In-Service Training on Partial Budgeting Techniques

FOOD SECURITY RESEARCH PROJECT

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Mount Makulu, Lusaka, Zambia

OUTLINE

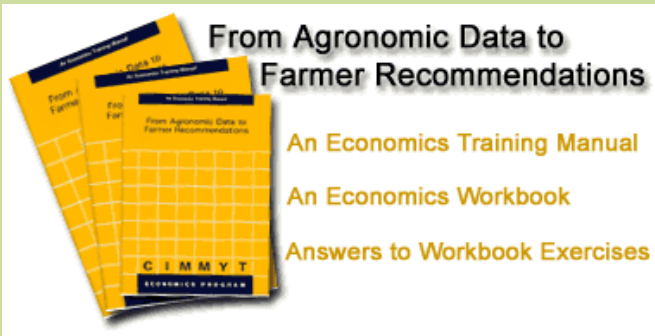
- 9:30-10:00 -- Introduction of participants; Goals and Objectives
- 10:00-11:00 -- Overview of partial budgeting and key concepts
- 11:00-11:15 -- Tea break
- 11:15-13:00 -- Key components of partial budgets
- 13:00-14:00 -- Lunch
- 14:00-15:00 -- Key components of partial budgets (cont.)
- 15:00-15:30 -- Marginal analysis
- 15:30-15:45 -- Tea break
- 15:45-16:30 -- Data needs and wrap-up

MAIN OBJECTIVE & GOAL

- **Main objective:** To provide an orientation on partial budgeting, highlighting the key components in the analysis and the key data needs
- **Goal:** At the end of the training, the participants are expected to know what information is needed to conduct a partial budgeting analysis

Acknowledgments

- This training uses the 1988 CIMMYT Manual



Available at:
http://www.cimmyt.org/english/docs/manual/agronomic/manual/contents.htm

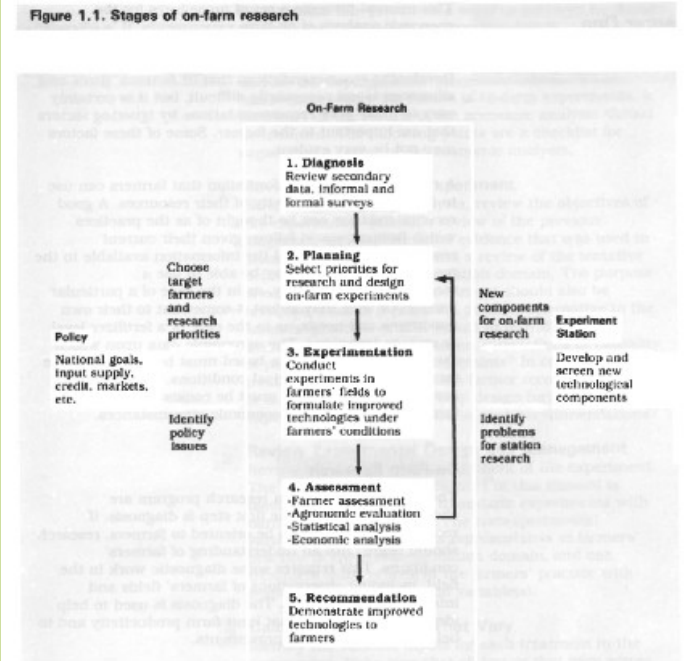
Trials staged by GART & ZARI

- Please tell us about some of the on-farm trials which your organizations have staged
- Why were some of the on-farm trials staged in certain locations?

On-Farm vs. On-Station Experiments

- Statistical or economic analysis is done using standard units -- i.e., on a per-hectare basis; e.g., person-days/ha, yield/ha, cost/ha
- On-station experiments: =>Small plot size. All variables will be observed based on that small plot.
  - Measurements under such arrangements are prone to serious problems when extrapolating to a per hectare basis

STAGES OF ON-FARM RESEARCH



Source: CIMMYT 1988)

Characteristics of On-Farm Experiments

...that make them amenable to economic analysis:

1. Examine only a few factors at a time (e.g., 4 or less)
2. Include farmers' current practices as one of the treatments
3. Nonexperimental variables should reflect farmers' actual practices (e.g., management)
4. Experiment locations are representative of farmers' conditions

On-Farm Experiments

- Work in small groups to determine if an experiment is designed so that an economic analysis of the results is possible (Exercise 3)
- Refer to "Characteristics of On-Farm Experiments"

Recommendation Domain

- A group of farmers who have similar circumstances and for whom it is likely that the same recommendation will be suitable.
- Could be defined by agroecological and/or socioeconomic circumstances and/or management practices
- Statistical and economic analysis will use pooled data from a recommendation domain

Tool for economic analysis: The partial budget

- Partial Budgeting is the process of examining only those costs, returns and resource needs that change with a proposed adjustment.

- This technique compares added revenues and costs of the proposed change with revenues and costs of the present practice.

Example of a partial budget

	Hand weeding	Herbicide
Average yield (kg/ha)	2,000	2,400
Adjusted yield (kg/ha)	1,800	2,160
Gross field benefits ($/ha)	3,600	4,320
Cost of herbicide ($/ha)	0	500
Cost of labor to apply herbicide ($/ha)	0	100
Cost of labor for hand weeding ($/ha)	400	0
Total costs that vary ($/ha)	400	600
Net benefits ($/ha)	3,200	3,720

Source: CIMMYT 1988)

Why is it called a "partial" budget?

- Because not all costs are included in the budget, only the costs that vary are included (i.e., costs that are different between two treatments)

Example of a Complete Budget

	Treatment			
Variable	1	2	3	4
Yield (kg/ha)	2,000	2,100	2,500	2,600
Adjusted yield (kg/ha)	1,600	1,680	2,000	2,080
Gross field benefits ($/ha)	5,600	5,880	7,000	7,280
Tillage cost ($/ha)	1,200	1,200	1,200	1,200
Planting cost ($/ha)	400	400	400	400
Cost of seed ($/ha)	75	75	75	75
Weeding cost ($/ha)	1,600	1,600	1,600	1,600
Cost of N ($/ha)	0	0	350	350
Cost of P_2O_5 ($/ha)	0	300	0	300
Application cost ($/ha)	0	150	150	150

Source: CIMMYT 1988)

Partial budgets exclude costs that are the same among all treatments

Variable	Treatment 1	2	3	4
Yield (kg/ha)	2,000	2,100	2,500	2,600
Adjusted yield (kg/ha)	1,600	1,680	2,000	2,080
Gross field benefits ($/ha)	5,600	5,880	7,000	7,280
Cost of N ($/ha)	0	0	350	350
Cost of P_2O_5 ($/ha)	0	300	0	300
Application cost ($/ha)	0	150	150	150

Source: CIMMYT 1988)

Uses of a partial budget

- Used to make recommendations to farmers about new farming practices
  - Partial budgets helps identify treatments that are economically viable and are likely to be adopted by farmers
- Used to refine the treatments in an experiment

Key components of a partial budget

1. Average yield (kg/ha)
   - Coming from different trials in a recommendation domain

Location	Recommendation domain	Treatment yield (kg/ha) 1 Local variety, no fertilizer	2 Improved variety, no fertilizer	3 Local variety with fertilizer	4 Improved variety with fertilizer
1	A	960	910	1,560	1,380
2	A	1,010	620	1,820	1,450
3	B	1,820	1,650	2,240	2,920
4	A	570	490	980	820
5	B	2,270	2,420	2,750	3,300
6	B	1,900	1,740	2,190	2,840
7[a]	A	200	200	200	200
8	B	2,430	2,010	2,740	3,210
9	A	890	620	1,480	1,370

[a] Trial lost due to drought. Yield estimated to be 200 kg/ha across treatments.

Average Yield	**T1**	**T2**	**T3**	**T4**
Rec. Domain A		726	568	1208
1044				
Rec. Domain B	2105	1955	2480	3068

Source: CIMMYT 1988)

Key components of a partial budget (2)

2. Adjusted yield (kg/ha)
   - If you believe that there are differences between the experimental results and the yields farmers might expect using the same treatment, the average yields should be adjusted downward
   - Why might farmers' yields be different from experimental results?
     - differences in management, plot size, planting date, harvest date, form of harvest, etc.
   - How to determine % adjustment:(1) compare yields between experimental treatments and farmers' fields OR (2) think about sources of differences and estimate percentage adjustment
   - Total adjustment should be 5-30%
   - NOTE: If you have farmers manage the experiment, you don't have to worry about yield adjustments

Key components of a partial budget (3)

	Hand weeding	Herbicide
Average yield (kg/ha)	2,000	2,400
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Source: CIMMYT 1988)

Key components of a partial budget (4)

3. Field price (ZMK/kg)

=price farmers receive - harvest & marketing costs

Ex) maize: 760 ZMK/kg - 100 ZMK/kg = 660 ZMK/kg

- Examples of harvest and marketing costs?

-->harvesting, shelling, threshing, bagging, transport to point of sale, etc.

- E.g.: FRA price vs. private buyer
- Numerical example (Exercise 17A)
  - Compute maize price per kg ($/kg)
  - Compute transport price per kg ($/kg)
  - Compute harvesting and shelling price per kg ($/kg)
  - Field price ($/kg) = maize price per kg - transport price per kg - harvesting price per kg - shelling price per kg

Key components of a partial budget (5)

4. Gross field benefits (ZMK/ha)

=adjusted yield (kg/ha) X field price (ZMK/kg)

EX) field price of maize = 660 ZMK/kg

<u>adjusted yield = 1,200 kg/ha</u>

Gross field benefits = 660 X 1,200

= 792,000 ZMK/ha

Key components of a partial budget (6)

5. Costs that vary (ZMK/ha)

=costs per hectare of purchased inputs, labor, and machinery that **vary** between experimental treatments

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Key components of a partial budget (7)

5. Costs that vary (ZMK/ha) (cont.)

- Include costs even if no money is paid
  - Ex) Household members do weeding and are not paid a wage
- Opportunity cost = the value of any resource in its best alternative use
  - Ex) HH members could be earning money as laborers rather than weeding on their family's farm-->even though they aren't paid a wage, the opportunity cost of their weeding is the wage they would have earned as laborers

Key components of a partial budget (8)

5. Costs that vary (ZMK/ha) (cont.)

- Should be expressed in ZMK/ha
  - Start with the **field price of the variable input (ZMK/unit)** = the value that must be given up to bring an extra unit of input into the field = price farmers pay per unit + transport costs per unit
    - EX) no fertilizer vs. basal fertilizer experiment: basal fertilizer is a cost that varies. Basal fertilizer costs 100,000 ZMK /50-kg bag at a nearby market and 5,000 ZMK/bag for transport
      - Field price of basal fertilizer = 105,000 ZMK/50-kg bag =2100/kg

Key components of a partial budget (9)

5. Costs that vary (ZMK/ha) (cont.)

- Should be expressed in ZMK/ha
  - Then compute the **field cost of the variable input (ZMK/ha)** = field price (ZMK/unit) X number of units/ha
    - EX) field price of basal fertilizer = 2,100 ZMK/kg and 200 kg/ha are used in the treatment -->field cost of basal fertilizer =2,100 X 200 = 420,000 ZMK/ha

Key components of a partial budget (10)

5. Costs that vary (ZMK/ha) (cont.)

- Identifying variable inputs: think about how inputs vary among treatments
- After identifying the variable inputs, MONITOR the prices of these inputs at the time of year when they would be purchased for the treatment-->this is the price you should use in the partial budget (not the price from another time of year)

Key components of a partial budget (11)

5. Costs that vary (ZMK/ha) (cont.)

- TYPES OF VARIABLE INPUTS
  1. **Purchased inputs**
     - If input is purchased, use the retail price at the retail outlet the farmers would typically use and for the package size the farmer would typically buy (plus any transport costs)
     - If using own inputs (e.g., seed) and not buying the input, use the **"opportunity field price"** = the price at which farmers would buy that input at the local retail outlet

Key components of a partial budget (12)

5. Costs that vary (ZMK/ha) (cont.)

- TYPES OF VARIABLE INPUTS
  2. **Equipment and machinery**
     - If one treatment requires equipment not used in other treatments, that equipment is a variable input and need to estimate the field cost
     - Estimate the **per hectare field cost** of the equipment using the **average rental rate** in the locality (whether the farmer owns or rents)
     - EX) 6 sprays costs 75,000 ZMK; 1 spray covers 1 ha -->field cost of a sprayer is 12,500 ZMK/ha

Key components of a partial budget (13)

5. Costs that vary (ZMK/ha) (cont.)

- TYPES OF VARIABLE INPUTS

  3. Labor

  - Important to include both hired and **family** labor
  - **Hired labor:** use the actual wage rate (plus any non-wage payments normally offered) and then convert to ZMK/ha
  - **Family labor:** use the daily wage rate paid to hired labor in that locality OR if the person has to take the day off from another wage activity to work on the farm, use their wage rate (opportunity cost of labor)-->convert to ZMK/ha

Key components of a partial budget (14)

5. Costs that vary (ZMK/ha) (cont.)

- TOTAL COSTS THAT VARY = the sum of the costs that vary for a particular treatment

	Hand weeding	Herbicide
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Total costs that vary ($/ha)	400	600
Net benefits ($/ha)	3,200	3,720

Source: CIMMYT 1988)

Key components of a partial budget (15)

5. Costs that vary (ZMK/ha) (cont.)

- Exercise 13: Costs that vary - use the "data" to list all costs that vary for all treatments. Calculate costs that vary ($/ha) for Treatment 1 only

Costs that vary	Treatment 1
list	

- For 1 of the proposed trials done by GART and 1 for ZARI, think about the costs that vary --> work in small groups, then present to the group

Key components of a partial budget (16)

6. Net benefits
   =gross field benefits - total costs that vary

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Cost of labor to apply herbicide ($/ha)	0	100
Cost of labor for hand weeding ($/ha)	400	0
Total costs that vary ($/ha)	400	600
Net benefits ($/ha)	3,200	3,720

- Net benefits vs. profits

Source: CIMMYT 1988)

Review of steps for creating a partial budget

1. Identify the locations that belong to the same recommendation domain
2. Calculate the average yields across sites for each treatment
3. Adjust the average yields downward if it is believed that there are differences between the experimental results and yields farmers might expect using the same treatment.
4. Calculate a field price for the crop and multiply by the adjusted yields to give the gross field benefits of each treatment.
6. Identify and calculate the costs that vary for each treatment
7. Calculate the net field benefits = gross field benefits - total costs that vary

Statistical analysis before the partial budget

- Before doing the economic analysis (partial budget), it is important to first do statistical analysis to compare the average yields between treatments
- If there are NO significant differences between average yields, a partial budget is not necessary. The treatment with the lowest costs that vary should be recommended.
- If there ARE significant differences between average yields, proceed with the partial budget approach.

Using the partial budget to select the preferred treatment

1. **DOMINANCE ANALYSIS**

- List the treatments in order of increasing total costs that vary (and include net benefits of that treatment)
- A dominated treatment is any treatment that has net benefits that are less than those of a treatment with lower costs that vary.

Using the partial budget to select the preferred treatment (2)

1. **DOMINANCE ANALYSIS**

Table 4.1. Dominance analysis, weed control by seeding rate experiment

Treatment	Weed control	Seeding rate (kg/ha)	Total costs that vary ($/ha)	Net benefits ($/ha)
1	None	120	2,400	10,360
3	None	160	3,200	10,136 D
2	Herbicide	120	3,875	11,765
4	Herbicide	160	4,675	11,965

Source: CIMMYT 1988)

- A dominated treatment is clearly undesirable so should not be considered in subsequent analysis

Using the partial budget to select the preferred treatment (3)

2. MARGINAL ANALYSIS

- **Marginal rate of return =** the marginal net benefit (i.e., the change in net benefits) divided by the marginal cost (i.e., the change in costs), expressed as a percentage

Treatment	Weed control	Seeding rate (kg/ha)	Total costs that vary ($/ha)	Net benefits ($/ha)
1	None	120	2,400	10,360
3	None	160	3,200	10,136 D
2	Herbicide	120	3,875	11,765
4	Herbicide	160	4,675	11,965

EX) The marginal rate of return of going from Treatment 1 to Treatment 2 is:

$$\frac{\$11,765-\$10,360}{\$3,875 - \$2,400} = \frac{\$1,405}{\$1,475} = 0.95 = 95\%$$

The MRR of going from T2 to T4 is 25%

Using the partial budget to select the preferred treatment (4)

3. THE MINIMUM ACCEPTABLE RATE OF RETURN

- In order to use the results of the marginal analysis to make farmer recommendations, it is necessary to estimate the minimum rate of return acceptable to farmers in the recommendation domain

- Farmers can finance their purchases of inputs and/or equipment in a number of different ways:
  - Using their own money
  - Borrowing from informal credit markets
  - Borrowing from formal credit markets

-->depending on which of these they do, the minimum acceptable rate of return is estimated in different ways

Using the partial budget to select the preferred treatment (5)

3. **THE MINIMUM ACCEPTABLE RATE OF RETURN**

- If farmers use their own money, a minimum acceptable rate of return between 50-100% is usually adequate.
  - If the new technology is only a minor change of current practices, 50% is a good estimate
  - If the new technology is more significant change of current practices, 100% should be used
- If farmers borrow from the informal credit market, find out the interest rate usually charged by informal lenders. Multiply this rate by the number of months that the farmers will borrow the money, then double this number to get the estimated rate.
- If farmers borrow from the formal credit market, find out the interest rate usually charged by formal lenders and double it. Multiply this rate by the number of months that the farmers will borrow the money, then double this number to get the estimated rate.
- Exercise 25

Using the partial budget to select the preferred treatment (6)

3. **USING THE RATE OF RETURN AND THE MINIMUM ACCEPTABLE RATE OF RETURN**

Decision rule: Farmers should be willing to change from one treatment to another if the marginal rate of return of that change is greater than the minimum acceptable rate of return.

Using the partial budget to select the preferred treatment (7)

Exercise 32A: Split into two groups (GART/ZARI)-->GART groups does #1, ZARI group does #2 and then we come back together to discuss

On Exercise 32A:

1) Calculate gross field benefits = adjusted yield X field price
2) Calculate net benefits=gross field benefits - total costs that vary
3) Compute the marginal rate of return = [(change in net benefits)/(change in total costs that vary)]x100
4) Compare the marginal rate of return to the minimum acceptable rate of return (100%) and decide which treatment should be recommended to farmers in the recommendation domain

Using the partial budget to select the preferred treatment (8)

4. **SENSITIVITY ANALYSIS**
   Sensitivity analysis simply implies redoing a marginal analysis with alternative prices.

- If different prices are used in the partial budget analysis, it is possible that the preferred treatment might change
- This is what you saw in the exercise you just did --> if the output price changes, the preferred treatment might change
- Input prices can change, too. For example, in the herbicide experiment, if the price of herbicide increases or decreases, the total costs that vary would be affected, hence the MRR would also change
- Thus, before making a recommendation, it is important to see if the preferred treatment is the same even if prices change slightly

LIMITATIONS OF ECONOMIC ANALYSIS

- Using one season of data for practices that change soil dynamics over time (e.g., residue incorporation, liming trials, tillage trials, etc.)
- Using one season of data where agro-climatic conditions can strongly influence outcomes (e.g., planting basins trials)
- Technology shift that is a major change across various farm systems (whole farm budget comparisons are needed)

Data needs

- During the course of planning and implementing your trials, it will be important to monitor throughout the season:
  - Input field prices and amounts used/ha (e.g., fertilizers, seed, lime, herbicides)
  - Agricultural and other local wage rates
  - Hours of labor/ha required for various farm activities (e.g., weeding, land preparation, etc.)
  - Rental rates for equipment and machinery; and how many days rental required to cover 1 ha.
  - Rates for agricultural services (e.g., spraying, planting)

Data needs (2)

- Interest rates (formal and informal)
- Transport costs
- Harvesting and marketing costs
- Management used in trials -->it should be as close as possible to what farmers use
- What constraints farmers face and what characteristics they are looking for in a new technology
- Climatic/agro-ecological conditions

Data needs (3)

- Break into groups (GART/ZARI) and discuss data needs for potential trials in the upcoming season

Wrap-up

- Before recommending/introducing a new technology, on-farm trials should be conducted.
- The results of these trials should be evaluated to see if they are economically viable
- One tool to use for economic analysis is the partial budget
- Three key elements of the partial budget are the gross benefits, total costs that vary and the net benefits

Wrap-up (2)

- Once we have completed the partial budget, we can calculate the marginal rate of return (MRR) of switching from one technology/treatment to another
- This marginal rate of return needs to be greater than the minimum acceptable rate of return for the farmer to be willing to adopt the change (min. acc. RR depends on where farmer's capital is coming from)
- Finally, sensitivity analysis should be used to see if the recommended treatment is sensitive to changes in prices

THANK YOU

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FSRP: 260-21-1-221021/22