management.

The revealed preference approach could work very well if you're very early on in a program and you're able to elicit willingness to pay for a new service, new tool or innovation that is not possible to measure how consumption, workloads, empowerment, and how those aspects change because the innovation has just been developed.

Please watch the following **video** to learn more about this topic.

2B: Risk Aversion And Utility

The second part of the module will cover risk aversion and the concepts of certainty equivalent and risk premium. This is related to the different ways different people approach risk.

We will talk more about the gender differentiation in risk aversion and how important it is to take that into consideration. Then we will dive into the concept of expected utility.

It is important to not only look at how income and consumption change, but also how the stability of income changes. For instance, as a result of an intervention, you may see that income becomes more stable and that people are better able to smooth consumption and that now they have peace of mind. These aspects are also an important benefit that resilience interventions have that are very difficult to capture with traditional cost-benefit analysis approaches that are based on net present value.

How to capture those types of benefits from a reduction in risk and the volatility of income?

Risk Aversion, Certainty Equivalent And Risk Premium.

The "Coin Toss Problem".

Your employer offers you a cruel game. Instead of receiving your normal salary this year, you may flip a coin.

- If it lands on heads, you will be paid two times your normal salary.
- If it lands on tails, you will not be paid.

Will you play the game, or keep your normal salary? What if you only get 90% of your annual salary if you refuse to play?

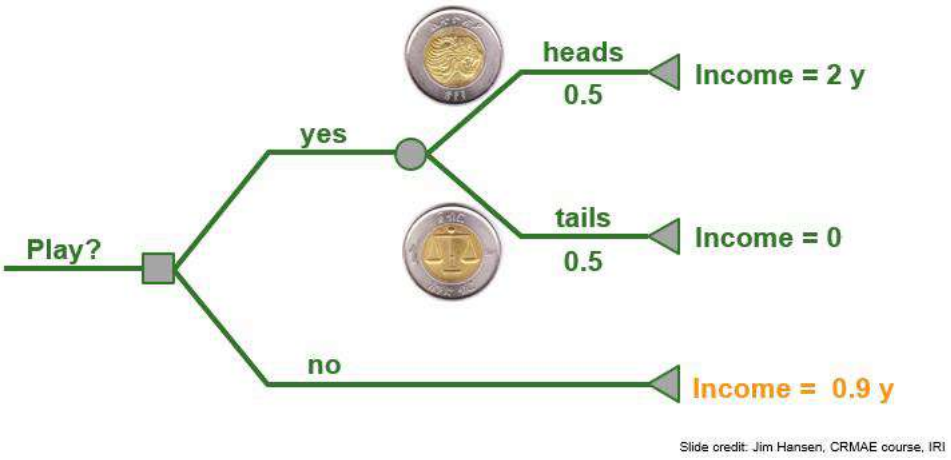


Figure 5. Coin Toss Problem. Source: Jim Hansen, CRMAE course, IRI.

This bring us to the notion of expected income, certainty equivalent and risk premium.

- Expected return: The income that an individual anticipates to receive from an intervention based on probable outcomes. It is the weighted average of outcomes. In the previous "Coin Toss" example, the expected return would be 0.5 * 2y + 0.5 * 0 = y

- Certainty equivalent (CE): Guaranteed return that someone would accept, rather than taking a chance on a higher but more uncertain return. In this example, maybe you're willing to accept, for example, 70% of your salary so that you don't have to take the risk. If you do take the risk, you might receive more money, but it's more uncertain and you don't want this uncertainty.

- Risk premium (RP): The amount of average return that a decision maker would be willing to sacrifice to eliminate risk. In other words, the risk premium would be the expected income.

The risk premium will always be positive if you're risk-averse. The risk premium is telling us what somebody would be willing to pay to get rid of the risk. It is the difference between the certainty equivalent and the expected income from a risky prospect.

Then: RP = Expected income - CE

In the previous module, we took future cash flows and converted them to a unit that we could compare with today by dividing them by the discount rate. In a way, the risk premium and certainty equivalent do something similar when the expected income is risky and when there are more possible outcomes with probabilities for them.

If we have an expected income and a certainty equivalent, then they can be compared to the certainty equivalent of the expected income that the intervention would give. It's a way of translating it all back to a unit of certainty. Just like with net present value, we bring everything back to a unit expressed in terms of today. This means that a climate information service would improve welfare if the expected return from the service is above the CE.

Approaches To Risk

Different people approach risk differently, depending on their attitudes. The following are the main types of risk attitudes:

- Highly Risk-averse: Requires a high return for taking on even a low level of risk.
- Mildly Risk-averse: Willing to accept a lower return for the same level of expected risk.
- Risk Neutral: Indifferent to risk; makes decisions purely based on expected return, with no preference or aversion to the level of risk.
- Risk Seeker: Prefers higher risk and may even accept a lower return for the opportunity to take on riskier ventures.

Please watch the following **video** to learn more about this topic.

Risk preferences might differ between men and women. Depending on somebody's level of risk aversion, an intervention might have a larger or a smaller impact on well-being. The type of intervention and the types of practices or technologies that are being promoted through that intervention will also influence the different impacts on well-being. These are aspects that purely monetary net present value would not capture.

Box 5. Self-check Exercise: Approaches to Risk. Consult Annex 1 for the Answers.

A farmer is deciding whether to purchase a weather forecast service to optimize planting decisions. Without the forecast, their income is uncertain and depends on weather conditions. Their income without would be $15,000 under good weather conditions (60% probability) and $5,000 under bad weather conditions (40% probability). Their income with the forecast would be $10,000, whether it is good or bad weather, assuming that the forecast skill is high and it would allow them to make anticipatory decisions such as drought-tolerant seeds.

1. **What is the expected income without and with forecast? (Hint: expected income = income on good weather * good weather probability + income on bad weather * bad weather probability)**

   a. Without forecast, the expected income would be $9,000 and with forecast, the expected income would be $11,000

   b. Without forecast, the expected income would be $11,000 and with forecast, the expected income would be $10,000

   c. Without forecast, the expected income would be $10,000 and with forecast, the expected income would be $11,000

2. **Based on the course theory, what is the definition of certainty equivalent (CE)?**

   a. The amount of average return that a decision maker would be willing to sacrifice to eliminate risk.

   b. Guaranteed return that someone would accept, rather than taking a chance on a higher but more uncertain return.

   c. The expected income.

3. **Considering a CE of $8,000, would this forecast service be improving the farmer's welfare? (hint: the service would improve farmer's welfare if: expected income > CE)**

   a. Yes

   b. No

   c. There would be no change.

Gender Differentiation In Risk Aversion.

Risk aversion depends a lot on different aspects. Research shows that, on average, women tend to be more risk-averse than men. This means that women are generally more cautious about the risks, and they may prefer safer options with more predictable outcomes.

There are a lot of other things that come into play, but in general, research shows more risk aversion in women. Women are also likely to invest in more conservative assets, such as bonds or savings accounts, whereas men are more inclined to invest in stocks or higher-risk types of assets. Women tend to prefer lower but more stable returns, and men tend to be more willing to take risks for a chance of a higher return, even if there is a higher risk or more uncertainty.

Gender norms play a big role in these dynamics. Social expectations and traditional gender roles can reinforce that risk-averse behavior in women. There is research showing that in societies where women have greater economic empowerment and autonomy, the gap in risk aversion between men and

women is not as obvious or as prominent. Therefore, external factors and opportunities can influence risk-taking behavior.

Financial products and financial services should be designed to cater to different risk preferences that appeal especially to both men and women, and provide appropriate options for diverse needs. Very often, that gender disaggregation is not done, and usually there are no options that cater for different risk references.

This shows that a whole climate intervention could be developed based on a certain assumption of risk aversion in the target audience. However, that risk aversion might be very different between men and women. This means that the uptake, the efficiency or the benefits coming out of the intervention might be very different depending on how those risk aversion levels are accurately captured.

Decision Analysis To Maximize Satisfaction: How To Quantitatively Measure Well-being?

There are different methods to assess the desirability of an investment and evaluate a program. Net Present Value is used to calculate how to maximize financial value, but does not account for risk or other benefits, such as well-being. Different approaches allow for measuring well-being, including the parametric, unconstrained preference, and revealed preference approaches. Well-being can be quantified through the parametric approach using the concept of expected utility. Expected utility can replace NPV in cost-benefit analysis.

Expected Utility

Concept used to quantify how individuals make 'rational' decisions under uncertainty
while considering their preferences and attitudes toward risk. It includes:

- Probability weights: probability calculations for each possible outcome.
- Utility function: a mathematical representation of an individual's preferences.

The formula is:
Expected Utility = $\sum_i$ Probability(O_i) × Utility(O_i)
where O_i represents each possible outcome
and Utility (O) is the utility (or satisfaction) associated with the outcome O.

Figure 6. Expected Utility Formula. Source: CBA for CIS online course, 2024.

The preferences of an individual are closely tied to their risk aversion, or their tendency to avoid taking risks. Probabilities could also depend on gender. For example, women can be more vulnerable to certain shocks.

Relation Between Risk Aversion And Utility (Satisfaction).

The risk aversion of an individual is captured in the shape of the utility function (U).

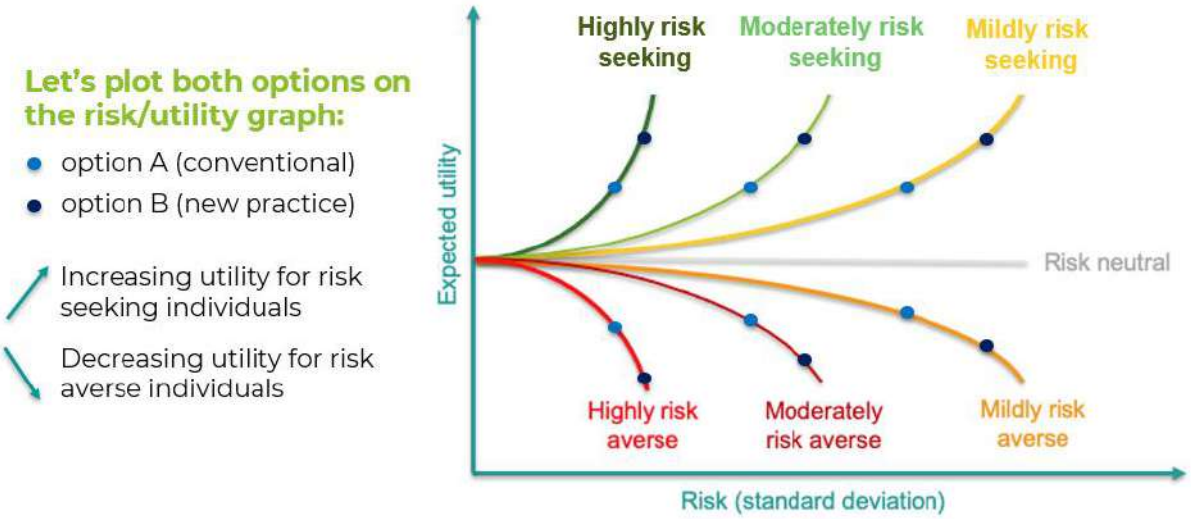


Figure 7. Graph on the Relation Between Expected Utility and Risk. Source: CBA for CIS online course, 2024.

The graph shows how expected utility and the different risk attitudes are related:

- Risk Seeking: utility increases with risk
- Risk Neutral: indifferent to risk, decisions are purely made based on expected return, with no preference or aversion to the level of risk.
- Risk-averse: utility decreases as risk increases

Measuring utility: Constant Relative Risk Aversion CRRA utility function

To calculate the expected utility, you need a utility function. The CRRA utility function is a utility function that models risk preferences over income or consumption. It is used to describe how individuals value consumption (x), with a focus on their attitude toward risk.

The formula is:

$$U(x) = \frac{x^{1-r}}{1-r} \quad \textbf{IF } r > 0 \ \& \ r \neq 1 \qquad \text{OR} \qquad U(x) = \ln(x) \quad \textit{IF } r = 1$$

where r represents risk aversion
and x represents consumption or income

- r=1, or high value of r : stronger risk aversion
- Lower value of r: weaker risk aversion
- r=0 : risk neutral individuals

Figure 8. CRRA utility function. Source: CBA for CIS online course, 2024.

Box 6. Self-check Exercise: Approaches to Risk. Consult Annex 1 for the Answers.

Suppose Kenyan farmers have two investment options A and B with the following risk and returns differentiated by gender:

- Option A with 90% probability yields monthly return of $35 and $45 for female and male farmers, respectively.
- Option B with 75% probability yields monthly return of $52 and $60 for female and male farmers, respectively.

The relative risk aversion constant (r) takes the following values considering a moderately risk aversion level, r=0.63 for men, and r= 0.75 for women. Using the CRRA utility function provided in the module, we obtained the following utilities:

- For the female farmer, the utility of option A is 9.73 and of option B is 10.74.
- For the male farmer, the utility of option A is 11.05 and of option B is 12.29

1. **What does the differences in r mean for male and female farmer?**
    a. The female farmer has a higher r because of a stronger risk aversion than the male farmer.
    b. The female farmer has a higher r because of a weaker risk aversion than the male farmer.
    c. The female farmer has a higher r because of she is a risk neutral individual.
2. **What is the expected utility of the male and female farmer from adopting each option? (hint: expected utility = sum of the Probability(Oi) × Utility(Oi) where i represents each option)**
    a. For the male farmer, the expected utility of option A is 8.76 and of option B is 8.06. For the female farmer, the expected utility of option A is 9.95 and of option B is 9.22
    b. For the female farmer, the expected utility of option A is 9.73 and for option B 10.74. For the male farmer, the expected utility of option A is 11.05 and of option B is 12.29

c. For the female farmer, the expected utility of option A is 8.76 and of option B is 8.06. For the male farmer, the expected utility of option A is 9.95 and of option B is 9.22

3. Which option would each farmer prefer?

a. Both female and male farmers would prefer option A.

b. Female farmer would prefer option A, male farmer would prefer option B.

c. Female farmer would prefer option B, male farmer would prefer option A.

Gender Considerations Around Expected Utility.

Gender could influence what outcomes from resilience interventions are valued and how. Men and women don't just value income in a certain way, but they might also assign different utility values even to the same outcomes for the same level of risk aversion. For instance, financial gains might be valued differently between men and women. Men, for instance, may place a higher utility on financial success, whereas women may place a higher value on security and stability. This could be partly reflected in risk preferences, but some of this might not be fully captured in risk preferences. It might need to be an extra term in a utility function beyond income that reflects these differences.

Emotional factors might also be playing a role in income or consumption. For instance, women might care more about outcomes that others in their family or their neighbors might be having compared to men. Social influences also play a role here. There are general societal expectations that can shape how the utility is formed and also how decisions are made. These aspects could be influenced by cultural norms, which could reinforce and mitigate these differences, influencing the probabilities of different outcomes. Due to different cultural norms and gender differences, it might be that in certain cultures, where women have certain responsibilities that men don't have, for instance, with caregiving responsibilities that might put women at higher risk. For example, cyclones result in higher mortality rates because of cultural responsibilities, that women would have. That would be a social influence that has an impact on how we would want to model the probabilities of different outcomes. The basic expected utility model does not factor in these aspects because it considers expected utility as a mere function of the probability of different outcomes occurring times the utility under those outcomes.

Those are aspects that in the basic utility function are not included, as it is just a function of income or consumption and risk preferences. But these emotional and social factors can be explicitly modelled and added to the utility function. Since expected utility is impacted by value systems, emotional relation effect, gender roles and societal expectations, these factors should be modelled and

added into the expected utility function. The following modules of this course will cover how to consider these factors added to the expected utility function.

Wrap-up of Module 2

In module two, we introduced the concept of risk aversion and benefits beyond the monetary ones considered in net present value from traditional cost-benefit analysis. We went into detail on how a reduction in risk exposure can have welfare implications, and how we can quantify those for risk-averse smallholder farmers beyond net present value. We spoke a lot about risk aversion, and we did this in the context of an expected utility framework. Expected utility depends on preferences, the probability of an outcome occurring and risk aversion. It is affected by gender because people might have different preferences, which might result in differences in how they value risk, but also in how men and women might adopt their practices and which technologies and practices they're using. This influences how men and women might respond differently to an intervention, which will result in different potential welfare benefits.

We also talked about the importance of having a clear theory of change (ToC) that identifies the desired benefits and impacts of your project. Developing a ToC from the project design will allow for better integration of gender and non-monetary benefits, and will evaluate those for assessing how the intervention improves the well-being of those farmers.

The idea is that people are doing the cost-benefit analysis of new resilience interventions, using these types of models and tools in order to inform whether those programs should be getting invested in or scaled up.

Recommended Readings of Module 2

- Bryan, E., Alvi, M., Huyer, S., & Ringler, C. (2024). Addressing gender inequalities and strengthening women's agency to create more climate-resilient and sustainable food systems. Global Food Security, 40. https://doi.org/10.1016/j.gfs.2023.100731

- Ihli, H. J., Chiputwa, B., Winter, E., & Gassner, A. (2022). Risk and time preferences for participating in forest landscape restoration: The case of coffee farmers in Uganda. World Development, 150, 105713.

- Paparrizos, S., Kumar, U., Amjath-Babu, T. S., & Ludwig, F. (2021). Are farmers willing to pay for participatory climate information services? Insights from a case study in peri-urban Khulna, Bangladesh. Climate Services, 23. https://doi.org/10.1016/j.cliser.2021.100241

MODULE 3: INCORPORATING CHANGES IN WOMEN'S EMPOWERMENT IN CBA THROUGH AN EXPECTED UTILITY FRAMEWORK.

Module Overview

Welcome! Module Three will build on the expected utility framework to value Climate Information Services (CIS) and Climate-Smart Agriculture (CSA) interventions. Particularly, it will look at control over income and reduced workloads, and provide examples of practical applications.

This module will cover how to measure a change in time use from resilience interventions and how to assess how people value their free time. It will also incorporate changes in women's empowerment in the cost-benefit analysis framework, especially bargaining weight and bargaining power. This is particularly important because a lot of climate resilience interventions are aiming to improve women's ability to cope, but also their empowerment to improve their resilience, since they are the most vulnerable to climate change. Incorporating these aspects will allow us to calculate not just an individual's utility, but the household utility, considering the bargaining weight of the husband and the bargaining weight of the wife.

Module Three will also cover data requirements to quantify the non-monetary benefits of resiliency interventions. We will look at calculating the probability of an event occurring, a climate or weather event, using an objective approach where you look at historical data, and how to do that with a subjective approach through participatory exercises with farmers to collect their estimates based on their experience and their knowledge.

Learning Objectives

3.1 Incorporate changes in women's empowerment—such as bargaining power and control over income—into cost-benefit analysis.

3.2 Measure non-monetary benefits of resilience interventions, including time use and well-being, using expected utility and preference-based approaches.

3.3 Identify data needs and tools (e.g. Pro-WEAI, GEI-CSV) for integrating empowerment, outcome probabilities, workloads, and risk into CBA of climate information services.

3A: How To Account for Changes In Empowerment?

Valuing A Change In Empowerment.

The International Research Institute for Climate and Society defines climate services using four pillars. The first pillar is good quality climate information available using the best available science, which means having reliable information. The second pillar is translating that into language information that is understandable by people who are not climate scientists, and in the language that speaks to them in the specific sector that they're in, with their specific level of education. The third pillar is communication, making sure that information goes to the right people, at the right time, through the right communication channels. The last pillar is the use, which is the capacity to act upon that information. They've gained knowledge about climate information, but how can they integrate it into their practices based on their decision-making power? We know that knowledge is power, but how can we quantify the impacts on empowerment from resilience interventions? This submodule will focus on that.

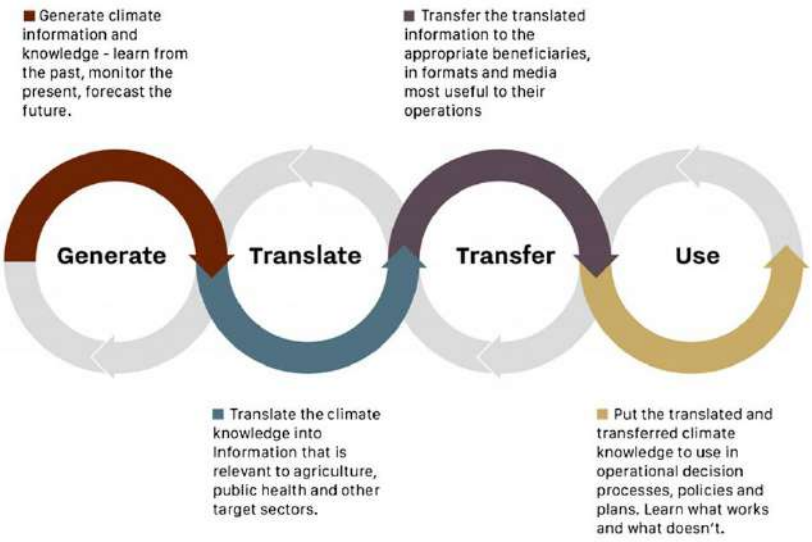


Figure 9. Climate Information Services Pillars. Source: Fiondella, 2021.

Climate information services access can empower the beneficiaries by providing information and enhancing people's ability to make informed decisions. People who previously didn't have access to that information might become empowered with new information. Then, there could be changes in power dynamics and bargaining procedures within households, which could lead to different outcomes. Some interventions might, on the one hand, increase women's empowerment in terms of control over income, which could lead to increases in household bargaining power, but then, at the same time, come with an increase in workloads. This results in not having an improvement in their bargaining power as a result of changes in time use because of their high workloads. It is important to measure these aspects, especially in the Global South, as women are among the most overburdened individuals due to traditional caregiving roles.

Women tend to have less access to information and less power because of a number of reasons, such as gender-specific constraints or climate information services not being tailored to the specific needs and situations of women. There's research showing that agricultural productivity is higher in households where both men and women receive the services, agricultural advisory and extension services, as compared to households where only men receive those services. This submodule will focus on women's empowerment and how to account for changes in empowerment in our cost-benefit analysis. It will cover two indicators of empowerment for measuring that at the project level: changes in household bargaining power and changes in time use.

How To Value A Change In Household Bargaining Power?

The basic expected utility model from Module 1 considers the household as one unit. Therefore, all decisions maximize the utility of the whole household. Module 1 showed a formula that didn't distinguish men and women, or husband and wife. But in practice, different household members may have different preferences. This results in having different utilities, which is a measure of satisfaction or well-being. Therefore, household resource allocations need to be considered as an outcome of a bargaining process.

Based on their bargaining process, everybody gets a "slice or a share of the pie". The size of this slice depends on the bargaining weight of an individual. That means how much their opinion weighs on the household decision-making. This is called the collective bargaining model.

Figure 10. Example of Bargaining Weights. Source: CBA for CIS online course, 2024.

Empowerment increases one person's bargaining weight, which means it increases their slice of the pie. It increases how much their preferences or their opinion weigh on the resource allocation for the whole household. When one person gains a higher bargaining weight, they receive a larger share of the resources.

Please watch the following **video** to learn more about this topic.

Bargaining weights offer a way to integrate those changes in empowerment in a cost-benefit analysis. Then, the household's expected utility can be defined as the weighted sum of each individual's utility using the bargaining weights. When the bargaining power of one person increases, it redistributes resources within the household. Important to consider that individual consumption, for example, the wife's consumption, is a share of the total household income, and the size of that share is determined by that person's bargaining weights.

Some additional Considerations.

Bargaining weights are not the only factor that plays a role in empowerment. There is also a trade-off between having extra consumption and working harder versus having less consumption or less income, but more free time through easier work.

Providing women with economic opportunities to enhance their empowerment is usually a desired outcome. If women have more information, that might help them increase their bargaining weight, their income and give them more economic opportunities. But it might also increase their workload on top of their domestic care work and might affect their free time. This is also something that

we have to take into consideration. It cannot be assumed that an increase in economic opportunities and an increase in workload will necessarily be something that increases someone's utility. The question is to what extent women benefit from an increase in control over the use of their income, potentially at the expense of an increase in work burden.

The full household expected utility formula can integrate both bargaining weights and leisure:

$$\text{Expected Utility} = w^h \times \sum_i \text{Prob}(O_{i,h}) \times \text{Utility}(C_{i,h}, L_{i,h}) + w^w \times \sum_i \text{Prob}(O_{i,w}) \times \text{Utility}(C_{i,w}, L_{i,w})$$

where $O_{i,h}$ and $O_{i,w}$ represents each possible outcome, and w^h and w^w are the bargaining weights, for husband (h) and wife (w). Weights will add up to one: $w^h + w^w = 1$.

Figure 11. Household Expected Utility Formula. Source: CBA for CIS online course, 2024.

To calculate this, you need:

- Preferences, time allocations, and income (ag + non-ag), for different household members
- Bargaining weights: Determine the share of consumption out of the household income. Individual consumption = Private income + Weight * Household (public) income. Can be collected using an empowerment tool such as the Women's Empowerment in Agriculture Index (WEAI) that will be discussed in module 3B.

Why does free time matter? It is because we are interested in quantifying the benefits of a reduced workload, which would translate into increased free time. And the way that we are trying to quantify the benefit of reducing workload is through our expected utility framework, in which somebody gets utility or well-being both from consumption and from leisure. And if we didn't have leisure in the utility, then free time indeed wouldn't matter.

Unconstrained preference approach: individual vs. household bargaining dynamics.

The unconstrained preference approach focuses on understanding what people's preferences are when there's no constraint, and then how those change when there's a constraint. It explores how much does the proposed intervention impacts the preferred behavior.

A study conducted with 112 couples in Zambia analyzed how weather forecasts and advisories influence agricultural investment decisions, welfare and intrahousehold bargaining dynamics of married couples, both individually and jointly.

The game:

- Each round is an agricultural season.
- Each round has a fixed budget endowment (no carry over from one round to the next), which be spent on maize seeds, and the rest is saved.
- Participant has 10 fields and has to choose for each field: leave fallow, or plant low/medium/high risk variety.
- Payoffs for each variety depend on weather (low/high rainfall)
- In some rounds, a forecast or forecast + advice is available before the planting decision. In some rounds, you don't have access to anything.
- At the end of the game, 1 round will be randomly paid out, based on the participant's allocations.
- Husbands and wives play 7 rounds individually (separately), followed by 5 rounds played jointly (as a couple), since we want to know how people make decisions as a couple and individually.

This is using the unconstrained preference approach, which means, first, we need to identify what people's preferred behavior is or what their preferences are regarding agricultural investment, regardless of the weather.

To identify that, we consider that decisions under certainty are the preferred behavior regarding agricultural investment:

- Without risk, farmers either save more (when there is 0% rain) or invest more in the high-risk variety (when there is 100% rain).

We also want to measure the impact of people making decisions as a couple versus people making decisions individually:

- An individual's decision, when not influenced by their spouse, is considered their preferred allocation.

The study compared this information with what happens when we introduce climate information services and how they vary from the preferred behavior for men and women.

- Husbands', wives', and couples' investment decisions all respond to forecast information.
- The more favorable the forecast, the riskier the investments made.

- The experiment found that forecasts and advisories cause people to invest more closely to their preferences without risk. This is because of the unconstrained preference approach.

Then, the study researched how CIS impact intrahousehold bargaining.

- When climate information was not provided, decisions taken together were closer to a man's preferences than to a woman's preferences due to the bargaining weights, as the husband has a higher bargaining weight.

- When climate information was provided, decisions became closer to what both men and women chose individually

- Providing forecasts and advice to couples helps both husbands and wives better align with their individual preferences.

- When preferences don't align, and wives and husbands would prefer doing something differently, the bargaining weight determines how much weight is put on someone's individual preference.

The unconstrained preference approach is a way to analyze how an intervention influences people's decisions as compared to their preferred behavior. Now, how do we know if climate information services are making people better off? The study used the formulas shown in Figure 12 to evaluate this.

The study used:

- **Household Exp. Utility** = $w^h \times \sum_i Prob(O_{i,h}) \times Utility(O_{i,h}) + w^w \times \sum_i Prob(O_{i,w}) \times Utility(O_{i,w})$

  where: w^h and w^w are the bargaining weights, for husband (h) and wife (w),
  $O_{i,h}$ and $O_{i,w}$ represents each possible outcome,
  Weights will add up to one: $w^h + w^w = 1$.

- **Utility function** $U_{icr} = \text{Log}(\text{Income}_{icr})$

- **The regression** used to understand how (i) forecast and advice, and (ii) decisions taken individually/as a couple, influence income, is:

$$\text{Log}(\text{Income}_{icr}) = \alpha_c + \text{Wife}_{icr}\beta_1 + \text{Couple}_{icr}\beta_2 + \text{Forecast}_{icr}\gamma_1 + \beta_3\text{Advice}_{icr}\gamma_2 + I(Forecast = x\%)_{icr}\gamma_3 + r_{icr} + \varepsilon_{icr}$$

Figure 12. Unconstrained Preference Approach. Source: CBA for CIS online course, 2024.

The first formula shows the household expected utility as a function of the bargaining weights of the husband and wife times the sum of probabilities of outcome times the utility of each of those outcomes. This study didn't have the risk preferences of participants (r); therefore, it used the log of income as a utility function for simplicity (as seen in Module 2). It is a way to overcome some data limitations when you don't have all the information that you need, without having to assume that there is risk neutrality. It is assumed that risk aversion remains constant over the wealth distribution.

Overall, results reflect the outcomes of a bargaining process. Without CIS, the household member with more bargaining power had more influence on the decisions made. With CIS, women's bargaining position may be stronger. Climate information also influenced the couple's bargaining process to reach a shared and common decision.

Want to know more about it? Consult the following document.

Kramer B, Trachtman C, Zuze L. 2023. Information as a Source of Empowerment: The Role of Climate Information Services. AICCRA Working Paper no.17. Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA). https://hdl.handle.net/10568/135668

Revealed Preference Approach: WTP For Control Over Income And Reduced Workload

The revealed preference approach uses willingness to pay, which is how much someone is willing to pay to have access to something or to remove a constraint or uncertainty. It explores how much income someone would be willing to sacrifice to do so, which is the risk premium.

To estimate whether an increase in women's control over income is big enough to justify an increase in their workload, a study conducted in Rwanda with 1,000 respondents from 5,000 households. Researchers analyzed two indicators of empowerment, the control over income and the time use, and they quantified how the respondents value the trade-offs between the two.

The experiment questions were "how much income is someone willing to sacrifice in order to be paid himself or herself instead of their spouse?" (Risk premium, WTP for control over income, WTP for reducing workload) and "how much is someone willing to pay to free up some free time?" (CE).

This is how information on how much income somebody is willing to sacrifice in order to be paid themselves, as opposed to their spouse, can be collected. That gives a sense of how much people value their own control over income. Figure 13 and Figure 14 show the scenarios that were given for the experiment.

How much income is someone willing to sacrifice in order to be paid him- or herself?
(adapted from Almas et al, EJ 2018)

For these scenarios, do you prefer …

▪ RWF 3,000 paid to yourself	OR	▪ RWF 2,500 paid to your spouse
▪ RWF 2,500 paid to yourself	OR	▪ RWF 2,500 paid to your spouse
▪ RWF 2,000 paid to yourself	OR	▪ RWF 2,500 paid to your spouse
▪ …		▪ …
▪ RWF 1,000 paid to yourself	OR	▪ RWF 2,500 paid to your spouse

Figure 13. Reveled Preference Approach, case study. Source: Almas et al. EJ 2018

How much is someone willing to pay to free up time? (adapted from Agness et al, NBER 2021)

For these scenarios, do you prefer …

▪ RWF 2,500	OR	▪ RWF 2,500 + 1 day of labor
▪ RWF 2,500	OR	▪ RWF 2,000 + 1 day of labor
▪ RWF 2,500	OR	▪ RWF 1,500 + 1 day of labor
▪ …		▪ …
▪ RWF 2,500	OR	▪ RWF 500 + 1 day of labor

Figure 14. Reveled Preference Approach, case study. Source: Almas et al. EJ 2018

This setup allowed researchers to estimate how much participants value a reduction in labor effort. It's important to note that this wasn't a completely free day of labor, since participants still had to give up some of their income from the experiment. However, those who selected the labor option did receive actual labor support in the experiment.

This is a way to assess how much people value their free time or how much they're willing to pay for more free time. For the first experiment question, in the latter choice, most people switch and choose a higher level of income paid to their spouse. For the second experiment question, in the latter choice, as the labor cost goes up, most people switch and choose not to pay for labor. The switching point reveals how much each individual is willing to pay for an extra day of help in the field. Then there was also a survey question which looked at the level of empowerment, which included control over income and time use of men versus women. That found, unsurprisingly, that overall, women are less empowered than men. Some of the contributors to this empowerment were a lack of autonomy in decision-making, limited self-efficacy and high workload.

The results showed that women are willing to sacrifice more household income in order to gain control over income than their husbands. Even when the income is paid in cash or in kind, both men and women are willing to forgo substantial amounts of income in order to free up time. It tells us that time-saving practices and technologies in agriculture might increase empowerment more than just additional economic opportunities. Traditional CBA that only focuses on economic opportunities and monetary outcomes would miss these aspects.

Parametric Approach: Consumption And Leisure.

Please watch the following **video** to learn more about this topic.

In the parametric approach, you need to assume a specific utility function to calculate expected utility. The downside is that choosing the utility function requires making a number of assumptions.

Box 7. Self-check Exercise: Parametric Approach. Consult Annex 1 for the Answers.

1. **Why is it important to consider both control over income and workloads when assessing changes in women's empowerment?**
   a. Because income is more important than time use in all households.
   b. It is not necessary to consider those factors when assessing empowerment.
   c. Because increased control over income may come at the cost of increased workload, reducing overall well-being.
2. **We want to value a change in empowerment from a certain intervention, specifically, how this intervention may influence people's decisions as compared to their preferred behavior. Which approach should we use to value this change in empowerment?**
   a. Unconstrained preference approach.
   b. Revealed preference approach.
   c. Parametric preference approach.
3. **What does an increase in a woman's bargaining weight within a household imply in the context of cost-benefit analysis?**
   a. Her preferences have more influence on the household decisions and resource allocation.
   b. She works fewer hours on average.
   c. Her income is higher than her husband's income.

Key points

Expected Utility is a **measure of an individual's satisfaction** associated with the probability of occurrence of a specific outcome and the individual's risk aversion.

$$\text{Expected Utility} = \sum_i \text{Probability}(O_i) \times \text{Utility}(O_i)$$

A **change in empowerment** can be modeled by specifying household expected utility as the weighted sum of each individual's utility, using **bargaining weights.**

$$\text{Expected HH Utility} = w^h \times \sum_i \text{Prob}(O_{i,h}) \times \text{Utility}(O_{i,h}) + w^w \times \sum_i \text{Prob}(O_{i,w}) \times \text{Utility}(O_{i,w})$$

A **change in time use or work burdens** can be included in the expected utility calculation by adding not only **consumption** but also **leisure** in the utility function.

$$\text{Expected Utility} = \sum_i \text{Probability}(O_i) \times \text{Utility}(C_i, L_i)$$

Full formula:

$$\text{Expected Utility} = w^h \times \sum_i \text{Prob}(O_{i,h}) \times \text{Utility}(C_{i,h}, L_{i,h}) + w^w \times \sum_i \text{Prob}(O_{i,w}) \times \text{Utility}(C_{i,w}, L_{i,w})$$

Figure 15. Expected Utility Key Points. Source: CBA for CIS online course, 2024.

The benefits of climate information services are often discussed in terms of risk, workloads and empowerment. Those impacts that are seen in many theories of change can be valued using expected utility.

Expected utility is a measure of an individual's satisfaction associated with the probability of occurrence of a specific outcome and that person's risk aversion. A change in empowerment can be modelled by specifying household expected utility as the weighted sum of each individual's utility using bargaining weight. A change in time use or work burdens can also be included in the expected utility calculation by adding not only consumption, but also leisure to the utility function.

In the unconstrained preference and the revealed preference approaches, there is no need to specify utility functions for collecting Information on preferences (key to measuring well-being). For the revealed preference approach, you can use WTP as a proxy for the derived benefits from an intervention. For the unconstrained preference approach, you can compare preferences with actual behavior.

For conducting these calculations, yield and prices for various crops, which are usually relatively easily available, can be used. To estimate income from other sources under varying weather conditions (good, moderate, bad), one can use yield and price data for common crops, which are usually readily available. Seed providers often include performance information under different weather scenarios, and it's also important to account for estimated costs of agricultural inputs—such as seeds, fertilizers, herbicides, and labor—under each condition. There are agricultural budgets, commonly used in extension services, that offer structured ways to calculate these costs. These tools and data sources are standard in the agricultural field and should be familiar to practitioners.

Now, in order to calculate expected utility, we've seen that you need to know or estimate the probability of the occurrence of a specific outcome under different possible weather conditions. The following submodule will cover that.

3B: Practical Application of CBA Framework.

Data Requirements To Quantify Non-Monetary Benefits For CBA.

The following video will introduce you to the data requirements for applying the expected utility framework, including the non-monetary benefits from resilience interventions covered in the previous modules.

Please watch the following **video** to learn more about this topic.

Measuring Probabilities at the Project Level.

Calculating probabilities: objective approach.

The objective approach, for all possible outcomes, you can estimate their probabilities using historical data. For example, how good or how bad was the rainfall in the past 30 years?

The following graph in Figure 16 shows the total rainfall per year in Cape Verde, Senegal from 1993 to 2022. Each bar represents how much total rain this region in Senegal got each of those years.

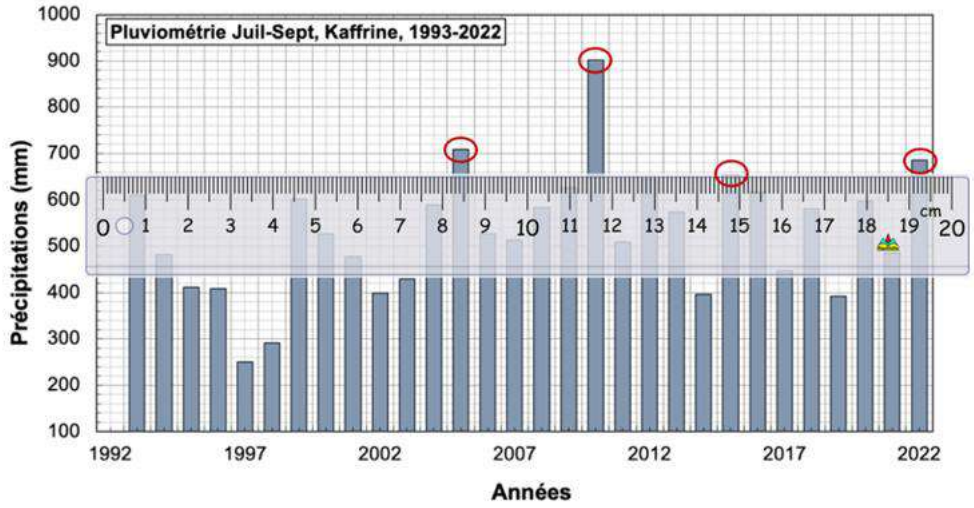


Figure 16. Example of Objective Approach for Calculating Probabilities. Source: CBA for CIS online course, 2024.

In this example, a farmer needs to choose what seeds to buy this year for their crop. The farmer needs at least 650 mm of rainfall for a specific variety chosen to provide a very good yield. What would be the probability of such an outcome if I look at this graph?

This exercise has been conducted in the field even with illiterate farmers. There are different ways of explaining depending on the level of education of the people working with.

Using the graph, we would look at precipitation to determine how many times in the past, in the historical information shown in the graph, the total rainfall was above 650mm. In this example, 650 mm of rainfall occurred four times in the past 30 years of data; therefore, the probability is 4 out of 30. Would the farmers invest in this specific variety if their chance of getting a very good yield is 4 out of 30? Not.

With climate change, historical data cannot provide you with a forecast or a prediction of what will happen for sure, but it will give a sense of a probability for the specific area based on a long dataset, needing at least 20 years of data. More advanced approaches would use climate or crop models combined with forecasts. Then, forecasts will be able to tell aspects such as the probability of some events happening in the next rainy season or the probability of the next rainy season being well above average. But without a forecast, the objective approach can provide a first layer of understanding of probabilities.

Estimating Probabilities: Subjective Approach.

The subjective approach is a participatory process. For example, you ask farmers to state the number of years that they expect good weather, moderate drought, or extreme drought, say for the next 10 years. This is based on farmers' perception.

This can be done more advanced by conducting an expected elicitation method using visual tools, such as tokens that you can give to farmers. For example, you give farmers 25 tokens, and they have to distribute them within five bins that each indicate a different income range. This is shown in Figure 17: the first bin is income between 0 and 2,000, the second bin is income between 2,000 and 4,000, etc.

Figure 17. Example of Subjective Approach for Calculating Probabilities. Source: CBA for CIS online course, 2024.

You ask them to distribute their tokens among those different bins based on their perception of the number of years that they expect good weather, moderate weather, and bad weather for the next 10 years. The number of tokens that they put in each bin divided by the total number of tokens is the probability of that outcome according to farmers' perception.

In this example, each token represents a 4% chance. That would mean that they consider that there's an 8% chance that they earn between 0 and 2,000. Then the highest probabilities would be between 4,000 and 6,000. This is a subjective method, but it's based on farmers' understanding of their environment, experience and perception.

Measuring Risk Aversion at the Project Level.

Measuring risk aversion may involve asking individuals to choose between a sure, less risky payment and a riskier option. In the coin toss example, if a participant chooses to gamble, the payment depends on whether the coin lands on heads or tails, and if the participant chooses the sure payment, then the amount is fixed and there's no actual risk. These choices can be incentivized, meaning the selected option is played out and real money is paid based on the outcome.

Risk aversion can also be measured through unincentivized methods, which are purely hypothetical and don't involve real payouts. One example is the staircase method, used in the Global Preference Survey. It's similar to the coin toss exercise, but participants are asked to make a series of hypothetical choices.

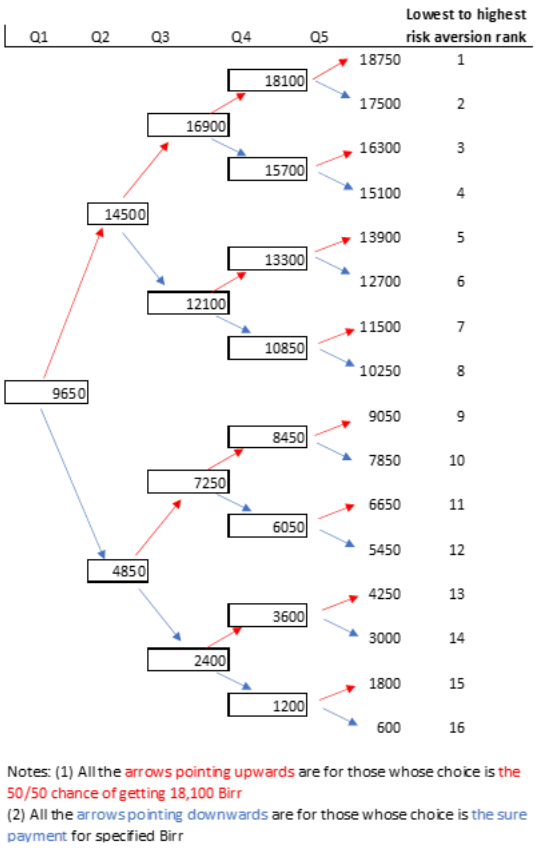


Figure 18. Measuring Risk Aversion: Decision Tree. Source: Kramer et al., 2023

The image shows an example of the staircase method, where the risky option is always a 50/50 chance between obtaining 18,100 Birr and zero. The amount of the guaranteed payment offered varies in each round. For instance, a participant might be asked:

- Would you prefer a guaranteed payment of 9,650, or a 50% chance to receive 18,100 or zero?

- If they choose the sure payment, they are then asked: Would you prefer a guaranteed 4,850, or again, a 50% chance at 14,500 or zero?
- Or if they had previously chosen the gamble: Would you prefer a sure 12,100 or take another 50% chance to win 16,900 or zero?

This process continues step-by-step, and by tracking when someone switches between the sure and risky options, researchers can rank individuals from least to most risk-averse.

Since this method is unincentivized, it's more cost-effective—no actual payouts are made, and the experiment is cheaper to run. However, it can introduce hypothetical bias, where participants might respond differently than they would if real money were at stake.

Want to know more about it? Check the Global Preference Survey **here** to download this instrument for a lot of different countries and currencies.

Box 8. Self-check Exercise: Data Requirements to Quantify Non-monetary Benefits. Consult Annex 1 for the Answers.

1. **What is the main difference between the objective and subjective approaches to estimating probabilities at the project level?**
   a. The objective approach uses expert opinions, while the subjective approach relies on historical data.
   b. The objective approach uses historical data, while the subjective approach is based on farmers' perceptions.
   c. The objective approach is based on farmers' perceptions, while the subjective approach uses forecasts.
2. **Consider a subjective elicitation exercise with five bins representing incomes between $0-2000, $2000-4000, $4000-6000, $6000-8000 and $8000-10000 during good weather. What does it mean if a farmer places 10 tokens out of 25 in the income bin representing earnings of 4,000–6,000?**
   a. The farmer believes there's a 60% chance of earning more than 6,000
   b. The farmer expects to earn 4,000–6,000 in 10 out of 25 years.
   c. The farmer perceives a 40% chance of earning between 4,000 and 6,000 during good weather.
3. **What is one key limitation of using the unincentivized "staircase method" to measure risk aversion?**
   a. It requires real payouts, making it expensive to implement.
   b. It does not allow participants to choose between risky and safe options.

c. It may introduce hypothetical bias since choices don't involve real consequences.

Measuring A Change In Time Use And Workloads at the Project Level.

The following video will cover how changes in time use and workloads might be valued, as the expected utility is also a function of how much free time somebody has.

Time allocation

Please watch the following **video** to learn more about this topic.

There's a wide range of interesting methods coming up nowadays to measure time use, and more research is being done on validating these different methods:

- Using logbooks, video diaries to document what people are doing at a given time of the day or apps where people can log in their time as they're starting a new activity.
- Methods to record both child care as a secondary activity and the primary activity at the same time. Especially useful for women who might be typically multitasking, such as farming and doing childcare at the same time.
- Using wristbands and movement trackers to measure how intensive the activities people are doing. For instance, if people are doing very hard work in the field, the tracking would pick this up as a strenuous activity.

Valuation of time

How much consumption is someone willing to forgo in return for an extra hour of time?

Please watch the following **video** to learn more about this topic.

Measuring Empowerment at the Project Level.

The other component in the expected utility framework is empowerment. This submodule will cover two tools for measuring developed by researchers from the CGIAR. The first one is the Project-level Women's Empowerment in Agriculture (Pro-WEAI), and the second one is the Gender Empowerment Index for Climate-Smart Villages (GEI-CSV).

Project-level Women's Empowerment in Agriculture Index (Pro-WEAI)

The Project-level Women's Empowerment in Agriculture Index (Pro-WEAI) is a specialized tool designed to measure how agricultural development projects affect women's empowerment. It builds on the original Women's Empowerment in Agriculture Index (WEAI) and adapts it to better capture the project level impacts in a more context-sensitive way.

Pro-WEAI has 10 core indicators with two optional indicators. There are optional modules with particular emphasis on livestock, nutrition and health. It focuses on three distinct types of agency, which reflect different dimensions of empowerment:

- Intrinsic agency ("power within"): how a woman views herself, her rights, and her role within the household and society.
- Instrumental agency ("power to"): whether women can take actions and access resources that improve their lives. It addresses the tangible aspects of empowerment, such as mobility, financial autonomy, and decision-making power.
- Collective agency ("power with"): captures the ability of women to act together and engage in collective action.

Each domain is equally weighted, ensuring a balanced view of empowerment across internal beliefs, practical capabilities, and social relationships.

Pro-WEAI does not directly ask about experiences of violence, but it uses attitudinal questions to infer power dynamics. However, these sensitive questions require strict ethical protocols, such as ensuring privacy during interviews and building trust with the respondent.

Recommended Use Cases

- Projects with explicit empowerment goals: Pro-WEAI directly measures outcomes relevant to such objectives.
- Gender-responsive projects: Even if empowerment isn't the main goal, gender-responsive components may impact empowerment.

- Gender-blind interventions: Measuring empowerment helps identify unintended consequences.

Whether or not empowerment is a primary goal of a resilience intervention, using Pro-WEAI can improve your understanding of how interventions affect women—and help ensure more equitable outcomes. By measuring empowerment, we can identify negative spillovers, adjust project design accordingly and monitor to ensure equitable benefits.

Figure 19. Pro-WEAI Wheel. Source: IFPRI.

Want to know more about it? Consult the Pro-WEAI resource center **here**.

Gender Empowerment Index for Climate-Smart Villages (GEI-CSV).

The GEI-CSV assesses whether climate-smart agriculture (CSA) approaches contribute to greater empowerment of both women and men. It allows for comparison across Climate-Smart Villages (CSV) and non-CSV areas, as well as between genders.

The index builds on the Women's Empowerment in Agriculture Index (WEAI), but is adapted to measure empowerment in the context of CSA interventions. It includes four domains: political (10% weight), economic (30% weight), agricultural (30% weight) and social (30% weight).

Respondents (both women and men) answer statements using a five-point Likert scale (ranging from strongly disagree to strongly agree). For the GEI-CSV calculation, only "Agree" and "Strongly Agree" responses are scored as 1; all other responses are scored as 0. Scores are summed within each domain, and the total GEI is calculated using the domain weights. An example of a

statement could be "Since the project intervention, I have been able to increase my ability to speak publicly in forums in my village".

It is broader in scope than Pro-WEAI, as it includes political and social domains in addition to economic and agricultural dimensions. Unlike Pro-WEAI, which measures current empowerment, the GEI-CSV captures perceived changes in empowerment by asking respondents to reflect on how their situation has changed since the intervention.

Measuring empowerment: Pro-WEAI and GEI-CSV limitations.

Tool	Characteristics	Limitations
Pro-WEAI	• Measures empowerment within agricultural development projects. • Focuses on the intrinsic, instrumental and collective agencies within the human, economic and social domains. • Survey-based tool: household and individual-level surveys with a mainly quantitative focus. Less subject to social desirability bias. • Complemented with a qualitative module to contextualize findings.	• Not specific for climate-related projects (but adaptations on the way). • Some survey questions may include value judgments which can make consistent interpretation difficult. • Need to address intersectionality as part of the sampling design. • Using Pro-WEAI for impact evaluations requires a treatment and control group that uses statistical techniques for comparing changes. This will be further explored in Module 4.
GEI-CSV	• Measures empowerment within climate-smart agricultural interventions. • Focuses on the inter and intrahousehold empowerment level within the political, economic, agricultural and social domains. • Self-reported tool through a structured questionnaire: qualitative and quantitative participatory methods.	• Limited applicability outside climate-related projects. • Relies on self-reported changes based on a Likert-scale. • Weights assigned to the indicators are determined through Focus Group Discussions which may introduce bias and be more resource intensive. • Builds partly on Pro-WEAI but additional indicators reduce its foundation in theory.

Figure 20. Pro-WEAI and GEI-CSV characteristics and limitations. Source: CBA for CIS online course, 2024.

It is also important to mention that, in principle, both members of the household, male and female, have to answer the surveys. In that way, we get the individual perceptions of empowerment, which allows us to construct bargaining weights based on the husband's and wife's scores. These interviews need to be done in private. That's just part of what makes it resource-intensive, having sort of an interview with both husbands and wives. The husband and wife cannot be sitting together and responding to these questions. If you're not much interested in the bargaining weights or in the gender parity, then you could also interview just wives and still get a women's empowerment score.

The Pro-WEAI may be more suitable for measuring project impacts more rigorously because of its use of Likert-type scale. As an exploratory tool to see where changes might potentially be observed, the GEI-CSV is a good tool.

Valuing The Cost Of A Climate Information Service.

This module has already covered how to assess the probability of an event occurring. It has also covered how to get a number for the risk aversion using the decision tree. And it has also covered how to measure empowerment from an intervention. Now, this submodule will cover another parameter which is to measure costs of a climate information services project in resilience building interventions.

There is currently no standardized approach to costing climate information services (CIS) development and implementation. One of the main challenges is that costs are distributed across multiple actors along the CIS value chain. Additionally, costs vary significantly depending on the type of CIS approach used—an area that remains under-documented.

Some fixed production costs are relatively straightforward to quantify. These include software development, mobile phones, vehicles (e.g., motorbikes), physical offices (with electricity, rent, etc.), meteorological station installation and maintenance, servers, and depreciation of office equipment.

There are also variable production costs, which can include staff salaries, stationery, training materials, monitoring activities, media promotion (especially relevant for communication-focused CIS), transportation, data analysis, and general overheads. These costs tend to fluctuate depending on the specific design and delivery method of the project.

Want to know more about it? Consult the following info note.

List, G., Kramer, B., Timu, A., Zebiak, S., & Rose, A. (2022). Costs of Climate Information Services Development and Implementation: A stakeholder consultation survey to inform a cost-benefit analysis toolkit. AICCRA Info Note. https://hdl.handle.net/10568/127022

Box 9. Self-check Exercise: Data Requirements to Quantify Non-monetary Benefits. Consult Annex 1 for the Answers.

Nyando is a basin in Western Kenya experiencing prolonged dry seasons, increased incidence of pests and diseases and extreme flooding. The region grows diverse crops including maize, beans and sorghum. We want to implement a Climate Information Service in a smallholder farming community in Nyando for informing their agricultural activities.

1. **Which data we would need to collect for applying the expected utility framework to evaluate women's and men's wellbeing from the intervention under different weather outcomes?**

    a. Only household income and yield data under normal and extreme weather conditions.

b. Data on income or consumption under different weather scenarios, risk preferences, weather scenarios probabilities, bargaining weights and leisure time for women and men within the household.

c. Climate forecasts, fertilizer use, and regional GDP to model productivity trends.

Wrap-up of Module 3

The data requirements to quantify several non-monetary benefits for cost-benefit analysis are:

- Improved risk management – data on risk preferences and income distribution.
- Changes in workloads – data on time use and one's valuation of time.
- Women's empowerment – individual data on bargaining weights.

Cost-benefit analysis helps compare the program costs with the monetary resources needed to equalize expected utility for those without and with CIS. Empowerment at the project level can be measured through Pro-WEAI and GEI-CSV. The first one provides indicators of intrinsic, instrumental and collective power, measured before and after an intervention. The second one captures self-reported changes in political, economic, agricultural and social power.

Recommended Readings

- Hickman, W., Kramer, B., Mollerstrom, J. & Seymour, G. (2023). ICES Discussion Paper. Fairfax, VA: George Mason University. https://d101vc9winf8ln.cloudfront.net/documents/46102/original/Valuing_Control_Over_Income_and_Time_Use_A_Field_Experiment_in_Rwanda_by_Hickman_et.al.pdf
- Hariharan, V. K., Mittal, S., Rai, M., Agarwal, T., Kalvaniya, K. C., Stirling, C. M., & Jat, M. L. (2020). Does climate-smart village approach influence gender equality in farming households? A case of two contrasting ecologies in India. Climatic Change, 158(1), 77–90. https://doi.org/10.1007/s10584-018-2321-0
- Malapit, H., Quisumbing, A., Meinzen-Dick, R., Seymour, G., Martinez, E. M., Heckert, J., Rubin, D., Vaz, A., & Yount, K. M. (2019). Development of the project-level Women's Empowerment in Agriculture Index (pro-WEAI). World Development, 122, 675–692. https://doi.org/10.1016/j.worlddev.2019.06.018

MODULE 4: EVALUATION METHODS TO GENERATE MORE RIGOROUS CBA ESTIMATES.

Module Overview

Welcome! Module Four will cover how we can evaluate resilience interventions in order to get more rigorous cost-benefit analysis estimates. We will start with evaluation concepts, including causal inference, counterfactual and average treatment effect. We will discuss validity in evaluation, and then we will bring up some of the challenges in resilience impact evaluation. Then, we will present different evaluation design approaches to assess the causal impact of interventions. Finally, we will also talk about how to plan credible resilience evaluations and what some of the research ethics considerations are. Instead of having to base our estimates on previous work and strong assumptions to estimate of how much resilience would be improved as a result of a resilience intervention, these approaches will help us in designing the rollout of these types of interventions in such a way that you can then inform cost-benefit analysis with rigorous estimates.

Learning Objectives

4.1 Understand key evaluation concepts (e.g. ATE, counterfactuals) to assess causal impacts of resilience interventions.

4.2 Compare experimental and quasi-experimental evaluation methods, and select appropriate designs for cost-benefit analysis.

4.3 Identify and address gender-related challenges and biases in impact evaluations.

4.4 Consider ethical principles and practical guidelines when designing, implementing, and analyzing resilience evaluations.

4A: Evaluation Concepts.

Evaluation Concepts: Importance Of Causal Inference.

- Evaluation: A systematic, objective assessment of a development intervention, in terms of impacts, outcomes or processes.
- Indicator: An objective metric used to quantify an impact or an outcome.
- Treatment and control: When interventions apply to a population of individuals, an evaluation involves comparisons of indicators between samples from intervention (or treatment) and comparison (or control) groups.
- Average Treatment Effect The average difference in outcome between a group that receives the intervention (treatment) and a group that does not (control).
- Counterfactual: What the state of the intervention group would have been in the absence of the intervention (hypothetical scenario).
- Attribution. Causal relationship between an observed change and an intervention's impact or outcome, accounting for all other factors that might influence the change.
- Process evaluation:

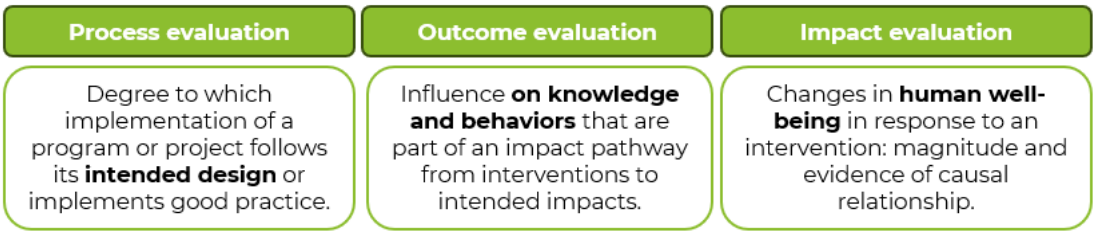


Figure 21. Importance of Causal Inference, Process Evaluation. Source: CBA for CIS online course, 2024.

Establishing causal effect: Average Treatment Effect.

The Average Treatment Effect (ATE) is the average difference in outcome between the group that receives the intervention (the treatment group) and the group that does not receive the intervention (the control group). It is calculated as shown in Figure 22:

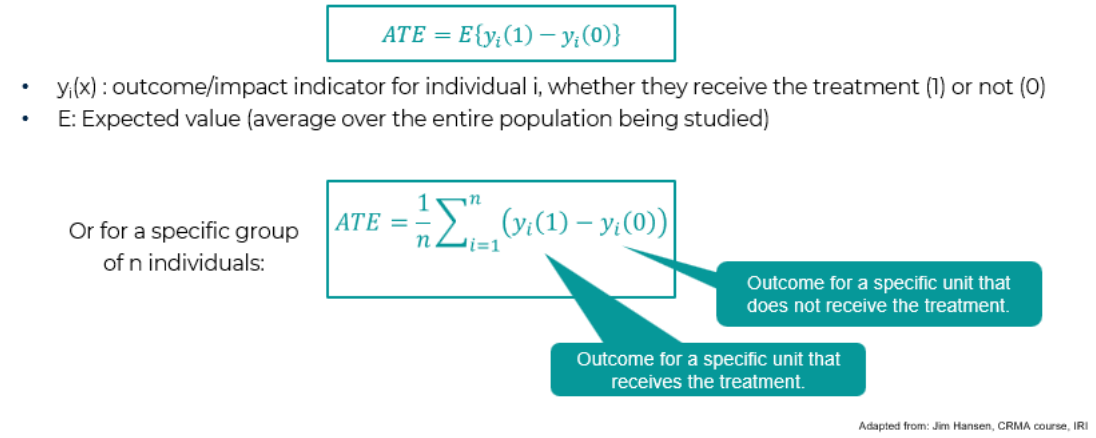


Figure 22. Average Treatment Effect. Source: adapted from Jim Hansen, CRMA course, IRI.

Please watch the following **video** to learn more about this topic.

In the average treatment effect, we are interested in the difference between the outcome for individual *(i)* if treated versus that same individual *(i)* if not treated. This covers the theoretical treatment effect for a given individual, which we can't observe in practice because if the moment somebody is treated, you can't see the outcome if not treated anymore.

Establishing Causal Effect: Counterfactual.

The counterfactual is the state of the intervention group in the absence of intervention. It helps us evaluate what their state would be if the group had not received the intervention. Without the counterfactual, you cannot distinguish whether a change in an outcome is due to the treatment or to other factors, which is very important for attribution. Considering the counterfactual is relevant as you can't observe the treated and the untreated outcomes simultaneously. Everyone is either in the treated group or in the control group, but not in both.

There's a whole body of evaluation methodology that has been developed to estimate the counterfactual because it is a hypothetical factor. The counterfactual cannot be directly observed because it's theoretical.

We can use the outcomes from the control group as an approximation of the counterfactual. Because the group is receiving the treatment, we can only estimate what would have happened to them using the control group. If the control group is well chosen and comparable to the treatment group, then their

outcomes can provide a good estimate of the counterfactual for the treatment group.

The confounding factors and the different types of biases can hide or distort the observed effects of an intervention. To deal with these factors, the following submodules will look at different approaches. In order to be able to attribute the change that you see to the intervention, you have to have those different methods to deal with the confounding factors and the potential biases that come into play.

Challenges In Impact Evaluation: Attribution

In Figure 23, we are looking at a potential intervention. On the horizontal axis, you see time and on the vertical axis, you see income.

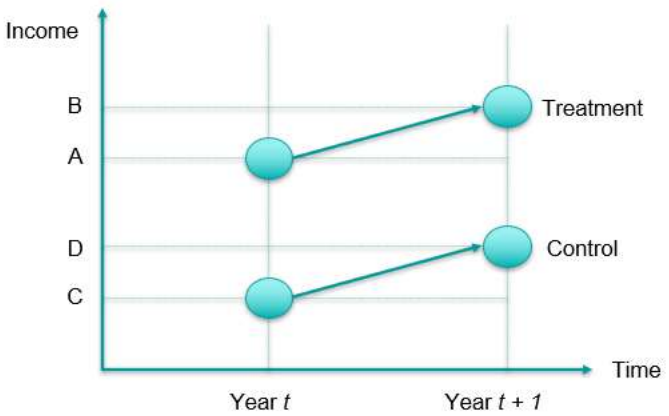


Figure 23. Graph Income vs. Time, as an Example to Analize Attribution. Source: CBA for CIS online course, 2024.

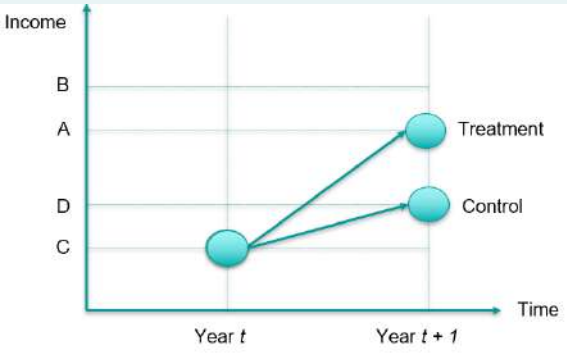
If at time t, people have an income of an amount of A and later in time at time t + 1, they have received the treatment and they have an income of B, an increase in income. Can we consider yes or no that the treatment effect is income B minus income A? The answer is no, because we need to know the counterfactual. This means that we need to know what would have happened to those same people if they had not received the treatment. Maybe their income would have increased the same way without the treatment due to other factors. Since we can't know that for sure, because they did receive the treatment, we use a control. In this example, the change in income for the counterfactual is D minus C, the change in income within our control group. In this case, we can see that there is the same change in income between time t+1 and time t, between the control group and the treatment group. The income has increased in the control group the same way as it has increased in the treatment group, which means the program effect is zero. The control group

didn't receive the treatment, which means their increase in income is due to something else.

Timing for conducting evaluation depends on the type of intervention, how much time it would take for the impacts to materialize, which would typically be the time over which you would want to measure outcomes. For example, if you have an agricultural intervention providing information in the middle of the year and in the middle of the growing season, it's unlikely that people can act on that information in that same season. Then, it would make sense to wait another season to evaluate what happens in the next season with planting decisions. Typically, we'd say in an agricultural intervention, you'd be looking at a period of at least one year or 1.5 years to get to that next season.

Box 10. Self-check Exercise: Challenges in Impact Evaluation. Consult Annex 1 for the Answers.

1. **What is the program effect in the example from the graph?**



   a. D – A

   b. A (income of the treatment group after the intervention)

   c. A – D

2. **Why do we need a counterfactual when establishing casual effect from resilience intervention's outcomes?**

   a. To measure how the intervention performs compared to similar projects in other regions.

   b. To calculate the financial cost of the intervention relative to its direct benefits.

   c. To know the state of the intervention group in the absence of intervention and identify other factors involved in the change of the outcomes.

3. **How can we measure the counterfactual when evaluating a resilience intervention?**

a. To know the state of the intervention group in the absence of intervention and identify other factors involved in the change of the outcomes.

b. Using the outcomes of the control group as an approximation of the counterfactual.

c. Establishing a specific group, apart from the treatment and control group, as the counterfactual.

Validity In Evaluation: Internal And External Validity.

Internal Validity.

- Degree to which observed effects can be attributed to the intervention rather than other confounding factors.
- High internal validity: there is confidence that the intervention is the cause of the observed outcome, and not some other factor.
- Achieving high internal validity requires rigorous study designs, such as randomization (reduces selection bias and confounding factors) and control for confounders. Those study designs will be covered in the module later on.

External Validity.

- Degree to which conclusions can be generalized to other populations, times or contexts.
- High external validity: the conclusions drawn from the study are likely to apply to populations or contexts that were not included in the study itself.
- Achieving high external validity often involves real-world settings, diverse samples, and observations over longer periods.

4B: Challenges in impact evaluation of climate adaptation interventions.

Individual characteristics (e.g., wealth, education, gender, risk tolerance or risk aversion) can lead to:

- Differences between adopter and non-adopter populations (self-selection bias).
- Different impacts within the adopter's population (impact heterogeneity).

There can be a time lag between intervention and impacts, because of:

- Time-varying climate impacts require many years to obtain robust estimates.
- Lag in building capacity to generate, translate, deliver, and use climate information. For example, you might start implementing your project, but it takes time for people to be familiar with all the information and start implementing it and getting better at using it.

Challenges in attributing impacts to specific interventions, because:

- The impact of resilience-building initiatives can come through synergies with other development interventions that are happening at the same time.
- It is difficult to isolate climate from other factors of change.

Climate information is shared along social and institutional networks (spillover effect), whilst a control sample should not have access to information.

Gender Considerations In Ates: Challenges.

When evaluating the ATE of an intervention, we aim to measure the causal impact of the treatment: what is the change that we are observing attributed to our treatment? However, gender considerations can become confounding factors that can distort the estimates if they're not accounted for:

- Gender response biases can occur when men and women respond differently to the same intervention because of differences in reporting or social/cultural influences on responses. It's not because the intervention affects them differently, but because of differences in reporting behavior.
- Gender composition of the respondent sample and the interviewer's gender can bias conclusions about the effectiveness of gender-focused interventions.
- Gender differences in take-up of or access to the intervention, as well as complementary products and services, could influence the impacts observed. For example, when a climate service is accessed through an app, it may be more accessible to men.

Self-reported data collection methods (e.g., surveys or interviews where participants describe their behaviors, attitudes, outcomes) can produce socially desirable outcomes. It occurs when somebody gives a response not based on what they think, but based on what they think is the most acceptable, either for the interviewer or based on cultural context. E.g.: In male-dominated

households or societies, women might provide responses that align with their husbands' or community leaders' views, rather than their own experiences. This tends to happen in focus group discussions or participatory processes. Gender-separated processes are needed because women may not say the same things or will not participate as much when in the presence of the elders or their husbands.

Gender Considerations In ATEs: How To Address Those Challenges.

One key concern in gender-focused ATE studies is response bias driven by the gender dynamics between interviewers and respondents. There are two effective strategies to mitigate this:

- Random pairing of interviewers and respondents: This approach tests for—and helps balance out—gendered interviewer effects on responses.
- Same-gender pairing or using interviewers of one gender: This reduces discomfort or social pressure, especially in sensitive topics.

By ensuring either random or controlled pairing, you create a cleaner data environment less impacted by gendered response biases. Further, you can estimate ATEs separately for men and women to avoid gender response bias.

To reduce gender-related confounding factors, identify pretreatment covariates. These are characteristics of individuals, groups or units that are not influenced by the intervention (e.g., education, age, asset control). These can be used to control for confounding factors. For example, a baseline measure of women's role in decision-making within the household will provide context on whether or not a woman is likely to have an independent perspective or be influenced by her husband. That baseline measure of her bargaining weight will give an indication of how likely she is to be affected by the social desirability bias or how likely she is to be able to say what she thinks, even in front of her husband. It provides complementary information to help make choices for controlling potential biases. These covariates are then used to balance treatment and control groups, accounting for background differences that might bias the ATE.

Since socially desirable answers often distort self-reported data, employing alternative measurement techniques helps mitigate these biases. Conducting conjoint experiments is an alternative; participants choose among hypothetical scenarios (like seed types or cropping systems), revealing trade-offs rather than direct opinions—minimizing desirability bias. Implicit Association Tests (IATs) are another alternative, which helps measure subconscious attitudes or biases by analyzing reaction times when people associate specific concepts. There are also direct behavioral measures, which involve observing the actual behavior rather than relying on self-reported behaviors.

4C: Evaluation Design Approaches - Assessing The Causal Impact Of Interventions.

This submodule will cover five different types of evaluation design approaches: randomized control trial (RCT), propensity score matching (PSM), instrumental variable (IV), regression discontinuity (RD) and difference in difference (DID). For each of those, it will cover pros and cons, how they work, what they help address, why you would choose each approach and examples.

Randomized Control Trial (RCT)

Please watch the following **video** to learn more about this topic.

Here is another example of RCT: a government launches a radio program that aims at teaching farmers climate -resilient practices. You want to know the impact of that program on farmers' adoption of climate resilience practices. But because it's broadcast publicly, all farmers typically have equal access to it. Therefore, you cannot randomize who listens to the program or not, as it is not possible to control that. But what can be done is creating an encouragement to listen to the program, which is something that can be randomized. Some farmers would be randomly assigned to receive an encouragement to listen to the program, and others wouldn't. If the encouragement is effective, then more farmers would be seen in the treatment group, in people who receive the encouragement, as compared to the control group.

What if you cannot randomize access?

- When you cannot randomize the intervention (e.g., a TV show or radio program), and everyone has access, consider an encouragement design, as assigning groups through randomization may be difficult.
- In this type of design, the randomly assigned treatment is an encouragement to access or use the intervention, not the intervention itself.

This creates random variation in the probability of an individual accessing the intervention. Feasible when intervention uptake is low without encouragement, and increases considerably with encouragement.

Strengths of the RCT:

- It provides a straightforward estimation and interpretation of the results.
- Randomization also allows for control of selection bias.

Limitations of the RCT:

- Confounding spillovers will be present if the control group is too close to the treatment. For example, if the treatment group have some family members in the control group, and they talk to each other, some people in the control group may have access to the treatment.
- The exclusion of a control group can be impossible or unethical.

Difference-in-Difference (DID)

Please watch the following **video** to learn more about this topic.

To test if the assumption made for the DID approach is true, we need pre-baseline data or another type of data that allows us to test this assumption before the intervention. For example, having data a year before the intervention (t_{-1}) and the year of the intervention (t) for the treatment and control group, it can be assessed whether the difference in yields from t_{-1} to t in the treatment is the same as the difference for the control. If those two are the same, then the parallel trends assumption is satisfied. Alternatively, administrative data or remote sensing data can also be used. Remote sensing can be used as a proxy to show that there were no changes in cultivation patterns or in yields in the treatment group that weren't observed in the control group before the intervention.

Figure 24 shows another example where you may want to evaluate the effectiveness of a new resilience intervention in improving crop yields.

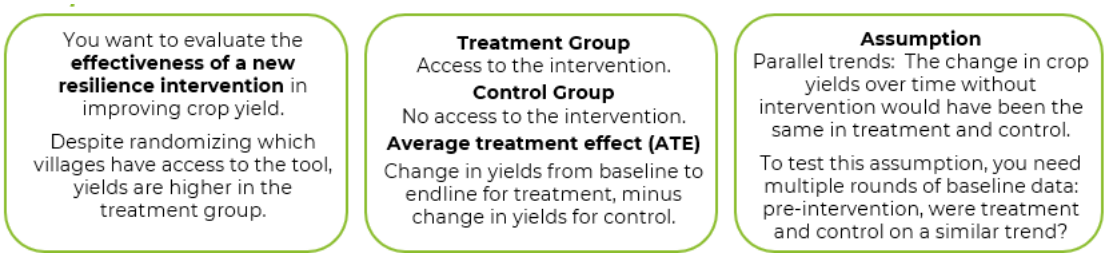


Figure 24. Difference-in-Difference Approach, Example. Source: CBA for CIS online course, 2024.

In the example, it was randomized which villages have access to the tool, but in the treatment group, yields are higher. Therefore, we need to control for those baseline differences. Accidentally, something went wrong in the randomization, some of the villages assigned to the treatment just had too high

yields compared to what was assigned to the control group. Then, we estimate the ATE by comparing yields from baseline to endline for the treatment versus the control.

Strengths of the DID:

- It filters out unobservable time-invariant differences between groups. For example, if in the control group, the counterfactual might have increasing yields, then an increase from before to after in the treatment group is not necessarily an impact that can be attributed to the intervention. Then, it is necessary to control for the change that would have happened either way in the control group. That's where DID is a very powerful tool.

- When randomization is not feasible, it helps reduce selection bias compared to other methods.

Limitations of the DID:

- Differences between intervention and control groups are assumed to be constant over time. If those trends are not constant, if, for instance, adopters were increasing yields at a much faster rate than non-adopters, then the difference in difference method isn't going to work. Unless there is a third round of data for the difference in difference to filter out those changing trends.

- Testing for parallel trends requires multiple rounds of baseline data or having administrative or baseline data.

Instrumental Variable (IV)

Please watch the following **video** to learn more about this topic.

Strengths of the IV:

- Exploits an external source of variation to estimate intervention status when participation is voluntary.

Limitations of the IV:

- Depends on an instrument that is strongly correlated with participation, but has no causal relationship with impact.

When using instrumental variables, we start with three main elements: a treatment variable, which indicates whether someone was exposed to or used an intervention; a dependent variable, which is the outcome we are interested in; and an instrumental variable. The process happens in two steps. First, we estimate the effect of our instrument, which is exogenous to the treatment. From this, we get a predicted treatment or predicted exposure. Second, instead of looking at the effect of the actual treatment on the dependent variable, we examine the effect of the predicted treatment on the dependent variable. This is why the estimation is done in two steps.

For the instrumental variable to be useful, it needs to meet certain conditions. First, the first stage needs to be strong enough, meaning the instrument must be relevant and should predict enough of the variation in treatment or intervention status. Second, it must be a valid instrument, which is difficult to show. Proving validity requires a deep understanding of the context and the intervention, especially to explain why the instrument affects the treatment exposure directly, but does not affect the outcome variable except through its influence on treatment exposure.

To see why instrument validity is so important, consider a case where we use distance from a demonstration hub as an instrument to study the adoption of practices promoted at the hub. While distance might predict whether people visit or engage with the hub, it can also be related to many other things. People living farther away may be in more remote areas, may lack transportation, and may struggle to bring back recommended inputs. Distance might also be tied to different climatic conditions that affect whether the practices are suitable. And since demonstration hubs are often located near agro-dealers or input retailers, people living closer may already have better access and may have been more likely to use the recommended practices even before the hub existed. In this case, distance could influence adoption through several other factors, not just through contact with the hub, making it a poor instrument.

Because finding a good instrument is so challenging, researchers sometimes create their own. For example, we might randomize whether someone receives reminders about a radio program, hoping this encourages them to listen. If listening affects their exposure to the treatment, we could use the reminder as an instrument. Sometimes this works well, but it's still important to think carefully about all the possible ways the instrument might be related to the outcome, beyond its link through the treatment. If other pathways connect the instrument and the outcome, it's better not to use instrumental variables at all, since the results won't be credible.

For example, in a randomized controlled trial where only 50% of the treatment group used the new technology, and even 10% of farmers in the control group ended up using it, a possible instrumental variable could be whether or not a farmer was assigned to the treatment group. You would assume that being

assigned to the treatment encouraged the use of the new technology. This assignment would then be used as the instrumental variable. The idea is that it affects crop yield only through its influence on the use of the technology, and not through other factors. You would first estimate how likely a farmer is to adopt the technology based on whether they were assigned to the treatment or not. Then, you would examine how this predicted adoption is related to actual crop yield. In this way, you combine the randomized assignment with instrumental variable estimation by using treatment assignment as the independent variable.

Propensity Score Matching (PSM)

Please watch the following **video** to learn more about this topic.

Strengths of the PSM:

- Reduces self-selection bias on observable characteristics. Although self-selection bias on unobservable characteristics is not being corrected.
- Can exploit secondary demographic data for matching variables. If baseline data is not available, but secondary demographic data is available. Then, demographic data can be used even if there is no baseline data.

Limitations of the PSM:

- It is assumed that the selection on unobservable characteristics would be completely controlled for by the observable characteristics. That might not be the case, for example, there may be more progressive farmers who have the same demographic characteristics as less progressive farmers. These just happen to adopt better technologies that are faster rate than less progressive farmers, and for that reason, there may be better outcomes.
- It can require large samples since it excludes a portion of available data, as the right matches have to be looked for.
- Impact estimates can be sensitive to propensity variables and the matching method. For instance, if gender is being left out, propensity score treatment estimates can be very different compared to when gender is included.

In summary, in propensity score matching, we have baseline characteristics of our intervention sample. We do not have a randomized control group, but we

do have data for other households collected as part of the same baseline data collection stage. We can look for the right matches for our intervention sample in the control work. For instance, households, farmers and individuals who are as close as possible to the people in our intervention sample.

Regression Discontinuity (RD)

Please watch the following **video** to learn more about this topic.

Strengths of the RD:

- Exploits eligibility cutoff to reduce selection bias.
- Easy to visualize and intuitive to communicate with policymakers.

Limitations of the RD:

- Limited to programs with eligibility thresholds.
- Depends on the assumption that intervention and comparison groups are similar at the cutoff.

This method is very easy and intuitive to visualize. In a regression discontinuity, there's a threshold; just above and just below that threshold, people are very similar. This could be, for instance, a program that is targeting people with certain levels of income or credit scores. People just above the credit score threshold are very similar to people just below the threshold. These can be used as a treatment and a control because they're very similar.

The challenge in RD is the need to evaluate a program that has an eligibility threshold. There also needs to be an assumption that at the cutoff, the intervention and comparison groups are very similar.

Strengths And Limitations Of The Evaluation Approaches.

Method	Summary	Strengths	Limitations
Randomized control trial (RCT)	Individuals or locations assigned randomly to intervention and control groups. Impact estimated as difference in indicators between intervention and control groups.	Straightforward estimation and interpretation. Randomization controls for selection bias, baseline not absolutely required.	Likely confounding from spillover if control and treatment are too close. Exclusion of control group can be impossible or unethical.
Difference-in-difference (DID)	Impact estimated as difference in change of indicators between intervention and control groups during intervention period, based on panel data.	Accounts for unobservable time-invariant differences between groups. Reduces selection bias in adoption of the intervention.	Requires baseline data. Differences over time or trends assumed constant between intervention and control groups.
Instrumental variable (IV)	Participation in intervention is predicted by an "instrumental variable" that is correlated with participation but uncorrelated with the impact.	Exploits external source of variation to estimate intervention status when participation is voluntary.	Depends on an instrument that is strongly correlated with participation, but no causal relationship with impact (i.e., 'random').
Propensity score matching (PSM)	Selects intervention and control sub-samples with similar observable characteristics correlated with participation. Impact estimated as difference in mean indicator between similar intervention and control subsamples.	Reduces (self-)selection bias on observable (but not unobservable) characteristics. Secondary demographic data can be used for matching.	Can require large samples since it excludes a portion of available data. Impact estimates can be sensitive to propensity variables and to matching method.
Regression discontinuity (RD)	Uses eligibility cutoff based on a continuous variable (e.g., age, income). Impact estimated as difference in outcome variable between the eligible and ineligible at cutoff.	Exploits eligibility cutoff to reduce selection bias and is easy and intuitive to visualize.	Limited to programs with eligibility thresholds. Depends on assumption that, at cutoff, intervention and comparison groups are similar.

Figure 25. Strengths and Limitations of the Evaluation Approaches. Source: CBA for CIS online course, 2024.

True experimental design (RCT)

- Randomization: Random assignment of participants to treatment and control groups that are statistically equivalent, controlling for observed and unobserved confounding variables.
- Control over variables: High degree of control over experimental conditions and variables, ensuring that only the intervention affects the outcome.
- Internal validity: Strong, randomization minimizes selection bias and ensures causality.
- Applicability: where randomization is ethical and feasible (clinical trials, lab experiments)

Quasi-experimental design (DID, IV, PSM, RD)

- Randomization: Does not use random assignment of participants. Instead, participants are assigned based on pre-existing conditions, decisions, or circumstances.
- Control over variables: Limited since pre-existing groups and less controlled conditions .

- Internal validity: Weaker, relies on statistical techniques or assumptions to infer causality.
- Applicability: real-world settings where randomization is impractical or unethical

Gender Considerations Of The Evaluation Approaches.

The following table shows additional aspects to consider for each of the evaluation approaches when designing the evaluation methods.

Method	Gender considerations
Randomized control trial (RCT)	For stratified randomization, ensure that both treatment and control groups have equal representation of men and women.
Difference-in-difference (DID)	For inclusion of covariates, include gender-specific covariates in the DID model to control for factors that might differentially affect the outcome for men and women. For example, include variables related to employment, education, and household responsibilities that may influence the impact of the intervention.
Instrumental variable (IV)	Ensure that the instrument is valid for each gender. In some cases, it might be necessary to use different instruments for men and women if a single instrument is not equally valid for both genders. Perform IV analysis separately for men and women to estimate the causal effect of the treatment on each gender.
Propensity score matching (PSM)	Include gender-specific covariates in the propensity score model that might affect the likelihood of receiving the treatment and the outcome differently for men and women. FHH can be matched to MHH with similar characteristics to reduce the influence of outliers on the treatment impact.
Regression discontinuity (RD)	Conduct separate RD analyses for men and women if the cutoff or threshold might differ by gender. Estimate separate RD models for men and women to identify if the treatment effect differs by gender.

Figure 26. Gender Considerations of the Evaluation Approaches. Source: CBA for CIS online course, 2024.

Box 11. Self-check Exercise: Evaluation Approaches. Consult Annex 1 for the Answers.

In Northern Uganda, a research institute developed a Climate Information Service that aims to improve smallholder farmers' resilience to climate change in gender-sensitive way (impact). It provides weather forecasts and agricultural advisories via short informative videos disseminated through social media. To evaluate the impact of the intervention, the research institute randomly assigned 25 households to control and treatment groups. The land is usually owned by large families made up of several households, these families usually hold weekly meetings. The intervention was tested during a crop season, after that, data was collected to evaluate outcomes on crop yield changes, changes in agricultural practices, and shifts in decision-making power for women.

1. **Which research evaluation approach was used for this intervention?**
   a. Propensity Score Matching
   b. Difference-in-Difference

c. Randomized Controlled Trial

2. **Which of the following aspects could affect the impact designed for the intervention?**

   a. The intervention's dissemination channel.

   b. The targeted region.

   c. The data collection method.

3. **Which of the following challenges could affect the validity of the evaluation of the intervention's outcomes?**

   a. Selection bias from voluntary participation

   b. Spillover effects due to information sharing.

   c. Inaccurate baseline data during the data collection process.

4E: General Guidelines And Research Ethics.

General Guidelines For Implementing Evaluation Design Approaches.

Allocate sufficient resources and time for conducting evaluation and engage appropriate evaluation expertise from the beginning in the evaluation design, implementation and analysis.

Work with partners, target beneficiary representatives and evaluation experts to define and validate a ToC that specifies the intended impacts and the pathways to achieving those impacts. Consider networks that would incentivize women's participation during the CIS evaluation. Make sure that you have the right people in the room who are both beneficiaries because they will be the ones understanding the needs and the impacts that you want to achieve, and then also make sure that you have someone with evaluation expertise. It is also important to consider networks that would help incentivize women's participation during the evaluation, pay attention to how services are implemented and what improvements or innovations are considered.

Pay attention to how services are implemented and what improvements or innovations are considered. Consider gender differences in access to climate information (communication strategies, dissemination channels), technology and education level.

- Evaluation can underestimate the benefits of climate services and climate risk management if the interventions are poorly designed or implemented.

- Climate service and climate risk management projects and programs are generally implemented in contexts where there has been a great deal of prior work.

Collect baseline data on impacts, outcomes and relevant characteristics before the intervention period. This includes information on the local context (gender dynamics, land ownership, decision-making power, access to agricultural tools and technologies) as well as gender-specific climate perceptions and vulnerabilities.

- Baseline data can be used to strengthen evaluation data collection instruments and guide sampling.

- DID analysis (based on baseline) can be combined with most other evaluation strategies to strengthen estimation and attribution.

Consider collecting and analyzing panel data (observations of the same subjects) over multiple years to capture the confounding effects of climate variability and other drivers.

- The magnitude of impact, and potentially even the mechanism of impact, can vary considerably in different years with different climatic conditions.

Identify factors that have the potential to bias evaluation results.

- Identify appropriate and measurable indicators of the intended impacts and intermediary outcomes, and any individual characteristics that are expected to influence adoption or impacts or confound results.

- Consider incorporating qualitative methods, such as focus groups, key informant groups or ethnographic methods, to deepen understanding of mechanisms by which interventions interact with individual characteristics and contexts to influence decision making and intended and unintended impacts.

Research Ethics.

Research involving human subjects needs to undergo ethics review to assess whether risks of participating in a study are minimal/justifiable relative to a study's potential benefits.

Ethics considerations include:

- Voluntary: Any subject should be approached to provide informed consent to participate and never be forced.

- Informed consent: This includes informing participants on research objectives, risks and benefits of participating, and their right to withdraw at any time during the study.

- Anonymity: Study participants' identity needs to be protected, and personal identifiers (including GPS coordinates) should not be revealed. This will provide a safe space for everyone to freely express and provide support in case of gender-based violence.

- Confidentiality: Data needs to be treated as confidential and not shared if it can be linked to an identifiable individual. This includes paying attention to where you store your results and who has access to them.

- Identify and address any ethical considerations in the interventions and the evaluation strategy.

- Ethical data collection should empower women by involving them in decision-making processes and ensuring their needs and perspectives are adequately represented.

- Ethical research respects and values traditional knowledge, as it can be equally important for the community as scientific knowledge. There is, unfortunately, a very strong tendency to consider scientific knowledge on one end and traditional knowledge on the other end, sort of implying that traditional knowledge is never scientific and sort of implying that it's not as valuable or as robust. But it's important to note that traditional knowledge is often based on observations over a long time, deep understanding and knowledge of the environment, the ecosystems and the interactions that happen between species around the communities. Then, it is very important to respect and value that and not only respect and value people's beliefs in different types of traditional knowledge, but also how they wish to communicate it.

- Because of contextual differences, international researchers obtain ethics approval from both their institutions and a local ethics review committee .

- Avoid extractive research: if you collect data in communities, make sure to explain what it is collected for, and try to go back to those communities to share your results. It happens very often that a community receives visitors who come from different countries, all kinds of organizations. The community uses their time to respond to questions and share information, but the organization never goes back to the community to share how the information was used or the conclusions that came out of it.

Box 12. Self-check Exercise: Research Ethics. Consult Annex 1 for the Answers.

Select whether the following scenarios are ethical or unethical.

Scenario 1: A researcher tests a new malaria drug by giving one group of malaria patients the drug and the other group a placebo.

Scenario 2: A pharmaceutical company tests a new cancer drug. Participants are informed about the trial, risks, and alternatives before giving their consent.

Scenario 3: A company conducts an RCT for a new vaccine in a developing country. The study budget includes vaccine development and vaccination cost, and the salaries of the study team.

Scenario 4: Researchers randomly assign schools to implement a new teaching method to test its effectiveness. Control schools continue using the existing method.

Scenario 5: An NGO tests different food supplementation programs in low-income communities to identify the most effective approach.

4D: Planning credible resilience evaluations.

Example of RCT: Munda Make Over case study.

We will now take you through an example of an RCT to see how to apply some of these things in practice. Currently, we are implementing this study in Zambia, and it is an impact evaluation of a TV show called Munda Makeover.

This program was based on the Kenyan TV show Shamba Shape Up, broadcasted every week on national TV, reaching millions of people. In the show, presenters visit a farm and ask the farmer what challenges they are facing. Then they bring in experts to talk to the farmer about solutions to those challenges. In this way, it is a very informative show, but presented in an entertaining way. This is called edutainment, edu for education, payment for the entertainment.

This is considered a very low-cost tool to get agricultural information to farmers. To put this in perspective, the production of one episode, which typically covers four types of solutions for different problems that a farmer might face, costs about $30,000. In this way, the intervention reaches millions of farmers across the country, improving their knowledge. This can be very cost effective to complement extension services. It is a very potentially cost-effective innovation that especially starts paying off because of the scale that you can achieve by working on national TV.

Because of this, different organizations, including NGOs, the private sector, the Ministry of Agriculture, and also CGIR centers, have been contributing to the cost of the show to get their content that they want to get to farmers on TV.

This is why the Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA), which is the program that is funding our course, decided to help scale out this show to Zambia. In Zambia, the show is called Munda Make Over.

Please watch the following **video** to learn more about this topic.

Previous research demonstrated that viewing the show was correlated with desirable outcomes. For instance, improved knowledge, increased intentions to adopt some of the recommended practices. But this was based on the comparison of people who viewed the show and people who didn't view the show. However, in that way, you're not getting at the causal effects of the show; it might just be that people who were viewing the show were already more knowledgeable, more likely to adopt these practices than non-viewers of the show. Then, you're not able to attribute the changes that you see over time between viewers and non-viewers.

The attribution can be done unless you can show that the parallel trends assumption holds for viewers and non-viewers, and the before-and-after the DID comparison can indeed be interpreted as causal estimates. This is the reason why we can't work with knowledge, attitudes, or practice surveys alone, and why we would still be interested in doing an impact evaluation in addition to that work.

Then, we get to the big challenge: how to construct a control group when we are evaluating a TV show? Considering everybody may have access to it.

Please watch the following **video** to learn more about this topic.

In situations where you have limited exposure to the intervention in your control group and the intervention is not expected to be widely used, adopted or accessed, then you could consider an encouragement design where you create random variation in the probability of accessing the TV show.

Now we have the predicted use of the show or the predicted probability that someone is watching the show, and our encouragement is the instrument. The predicted probability is then what we link to our outcome variables and see if people with a higher predicted probability, where we have used our instrument, the encouragement, will determine whether they are more likely to adopt recommended practices, whether they have improved knowledge and so on.

Wrap-up of Module 4

Module Four explored the average treatment effect as the average difference in outcome between the group that receives the intervention and the group that does not. The cost-benefit analysis can leverage the ATE estimates from impact evaluation before scaling a program in order to project benefits based on evidence and not just on assumptions. It can be used to evaluate, but also to give more concrete recommendations for scaling.

Impact evaluations should ideally be designed as part of a program pilot or rollout, and plan for baseline data collection and costing data. The Randomized Control Trials (RCTs) are the gold standard for estimating the ATE, but they're not always feasible. If RCTs are not possible, then you can consider encouragement designs or quasi-experimental methods. There are three approaches: the parametric approach, which maps observable indicators into a measure of well-being to calculate utility; the unconstrained preference approach, to measure how constraints affect people's preferences; and the revealed preference approach, which uses willingness to pay as a measure of well-being. These methods can all be complementary; for example, you can measure changes in income and income stability using an RCT, but then evaluate the impact on expected utility using a parametric approach.

This type of research typically involves human subjects; therefore, ethics and the approval process need to be considered.

Recommended Readings of Module 4

- Giacomo Branca. (2018). Cost-Benefit Analysis For Climate Change Adaptation Policies And Investments In Agriculture. https://openknowledge.fao.org/server/api/core/bitstreams/59173b3a-486a-42cc-8d80-8cf74fc974bc/content

- Glennerster, R. & Takavarasha, K. (2014). Running randomized evaluations: A practical guide. Princeton University Press. https://doi.org/10.1515/9781400848447

- Gumucio, T., Hansen, J., Huyer, S., & van Huysen, T. (2020). Gender-responsive rural climate services: a review of the literature. In Climate and Development (Vol. 12, Issue 3, pp. 241–254). Taylor and Francis Ltd. https://doi.org/10.1080/17565529.2019.1613216

CONCLUSION AND RECOMMENDATIONS

In this course, we saw that traditional Cost-Benefit Analyses (CBA) of resilience interventions, which often only focus on the Net Present Value (NPV), often overlook the gender dimensions of climate change impacts. While still important, monetary outcomes do not cover all the desired benefits from an intervention that shape farmers' resilience and well-being for both men and women.

Therefore, integrating a gender perspective into these evaluations is essential. Women and men experience climate risks differently due to distinct roles, access to resources, and decision-making power. This course addressed this gap by incorporating gender-sensitive metrics into evaluation frameworks:

- Expected utility framework: The NPV method only considers changes in expected income, without quantifying the benefits from reduced risk or vulnerability, which is the main outcome targeted by many resilience interventions. This framework allows the incorporation of monetary and non-monetary outcomes as well as capturing uncertainty, risk aversion, and time preferences. This framework makes CBA more realistic to different socioeconomic realities, especially for risk averse and vulnerable groups.

- Changes in women's workloads and empowerment: Interventions also frequently affect men and women differently in income, decision-making power, and workloads. The expected utility framework also offers methods to quantify the value of reducing time burdens placed on women (time use) and other indicators such as control over income.

- Impact evaluation methods: CBA can be strengthened by applying experimental and quasi-experimental approaches to measure gendered outcomes effectively. These methods involve addressing challenges such as self-selection, spillovers, and gender biases. Ideally, impact evaluation methods should be considered since the project design phase, for generating robust and more accurate results.

This type of research typically involves human subjects. Therefore, ethics and the approval process need to be considered. By combining these approaches, we can provide more comprehensive and inclusive assessments of climate services and resilience interventions.

APPENDIX I

Self-check Answers Box 1

Question 1

A. $-952.38 for year 0; $544.22 for year 1; $604.69 for year 2; and $658.16 for year 3.

B. $-1000 for year 0; $600 for year 1; $700 for year 2; and $800 for year 3.

C. $-1000 for year 0; $571.43 for year 1; $634.92 for year 2; and $691.07 for year 3.

Correct answer: option C. Explanation: Considering the formula, discounted cash flow=CF/(1+r)^t, where r is the discount rate, t the time of the CF and CF the cash flow given by revenue minus the costs, we have e.g., discounted cash flow of year 2= ($900-$200)/(1+0.05)^2= $634.92

Question 2

A. $897.42

B. $1,100

C. $0

Correct answer: option A. Explanation: NPV is the sum of the discounted cash flows for all years, for this example, it would be NPV = $-1000 + $571.43 + $634.92 + $691.07 = $897.42

Question 3

A. It is not profitable, it would result in a loss and should be considered.

B. It is profitable, the investment should be considered.

C. There is no difference.

Correct answer: option B. Explanation: Traditionally we say that an investment is profitable when NPV > 0.

Self-check Answers Box 2

Question 1

A. The individual will have a higher time preference, meaning that they value money from today more than money from tomorrow.

B. The individual will value money from today equally than money from tomorrow.

C. The individual will have a lower time preference, meaning that they value money from today less than money from tomorrow.

Correct answer: A. Explanation: Time preferences are related to how patient people are in preferring to receive money now or later, and how they place a value on future cash flows is related to the discount rate.

Question 2

A. A farmer who is facing strong liquidity constrains and risks.

B. A farmer from a developing country who borrows money informally from a local moneylender to buy drought-tolerant seeds.

C. A farmer from a developed country who has access to a loan from the bank to invest in drip irrigation technology.

Correct answer: C. Explanation: The WACC considers the cost of debt (loans) and interest rates and returns on equity as the discount rate, this is only applicable when there is a formal financial market in place.

Question 3

A. The WACC is the only option to determine the discount rate.

B. We can use the cost of debt (loans) and equity (share) to determine the discount rate.

C. We can use choice experiments to elicit farmers' preferences on discount rates, followed by a sensitivity analysis.

Correct answer: C. Explanation: There are survey tools that serve as a guide to elicit time preferences using choice experiments, e.g., the Global Preference Survey. Sensitivity analysis should also be part of the process.

Self-check Answers Box 3

Question 1

A. Anna values the $1,000 future cash flow at $1,150 today.

B. Anna values the $1,000 future cash flow at $1,000 today.

C. Anna values the $1,000 future cash flow at $869.57 today.

Correct answer: C. Explanation: Considering that the future money we want to bring back to present value is $1,000 and we are considering one year from now, we have NPV = $1000/(1+0.15)^1 = $869.57

Question 2

A. John values the $1,000 future cash flow at $1,000 today.

B. John values the $1,000 future cash flow at $952.38 today

C. John values the $1,000 future cash flow at $1,050 today.

Correct answer: B. Explanation: Considering that the future money we want to bring back to present value is $1,000 and we are considering one year from now, we have NPV = $1000/(1+0.05)^1 = $952.38

Question 3

A. John has higher liquidity constraints, meaning she has limits in access to loan and needs cash now. Anna is more comfortable waiting due to fewer constraints.

B. Anna has higher liquidity constraints, meaning she has limits in access to loan and needs cash now. John is more comfortable waiting due to fewer constraints.

C. Anna has higher liquidity constraints, so she is comfortable waiting. John has limits in access to loan and needs cash now.

Correct answer: B. Explanation: higher discount rates are related to a higher time preference, meaning that the individual will prefer immediate cash rather than late.

Self-check Answers Box 4

Question 1

A. Improved national Early Warning Systems.

B. Delivery of tailored weather forecasts through platforms accessible to both women and men that address their differentiated information needs.

C. Increased fertilizer subsidies for maize and wheat farmers.

Correct answer: option B. Explanation: An output is a direct result of project activities. A gender-responsive output would ensure equitable access to CIS — for instance, by using communication channels women use.

Question 2

A. Whether women and men perceive the climate information as trustworthy.

B. Policies or institutional frameworks that do not prioritize climate adaptation projects.

C. The choice of delivery channel (e.g., SMS, radio, farmer groups).

Correct answer: option B. Explanation: External factors are those that might influence the program but are outside its design or planning control.

Self-check Answers Box 5

Question 1

A. Without forecast, the expected income would be $9,000 and with forecast, the expected income would be $11,000

B. Without forecast, the expected income would be $11,000 and with forecast, the expected income would be $10,000

C. Without forecast, the expected income would be $10,000 and with forecast, the expected income would be $11,000

Correct answer: option B. Explanation: Remember that the expected income is the weighted average of outcomes. Therefore, without forecast = $15,000*0.6 + $5,000*0.4 = $11,000. While with forecast = $10,000*0.6 + $10,000*0.4

Question 2

A. The amount of average return that a decision maker would be willing to sacrifice to eliminate risk.

B. Guaranteed return that someone would accept, rather than taking a chance on a higher but more uncertain return.

C. The expected income.

Correct answer: option B. Explanation: The certainty equivalent is the amount of money that you would accept rather than taking a chance on something that's maybe higher but more uncertain.

Question 3

A. Yes

B. No

C. There would be no change.

Correct answer: option A. Explanation: Assuming that certainty equivalent is $8000, the expected income of $10000 with forecast is greater than the certainty equivalent.

Self-check Answers Box 6

Question 1

A. The female farmer has a higher r because of a stronger risk aversion than the male farmer.

B. The female farmer has a higher r because of a weaker risk aversion than the male farmer.

C. The female farmer has a higher r because of she is a risk neutral individual.

Correct answer: option A. Explanation: Having a higher value of r means a stronger risk aversion.

Question 2

A. For the male farmer, the expected utility of option A is 8.76 and of option B is 8.06. For the female farmer, the expected utility of option A is 9.95 and of option B is 9.22

B. For the female farmer, the expected utility of option A is 9.73 and for option B 10.74. For the male farmer, the expected utility of option A is 11.05 and of option B is 12.29

C. For the female farmer, the expected utility of option A is 8.76 and of option B is 8.06. For the male farmer, the expected utility of option A is 9.95 and of option B is 9.22

Correct answer: option C. Explanation: The expected utility is given by the sum of the Probability(O_i) × Utility(O_i) with O_i as each possible outcome. The utility formula was given within the text. Consider that, for example, if option A has a probability of 90% of having $35 as income, for a female farmer, then the remaining probability of 10% is $0 as income.

Question 3

A. Both female and male farmers would prefer option A.

B. Female farmer would prefer option A, and male farmer would prefer option B.

C. Female farmer would prefer option B, and male farmer would prefer option A.

Correct answer: option A. Explanation: The expected utilities of option A for both female and male farmers is higher than option B.

Self-check Answers Box 7

Question 1

A. Because income is more important than time use in all households.

B. It is not necessary to consider those factors when assessing empowerment.

C. Because increased control over income may come at the cost of increased workload, reducing overall well-being.

Correct answer: option C. Explanation: Some interventions might, increase women's control over income, therefore increases in household bargaining power, but come with an increase in workloads, which do not improve well-being.

Question 2

A. Unconstrained preference approach.

B. Revealed preference approach.

C. Parametric preference approach.

Correct answer: option A. Explanation: The unconstrained preference approach focuses on understanding what people's preferences are when there's no constraint, and then how those change when there's a constraint.

Question 3

A. Her preferences have more influence on the household decisions and resource allocation.

B. She works fewer hours on average.

C. Her income is higher than her husband’s income.

Correct answer: option A. Explanation: Household resource allocations need to be considered as an outcome of a bargaining process. The bargaining weight means how much their opinion weighs on the household decision-making.

Self-check Answers Box 8

Question 1

A. The objective approach uses expert opinions, while the subjective approach relies on historical data.

B. The objective approach uses historical data, while the subjective approach is based on farmers' perceptions.

C. The objective approach is based on farmers' perceptions, while the subjective approach uses forecasts.

Correct answer: option B. Explanation: The objective approach uses past data (e.g., historical rainfall), while the subjective approach is participatory and based on how individuals perceive the likelihood of future events.

Question 2

A. The farmer believes there's a 60% chance of earning more than 6,000

B. The farmer expects to earn 4,000–6,000 in 10 out of 25 years.

C. The farmer perceives a 40% chance of earning between 4,000 and 6,000 during good weather.

Correct answer: option C. Explanation: Each token represents 4% probability (100% ÷ 25 tokens), so 10 tokens = 40%.

Question 3

A. It requires real payouts, making it expensive to implement.

B. It does not allow participants to choose between risky and safe options.

C. It may introduce hypothetical bias since choices don't involve real consequences.

Correct answer: option C. Explanation: Since the staircase method is hypothetical (unincentivized), people might not behave the same way they would if real money was involved, introducing bias.

Self-check Answers Box 9

Question 1

A. Only household income and yield data under normal and extreme weather conditions.

B. Data on income or consumption under different weather scenarios, risk preferences, weather scenarios probabilities, bargaining weights and leisure time for women and men within the household.

C. Climate forecasts, fertilizer use, and regional GDP to model productivity trends.

Correct answer: option B. Explanation: Remember the full formula of the expected utility framework seen previously in the module 3A.

Self-check Answers Box 10

Question 1

A. D – A

B. A (income of the treatment group after the intervention)

C. A – D

Correct answer: option C. Explanation: We first calculate the change of the income in the treatment (A – C), then we calculate the change of the income in the control (D – C) and subtract both resulting in (A – C) – (D – C) = (A – D)

Question 2

A. To measure how the intervention performs compared to similar projects in other regions.

B. To calculate the financial cost of the intervention relative to its direct benefits.

C. To know the state of the intervention group in the absence of intervention and identify other factors involved in the change of the outcomes.

Correct answer: option C. Explanation: The counterfactual helps us to distinguish whether a change in an outcome is due to the treatment or to other factors.

Question 3

A. To know the state of the intervention group in the absence of intervention and identify other factors involved in the change of the outcomes.

B. Using the outcomes of the control group as an approximation of the counterfactual.

C. Establishing a specific group, apart from the treatment and control group, as the counterfactual.

Correct answer: option B. Explanation: Because the group is receiving the treatment, we can only estimate what would have happened to them using the control group when it is well chosen and their outcomes are comparable to the treatment group.

Self-check Answers Box 11

Question 1

A. Propensity Score Matching

B. Difference-in-Difference

C. Randomized Controlled Trial

Correct answer: option C. Explanation: There was a random assignment of participants to treatment and control groups.

Question 2

A. The intervention's dissemination channel.

B. The targeted region.

C. The data collection method.

Correct answer: option A. Explanation: The households in the region may have just one smartphone for the entire household, usually belonging to the husband. Then, it is likely that more men can access the information than women if the short informative videos are only disseminated through social media.

Question 3

A. Selection bias from voluntary participation

B. Spillover effects due to information sharing.

C. Inaccurate baseline data during the data collection process.

Correct answer: option C. Explanation: In this example, some households in the region hold weekly meetings. Then, a household in the treatment group, may share information to another household that is in the control group, having indirectly access to the intervention. This is the spillover effect.

Self-check Answers Box 12

Question 1

A. Ethical

B. Unethical

Correct answer: option B. Explanation: Withholding known effective treatment. It violates ethical principles by denying participants access to the standard available treatment, putting them at unnecessary risk.

Question 2

A. Ethical

B. Unethical

Correct answer: option A.

Question 3

A. Ethical

B. Unethical

Correct answer: option B. Explanation: Exploitation of vulnerable populations. The budget does not plan for long-term care or benefits for participants who experience adverse effects. It exploits vulnerable populations without ensuring their safety or providing adequate post-trial benefits.

Question 4

A. Ethical

B. Unethical

Correct answer: option A.

Question 5

A. Ethical

B. Unethical

Correct answer: option A.