MANUAL ON
GOOD PRACTICES IN EXTENSION RESEARCH & EVALUATION

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24

Methods of Analysing Impact of Agricultural Technologies

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Objectives

1. Introduce advanced methods of assessing impact of agricultural technologies
2. Explain the quantitative methods applied in assessing impact
3. Suggest future work for improving impact assessment

24.1 Introduction

- Assessing effects of an intervention on the user group is a crucial component for assessing the utility of a technological intervention.
- According to the World Bank, impact assessment is intended to determine more broadly whether the program had the desired effects (both positive and negative) on individuals, households, and institutions, and whether those effects are attributable to the program intervention (Baker, 2000).
- Impact is measured in terms of positive and negative, primary and secondary long-term effects produced by an intervention, directly or indirectly, intended or unintended.

24.2 Discussion

24.2.1 Importance

In National Agricultural Research and Education System (NARES), the impact assessment is used

- For assessing the socio-economic effects of an extension, technology or communication intervention;
- In the identification of problems associated with technologies and processes in the user system;
- For developing research and development priorities;
- For improving accountability for resources and efforts invested in the intervention.

24.2.2 Impact assessment framework

Impact assessment (IA) is an integral part of programme planning, implementation and evaluation. IA, along with processes like monitoring and evaluation, are employed to ensure progress of the work according to the programme objectives and to verify if results obtained are as desired by the implementing agency. IA measures the achievement of project milestones, outputs, outcomes and their impact on the targeted population. This process is pictorially depicted in Fig. 24.1.

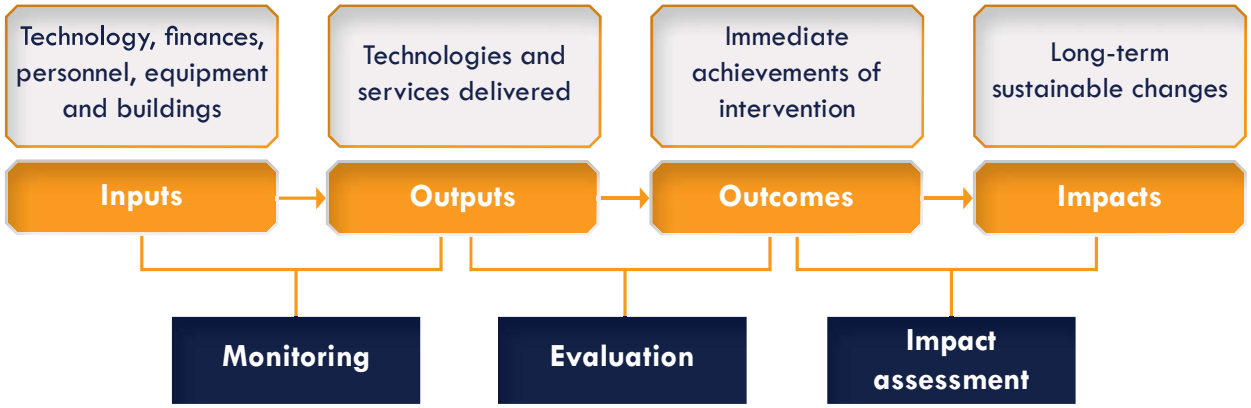

Fig. 24.1: Impact assessment framework (Adapted from Devos Vaughan and Associates - http://devosvaughan.com/services-programme-review.html)

Definitions of various elements in the impact assessment framework are displayed in Box 24.1.

Box 24.1: Definitions of elements in the Impact Assessment Framework

Inputs – All the resources that contribute to the production and delivery of outputs. Inputs include finances, personnel, equipment and buildings;
Outputs – The final products, or goods and services produced for delivery;
Outcomes – The medium-term results for specific beneficiaries that are a consequence of achieving specific outputs. Outcomes should relate clearly to an institution's strategic goals and objectives set out in its plans. Outcomes are 'what we wish to achieve';
Impacts – The long-term results of achieving specific outcomes, such as reducing poverty and creating jobs.

The quality of impact assessment depends on the soundness of the programme implementation process. For effective impact evaluation, the questions below need to be answered at every stage of technology or extension intervention.

(i) Planning

WHAT	realistic objectives and specific outcomes?
WHO	target/beneficiary group?
WHEN	duration?
WHY	assumptions?
SO WHAT	continuity and sustainability?

(ii) Implementation

HOW	methods? processes?

(iii) Evaluation

WHAT/WHY	type of assessments?
HOW/WHEN	methods in data collection?
WHO	community? stakeholders?
SO WHAT	continuity and sustainability?

(iv) Report

WHERE/WHEN/HOW	publishable platforms, e.g. social media, traditional media, print?
WHO	funding bodies and stakeholders? feedback to community?
WHY	benefits?

24.2.3 Indicators for impact assessment

- Indicators are common tools to assess the performance and then the impact of the technology/ extension/communication interventions. They measure the accomplishment of the project's goals and targets;
- Indicators should be defined during the formulation stage, but they often need to be specified in greater detail during implementation;
- Indicators should measure intangible as well as tangible changes, particularly in projects that value factors such as personal and social development;
- The procedure for selecting good impact indicators is described in Box 24.2.

Box 24.2: Procedure for selecting impact indicators

1. Decide the level of impact assessment (output/outcome/impact);
2. Identify a limited number of relevant indicators that adequately measure the selected impact level;
3. Select the data sources available and the type of data collection needed for each indicator;
4. Construct a matrix listing the indicators, identifying their importance for selected impact level (high/low), ease of obtaining data on the indicator (easy/feasible but effort/difficult levels) and the cost of data collection;
5. Prioritize indicators by importance, the ease of obtaining data, and cost and select a set of indicators using weighted matrix ranking/rating method;
6. Group selected indicators by source of data to determine the set of sources, which can provide data on clusters of indicators;
7. Make a final selection of a group of indicators and decide on a data collection plan in light of available logistical, human and financial resources, and time.

(Adapted from Badioli, 2011)

Indicators for assessing impacts of technology or extension interventions

What should be measured

- Technical aspects: physical input-output of goods and services;
- Institutional aspects: organizational and managerial aspects, including customs, tenure, local organizations, and cultural setting;
- Socio-cultural aspects: broader social implications, resource and income distribution, and employment opportunities;
- Commercial aspects: business and financial, securing supplies, and market demand;
- Economic aspects: economic efficiency, costs and benefits;
- Environmental aspects: biological and physical effects.

Social and behavioural indicators

- Changes in awareness, knowledge, skills level of beneficiaries;

- Increases in the number of people reached;
- Policy changes;
- Changes in behaviour, e.g., adoption;
- Changes in community capacity;
- Changes in organisational capacity (skills, structures, resources);
- Increases in service usage.

Socio-cultural indicators

- Food security;
- Poverty reduction;
- Status of women improved;
- Distribution of benefits across gender and geographical locations;
- Changes in resource allocation;
- Changes in cash requirement;
- Changes in labour distribution;
- Nutritional implications.

Technology level indicators

- Adoption of improved technology – symbolic and actual adoption;
- Horizontal impact – increase in area under improved variety/breed;
- Vertical impact – increase in productivity of improved variety/breed;
- Reduction in cost of production;
- Risk reduction;
- Increase in annual income/economic capacity;
- Jobs created.

Environmental impact measures

- Effect on soil erosion and degradation, silting, compact soil, soil contamination, water contamination;
- Changes in hydrological regimes;
- Effects on biodiversity, air pollution, greenhouse gases.

Institutional impact measures

- Changes in organizational structure;
- Change in the number of scientists;
- Change in composition of the research team;
- Multidisciplinary approaches and improvements;
- Changes in funding allocated to the program;
- Changes in public and private sector participation;
- New techniques or methods.

24.2.4 Approaches for impact assessment

Broadly, impact assessment approaches can be classified into quantitative, qualitative, participatory, and mixed-methods. Quantitative methods focus on generating quantitative data on the impact indicators, while qualitative methods are concerned with impacts within local socio-cultural and institutional context. Participatory methods include an exploratory assessment of impacts wherein users and mixed-methods combine both qualitative and quantitative approaches so as to provide a comprehensive view of the impacts within the socio-cultural milieu.

Quantitative impact assessment approaches

- Focus is on assessing the degree and extent of the impacts quantitatively. Some degree of quantification may be necessary in all impact assessments, in order to evaluate the success of the intervention and the extent of any adverse effects;
- Largely depends on micro-economic approaches following econometric models;
- Involving baseline studies – The precise identification of baseline conditions, definition of objectives, target setting, rigorous performance evaluation and outcome measurement;
- Costly and limited scope – Limited in the types of impacts which can be accurately measured and may pose difficulties for inference of cause and effect.

Types

a. Based on time period of assessment

Impact assessment may take place before approval of an intervention (ex ante), after completion (ex post), or at any stage in between.

Ex ante assessment

- Forecasts potential impacts as part of the planning, design and approval of an intervention;
- Example – Assessment of adoption of Genetically Modified Rice variety.

Ex post assessment

- Identifies actual impacts during and after implementation, to enable corrective action to be taken if necessary, and to provide information for improving the design of future interventions;
- Example – Knowledge gain of trainees from a multimedia CD on SRI method of cultivating rice.

b. Based on research design

Impact assessment may be conducted using various designs – Experimental, quasi-experimental and non-experimental designs.

1. Experimental approaches

(i) Randomized evaluations

- In randomized evaluations, the programme benefits are extended to a randomly selected treatment group (beneficiaries), while keeping an identical group as control;
- The progress of the treatment and control groups on selected impact indicators is tracked over time (Khandker et al., 2010).
- Randomised evaluations are used when
    - The eligible population is large enough to deliver the programme;
    - A program needs to be gradually phased in until it covers the entire eligible population.
- The major advantage of this approach is its ability to avoid bias in selecting respondents.

(ii) Pre-test/Post-test with random assignment to intervention or comparison groups

- In these randomized experiments, study subjects are randomly assigned to a group that receives the technological intervention (study or treatment group) or a comparison group that does not receive

the intervention (control or non-treatment group);
- Data for each group are collected before and after the intervention;
- At the end of the experiment, differences between the intervention and comparison groups can be attributed directly to the effect of the intervention, if the sample is large enough;
- Used in small samples consisting of less than 30 persons per group;
- Statistical methods are selected based on the research question
    - Whether the mean change in the outcome from before and after the treatment differed between the two groups – Repeated measures ANOVA;
    - Whether the post-test means, adjusted for pre-test scores, differ between the two groups – Analysis of Covariance (ANCOVA).

(iii) Post-test only randomised experiment

- Two groups are randomly assigned the subjects and treatment conditions;
- Data collected only after the intervention;
- Statistical tests – Regression, t test, ANOVA.

2. Quasi-experimental approaches

(i) Pre-test/Post-test with non-random assignment to intervention or control groups

- In this design, data are collected before and after the intervention;
- Assigning subjects to the intervention and comparison groups is non-random;
- Comparison groups in the quasi-experimental design can be identified through propensity score matching;
- Propensity score matching – The control population (non-beneficiaries) is selected by 'matching' them with the actual beneficiaries on a few observable characteristics (personal and socio-economic attributes);
- The matched control groups can be selected either before project implementation (prospective studies) or afterwards (retrospective studies);
- Approaches for matching the beneficiaries and non-beneficiaries – nearest-neighbour (NN) matching, caliper and radius matching, stratification and interval matching, kernel matching, and local linear matching (LLM) (Khandker et al., 2010);
- Statistical analysis – Reliability-corrected ANCOVA.

(ii) Two group post-test only with non-random assignment

- Data are collected only after the program has ended among participants who had received the intervention and among non-participants;
- Matching participants and non-participants with similar characteristics and accounting for any relevant differences are especially important in the post-test only design to isolate effects of the intervention.

(iii) Double difference or difference-in-differences (DID) methods

- Estimates the effect of a specific intervention by comparing the changes in outcomes over time between a population that is enrolled in a program (the intervention group) and a population that is not (the control group);
- Can be applied in both experimental and quasi-experimental designs and requires baseline and follow-up data from the same treatment and control group;
- A baseline survey is conducted prior to the intervention to assess the outcome indicators with both beneficiaries (treatment) and non-beneficiaries (control or comparison), which are compared to

estimate the differences (Khandker et al., 2010);

- After the intervention, the survey is repeated to assess the differences in treatment and control groups;
- The mean difference between the 'after' and 'before' values of the outcome indicators for each of the treatment and comparison groups is calculated followed by the difference between these two mean differences. The second difference i.e., difference in the difference is the estimate of the impact of the program;
- Statistical methods – Repeated measures ANOVA, Repeated measures liner regression analysis, propensity score matching;
- Useful technique to use when randomization on the individual level is not possible.

(iv) Regression discontinuity design

- A pre-test – post-test comparison method design that elicits the causal effects of interventions by assigning a cut-off or threshold above or below which an intervention is assigned;
- In this design, the participants are assigned to intervention or comparison groups solely on the basis of a cut-off score on a pre-intervention measure.
- The average treatment effect is estimated by comparing observations lying closely on either side of the threshold;
- Used in those conditions in which randomization is unfeasible and the researcher is interested in targeting an intervention or treatment to those who most need or deserve it;
- Two types of regression discontinuity designs:
    - Sharp method which assigns a discrete cut-off point for both beneficiaries and non-beneficiaries and compares means of treatment effects to assess the impact;
    - Fuzzy method was used in instances where a few eligible people are excluded from the intervention or became ineligible due to other reasons. The fuzzy version is the widely used method.

3. Non-experimental designs (MLE, 2013)

- These designs have only an intervention group without any control;
- Weakest designs for impact assessment;
- Used under (i) limited resource condition, (ii) researchers are unable to create a comparison group, (iii) when an intervention covers the entire population.

(i) Pre-test/post-test designs

- The researcher measures pre- and post-intervention changes in the specific phenomenon (outcome indicator) between subjects;
- When changes occur in outcome indicators among the intervention participants, they cannot attribute all these changes to the intervention using this design alone because there is no comparison group.

(ii) Time-series designs

- The changes in outcome indicator over time is estimated to determine trends;
- The data is collected multiple times before and after the intervention to analyse trends before and after.

(iii) Longitudinal study

- The researcher records repeated measures of the same variables from the same people;
- A panel design is a special type of longitudinal design in which evaluators track a smaller group of

people at multiple points in time and record their experiences in great detail.

(iv) Post-test only design

- Researchers observe the intervention group at one point in time after the intervention, focusing particularly on comparing responses of sub-groups based on such characteristics as age, sex, ethnicity, education or level of exposure to the intervention.

Methods to strengthen non-experimental impact assessment

(a) Measure participants' level of exposure to the program: Measuring the participants' initial level of exposure to the intervention aspect will help to offset selection bias;
(b) Collect data from the same participants over time using a panel or longitudinal design: Individuals serve as their own control;
(c) Instrumental variable (IV) methods.

- A statistical estimation method to be used with non-experimental design of impact analysis;
- Unobservable biases in sample selection are minimised by including a new variable in the analysis;
- The new variable is called as 'instrumental variable' since it increases the probability that a person be selected as beneficiary in the study, but is demonstrated to have no influence on the outcome of the intervention;
- For example, 'geographical variation' may be included as an instrumental variable when assessing the impact of poverty alleviation programmes.

Economic impact assessment

A. Partial Budgeting Technique (PBT): This is another useful technique for studying the economic impact of a small scale intervention or a single technology adoption. For example, intervention in terms of drip irrigation in tomato cultivation can be studied using this approach. This technique has four components:

1. Increase in income;
2. Reduction or elimination of costs;
3. Increase in costs;
4. Reduction or elimination of income.

Profit/Loss = [Added returns - Added costs] + [Reduced costs - Reduced returns]

Features of this method

- The technique is simple and easy to learn;
- It examines only net changes in costs and benefits, therefore it is effective for assessing economic viability of single intervention technologies;
- It requires less data than whole farm budgeting since fixed costs are not examined;
- It allows early conclusions about the adaptability of the new technology.

Partial Budget for Drip Irrigation intervention where flood irrigation was practiced:

A. Added Income:
Additional income – 25000
(Difference in revenue earned)

B. Added cost:
Labour cost – 700
Drip system cost – 40000

(Seasonally apportioned)
Total added cost – 20700

C. Reduced income: Nil

D. Reduced cost:
Labour cost – 2500
Water cost (imputed) – 2000
Total reduced cost – 4500

A-B-C+D = 25000+4500-20700-0 = 8800

B. Net Present Value (NPV)

The NPV of an investment is a simple criterion for deciding whether or not to undertake an investment. NPV answers the question of how much cash an investor would need to have today as a substitute for making the investment. If the net present value is positive, the investment is worth taking on because doing so is essentially the same as receiving a cash payment equal to the net present value. If the net present value is negative, making the investment today is equivalent to giving up some cash today and the investment should be rejected. If the p rojected return on an investment is identical to the selected discount rate, the NPV=0 and the investor is indifferent with respect to making the investment. NPV is the present value of all benefit discounted at the appropriate discount rate, minus the present value of all costs discounted at the same rate. Symbolically it can be mentioned that:

$$NPV = \sum_{0}^{t} \frac{(B_t - C_t)}{(1+r)^t}$$

Where: B_t is the benefit at time t
C_t is the cost at time t
r is the discount rate
t refers to the time period

C. Benefit-Cost Ratio (BCR)

The benefit-cost ratio takes the times series data on benefits and costs used to construct NPV and organizes them in a ratio form rather than as an absolute value. Alternatively, the BCR can be defined as the ratio of the discounted benefits to the discounted costs of an investment with reference to the same point in time.

$$BCR = \frac{\sum B_t(1+r)^t}{\sum C_t(1+r)^t}$$

D. Internal Rate of Return (IRR)

The IRR reveals the rate of growth of capital invested in the business. For purposes of analysing the economic impacts of R&D, IRR is called as private rate of return (PRR) when the return to a single company's (the innovator's) R&D investment is being studied, or the social rate of return (SRR) when industry-wide or economy-wide rates of return are estimated. IRR is the rate at which NPV=0 and it can be easily computed using GOAL SEEK option under WHAT-IF ANALYSIS of MS EXCEL. Otherwise, the following formula may be used

$$IRR = r_1 + \frac{NPV_1}{NPV_1 - NPV_2}(r_2 - r_1)$$

r_1= lower discount rate chosen
r_2= higher discount rate chosen
NPV1= NPV at r_1
NPV2= NPV at r_2

Cost concepts

To measure the profitability of new technology, the following cost concepts can be used

- Cost A1 = All actual expenses in cash and kind incurred in production;
- Cost A2 = Cost A1 + Rent paid for leased in land;
- Cost B1 = Cost A1 + Interest on value of owned capital assets;
- Cost B2 = Cost B1 + Rental value of owned land and rent paid for leased in land;
- Cost C1 = Cost B1 + Imputed value of family labour;
- Cost C2 = Cost B2 + Imputed value of family labour;
- Cost C3 = Cost C2 + 10% of Cost C2 on account of managerial functions performed by the farmer.

Other important tools

- Adoption rate/index/quotient
- Factors influencing the adoption of a technology (logit/probit)
- Consumer surplus model
- Dummy variable regression models
- Structural change in time series models
- Input-output model/SAM
- Competitiveness index (for exports)

Participatory approaches

- Participatory Impact Assessment (PIA) is an extension of Participatory Rural Appraisal (PRA) and involves the adaptation of participatory tools combined with more conventional statistical approaches specifically to measure the impact of technology and extension interventions on people's lives;
- Consists of a flexible methodology that can be adapted to local conditions;
- Acknowledges local people or project clients as experts by emphasizing the involvement of project participants and community members in assessing project impact;
- Participatory impact assessment answers the following questions:
  - What changes have there been in the community since the start of the project?
  - Which of these changes are attributable to the project?
  - What difference have these changes made to people's lives?
- Most extension research employs a qualitative participatory approach to assess the 'perceptual impacts' using participatory methods, such as Participatory Rural Appraisal, Focus groups, case studies, participant observation, etc.;
- This approach plays an important role in impact evaluation by providing information useful to understand the processes behind observed results and assess changes in people's perceptions of their well-being;
- Participatory methods can be used to improve the quality of survey-based quantitative evaluations by helping generate evaluation hypothesis and strengthening the design of survey questionnaires and expanding or clarifying quantitative evaluation findings (Khandker et al., 2010);
- A recent approach for participatory impact assessment is MAPP, which is described in Box 24.3.

Box 24.3: Method for Impact Assessment of Poverty Alleviation Projects, 1998

An innovative impact assessment approach developed by Ms. Susanne Neubert of German Development Institute, Germany, called MAPP (Method for Impact Assessment of Poverty

Box 24.3: Method for Impact Assessment of Poverty Alleviation Projects, 1998

Alleviation Projects, 1998), combines a quantitative approach with participatory assessment to derive tangible results in order to address the needs of managers and policy makers. In this method, impact is assessed through a series of workshops with stakeholder representatives. It has wide applications to analyse complex development goals like poverty reduction, democratization, good governance, economic and sustainable development.

A detailed description of various impact assessment methods used in socio-economic research can be found at http://are.berkeley.edu/~sadoulet/papers/deJanvryetal2011.pdf

A few applied impact assessment methods commonly found in the literature on impact study are presented in Table 24.1. However, a right mix of both qualitative and quantitative techniques are required to study the impact.

Table 24.1: Impact Assessment Methods and Techniques

Impact type	Method	Technique
Intermediate impact • Institutional changes • Changes in the enabling environment	Survey, monitoring	Simple comparison/trend analysis
Direct product of research	Effectiveness analysis using logical framework	Simple comparison: target vs. actual
Economic impact	Econometric approach, surplus approach	Production function, total factor productivity, index number methods, and derivatives
Socio-cultural impact	Socio-economic survey/ adoption survey	Comparison over time
Environmental impact	Environmental impact assessment	Various • Qualitative • Quantitative

24.3 Key Points

- Impact assessment (IA) is crucial for judging the utility of an intervention.
- In NARES, impact assessment was studied to assess socio-economic effects, problems with technologies and process, prioritization of research projects and to justify the costs sunk into research.
- The IA framework includes inputs, outputs, outcome and impacts. Identification of criteria and indicators greatly affects IA studies.
- Indicators, which are developed specifically for technical, institutional, socio-cultural, commercial, economic and environmental aspects, have to be spelt out clearly and objectively, so that it is amenable for precise quantification. Both quantitative and qualitative methods are used in IA studies.
- Although the quantitative approach is preferred for better results, yet the qualitative approach is a sinequa non in many instances. IA is classified in many ways, viz., ex-ante and ex-post; experimental,

quasi-experimental, and non-experimental.

- The popularly adopted economic impact assessment techniques include partial budgeting techniques such as Net present value, benefit-cost ratio and internal rate of return. Other techniques such as economic surplus model, regression models, structural change in time series data, input-output model, etc. were used often for economic-impact assessment.

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