Techniques for Impact Assessment of Technologies

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Abstract

Impact assessment is a process of formal, evidence-based procedure to assess the effects of technology/ project/intervention in terms of economic, social and environmental effects. Ex ante impact analysis is done to know what the impact of an intervention might be. It is done at need analysis and planning stage of project cycle. Ex post impact assessment is done to know to what extent and how an intervention brings out a change it was intended to. It is mostly used to know the impact of technologies, etc. For agricultural projects and technologies, mostly economic impact assessment in terms of increase in yield, rise in net profit, etc. is done to know the effects of technology/ intervention. Considering the scope of this article, it deals with only economic impact assessment. Economic impact can be assessed with many techniques. Considering budget available, data availability etc. suitable method can be chosen.

Introduction

In agricultural sector, when we introduce any interventions that directly target farmers, our primary objective will be increasing agricultural production, productivity and profitability with the purpose of increasing agricultural income. These interventions may be introduction of a new variety, improvement in the crop management, natural resource management, water management, training to farmers, post-harvest management, farmer credit or improved access to market. These interventions may not only lead to the intended result, but also to unanticipated effects, which can be either positive or negative effects. Therefore, to identify the consequences of the proposed action, impact assessment is done. Impact assessment is a systemic analysis of the intervention, related to its contribution to outcome and goal. It is used to ensure whether the intervention is technologically feasible, economically viable, socially acceptable and environmentally sustainable.

Impact Assessment

Impact assessment is the analysis of the significant change that has occurred due to an action or series of actions (intervention). This involves what has changed, for whom, how vital the change was, how long the change will last and in what ways our actions have contributed to that change. It is important to assess the impact of the intervention to determine the success of the intervention, how it has impacted the beneficiaries and the local community, and also to use the findings of the assessment for recommending changes in the policies. It also helps us to be accountable to the funding agencies or institutions for which we are working.

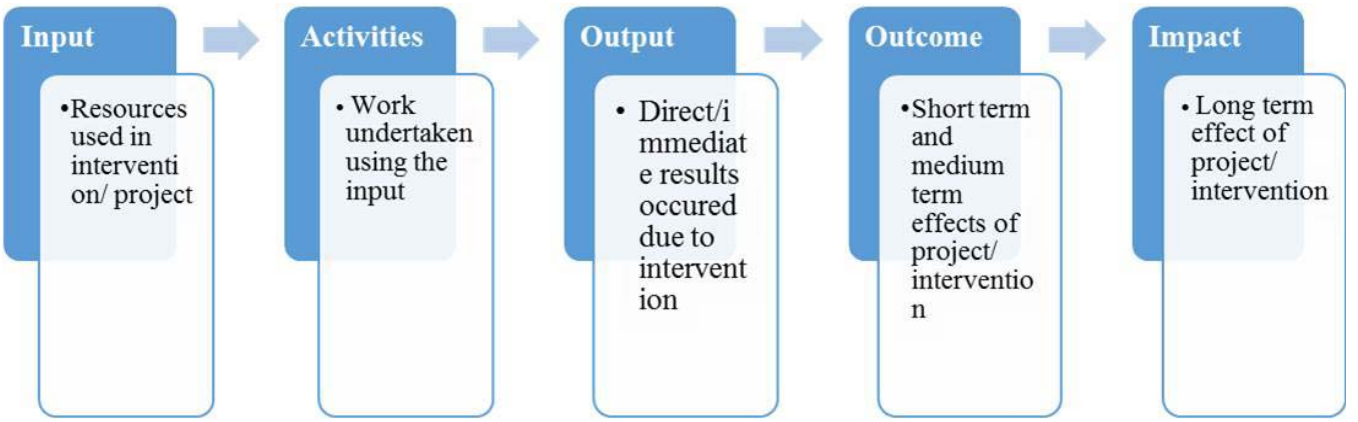
Impact assessment tries to establish a causal relationship between inputs and changes in terms of magnitude or scale or both. Based on effect, the impact of any intervention can be (Rogers 1995, Airaghi *et.al.* 1999, Kelley *et.al.* 2008)

- Positive or negative
- Direct or indirect
- Primary or secondary
- Intended or Unintended
- Short/Medium/Long term

For example, if we are introducing a new processable variety of pigeon pea LRG 52 (Amaravathi) with good dal recovery in the farmers' field in selected village, the input will be new crop variety i.e. LRG 52. The activities involved will be all the cultivation practices under taken as per the package of practices and processing of the pigeon

pea. The output of the intervention be increased production of LRG 52 variety of pigeon pea and increased processing in the selected village. The outcome of the project will more profit to farmers and greater food security. In the long run, the impact of the project will be poverty reduction, economic growth and social development of the village.

Logic Model Approach



Intended result **Planned work**

Approaches of Impact Assessment

With reference to the purpose for which the impact or change is assessed, there are different approaches for impact assessment. Broadly, there are two main approaches

1. Ex ante impact assessment: Usually done to know what the impact of an intervention might be. It is done at need analysis and planning stage of project cycle. Here the future benefits of the project/intervention will be calculated in terms of economic benefits, productivity increase, effect on environment etc.
2. Ex post impact assessment: Usually conducted to know to what extent and how an intervention brings out a change it was intended to. This is done after the technology/ intervention has been widely adopted by farmers/ beneficiaries. It is mostly used to know the impact of technologies.

Levels of Impact Assessment

Impact assessment can be done at many levels. We can do farm level impact assessment focussing on the well-being of farmer. In this, we can focus on his crop yield, income, household food security, risk mitigation, natural resource management at the farm level etc. The assessment can also be done on regional, national or sector level. For example the performance of agriculture sector focussing on production, prices of the produce, employment generation, natural resource utilisation/management, poverty reduction etc. The performance of economy i.e. economy

Difference between Monitoring, Evaluation and Impact Evaluation (Flynn, 2010)

Monitoring	Evaluation	Impact Evaluation
Measures on-going activities	Measures performance of the project against objective	Measures changes: positive or negative, intended or not
Important during implementation of the project	Important in the middle or at the end of the project	Can be included at all stages and/ or after the end of the project
Focus on intervention	Focus on intervention	Focus on affected population
Focus on outputs	Focus on outcomes	Focus on impact
'What is being done'?	'What has happened? Did we achieve what we intended to achieve?'	'What has changed? For whom? How significant it is for them?'

level impact can also be assessed by taking into account the contribution of the project/intervention to national income, savings, food security, trade, poverty alleviation etc.

Steps for Impact Assessment

I. Select technology/intervention/project for impact assessment

Identify the technology/intervention/project for which the impact assessment has to be done.

II. Identify target domain

Define the type of assessment that we have to do i.e. whether it has to be done at economic level (net benefit, rate of return etc.), social aspect (access to information, social network, changes in organization, gender equity, poverty alleviation etc.), human capital (changes in knowledge, attitude, skills), environmental (natural resource management, change in environment pollution/contamination level, soil and water conservation etc.) or combination of these.

III. Define level of impact assessment

At this stage, clarify the purpose for which the impact assessment is done and at which level we have to do the impact assessment i.e. farm, regional, sectorial, national etc.

IV. Select the comparison method for impact assessment

In order to evaluate whether there is any effect due to the project/ intervention, we have to do comparison. There are different ways of comparison to analyse the impact. They are:

(1) Before and after method: The same group of farmers will be used for comparing the changes that have occurred due to the intervention i.e. condition of farmers before intervention will be compared to their condition after the intervention. For example, if the introduction of LRG 52 variety of pigeon pea has increased the income of the farmers in comparison to the normal variety, then it can be said that the intervention had a positive effect on the income of farmers. The advantage of this method is that since we are dealing with the same group of people, there will not be any significant differences between the treatment and the control in socio-economic and agro-ecological terms. Disadvantage of this method is that since farmers knew that they are a part of the project/ intervention, sometime they may respond to the questions differently. Also if the intervention is influenced by weather conditions, sometimes using before-after method may give biased results.

(2) With and without method: In this method, two different groups will be studied at the same time, i.e. one with the intervention and another group without the intervention. Due to the project/intervention (cultivation of LRG 52 variety of pigeon pea) if treatment group has increase in income by 40% and control group has increase in income only by 15%, we can say that the intervention had a positive effect on the income of farmers. This method also has its own advantage and disadvantage. Two groups will be compared during the same year during the same weather conditions. But it is very difficult to get a treatment group and control group with similar socio-economic and agro-ecological conditions.

(3) Comparison "with and without" combined with "before and after" method: Another way to compare the effect of intervention is to compare the group that has benefited from the intervention/project with the group that has not benefited from the project at two points of time i.e. before and after. Therefore, a baseline study of both treatment and control group must be done and ensured that both the groups are sufficiently similar. After the intervention, data will be collected again from both the treatment and control group. This method provides a better way to compare the effects of the intervention/project.

V. Select the sample size for evaluating impact

After deciding on the method for comparing the impact assessment, it also important to select appropriate sample size for impact assessment. There are different methods for deciding sample size depending on the type of sampling. To determine the sample size based on the principles of simple random sampling is given below:

(1) Calculate sample size where population (N) is infinite

$$n_o = \frac{Z^2_{\alpha/2} * P(1-P)}{e^2}$$

Where:

n_0 = sample size;

Z = Confidence level selected, this is determined by the value of á. For a confidence level of 95% (á = 0.05), which is commonly used, this value is 1.96

P = expected proportion of response from the respondents. When you do not have previous knowledge of this information usually a 50% probability is normally used;

e = error or maximum tolerance level of the sample. Generally, a maximum error of 5% to 10% is expected

When we do not know the characteristics of the population, the value of Z and P is predetermined as Z==1.96 and P= 0.5 .Therefore,

When tolerance level, e=5%

$$n_0 = \frac{1.96^2 * 0.5 * 0.5}{0.05^2} = 384$$

When tolerance level, e=10%

$$n_0 = \frac{1.96^2 * 0.5 * 0.5}{0.10^2} = 96$$

(2) $N > n_o(n_0 - 1)$ where: N is the size of the population

If this condition proves to be correct, then n_o is equal to the size of the sample to be selected. If this condition is not satisfied, we have to calculate the sample size using the following formula

$$n = \frac{n_0}{1 + \frac{n_0}{N}}$$

Eg: To calculate the sample size required to estimate impact assessment of two population of farmers with 500 and 10000 inhabitants

Population	Tolerance level	n_0	$N > n_o (n_0 - 1)$ Condition prove to be correct	Total number to be sampled
500	5%	384	No	217
500	10%	96	No	81
10000	5%	384	No	370
10000	10%	96	Yes	96

But in many cases sample size is determined by considering the human and financial resources that are available to carry out the impact study.

VI. Designing baseline survey

Baseline survey should be conducted, in both the groups i.e. the treatment and the control group. The two groups should be sufficiently similar so that the situation after the intervention/project can be evaluated. The baseline is a report of the existing situation of the groups as a function of variables defined for a specific project. In this particular

case, the baseline is the area under processable pigeon pea variety LRG 52 and the extent of processing done by farmers. Variables referring to human (farmer knowledge about the variety, skill in processing), social (presence of farmers group, NGO's, FPO etc.), economic and environmental (use of fertilizer, water, pesticides) aspects can also be considered for the baseline study before the project begins. Later on, the results of the baseline study will be compared with the survey results after the project has been completed to analyze whether the introduction of new variety has generated any significant change in the indicators. In short, baseline study is the initial measurement of the variables, using the indicators that are expected to be modified by the introduction of new variety. Therefore, it is essential to define indicators that should be measured in the baseline study and afterwards. Data can be collected by interviews using structured or semi-structured interview schedule, focused group discussion, participant observation, case studies etc. Information from secondary sources or other available sources of information can also be used to collect data in a baseline study.

VII. Define indicators for impact assessment

Indicators are variables that are used to measure the result of an action i.e. the consequence of the intervention. The measurement can be either quantitative or qualitative. An impact indicator shows whether the intervention/ project output had any further implication (positive/negative, anticipated/unanticipated) on the overall population, situation or the surrounding. A good indicator will be logically related to the identified objective. In order to identify the indicators that measure the impact, it is important to know the objective of the project i.e. what the project/ intervention aims to attain at a given point of time. We have to define indicators for each type of impact. Few examples of impact indicators are given below:

Impact Indicator	Unit
Yield	q/ha
Productivity	q/ha
Agricultural Income	Total income (Rs.)
Agricultural Profit	Net income (Rs./ha)
Food Security	Food security index
Land cultivated	Percentage or ha
Knowledge of resource management practices	Yes=1, N0=0 or Percentage of farmers who know about the practices
Technology Adoption	Yes=1, N0=0 or Percentage of adopters
Skill to operate dal mill	Percentage of farmers who properly operate the dal mill

VIII. Select appropriate methodology

(1) Methods for measuring economic impact

Different methods like benefit-cost analysis, partial budgeting technique, trend forecasting, economic surplus model, econometrics, general equilibrium analysis, production approach etc. can be used for measuring economic impact. Some of the methods are described below:

(a) Benefit-Cost Analysis: This method includes the Net Present Value (NPV), Benefit-Cost Ratio (BCR) and Internal Rate of Returns(IRR)

NPV: It 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.

NPV < 0, project/intervention is not profitable

NPV >0, project/intervention is profitable

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

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

BCR: It is the ratio of the discounted benefits to the discounted costs of an investment with reference to the same point in time. Higher the BCR, better the intervention.

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

IRR or Return on Investment: It is the rate at which NPV=0. IRR gives us a percentage value that indicates the profitability of the project. IRR is a way to compare between other similar options of investment (opportunity cost). If IRR is higher than the opportunity cost of investment in the project, it means the project has a positive impact

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

r_1 = lower discount rate chosen

r_2 = higher discount rate chosen

NPV_1 = NPV at r_1

NPV_2 = NPV at r_2

(b) Partial Budgeting: This method is used when we have to calculate the economic impact of a small scale intervention or a single technology adoption. This method requires less data and allows early conclusions. In this method, if the profit remains same or decreases the intervention/technology is not more profitable than the technology used by farmer and therefore it should not be recommended. If the profit increases, the intervention/technology should be recommended to the farmers.

Profit/Loss= (Added returns -Added costs) + (Reduced costs - Reduced returns)

(c) Economic Surplus Model: To estimate economic impact, this model requires data related to technology targeted domain (production system, crops, inputs, outputs), yield and cost changes (increasing/stabilized), adoption level, R& D lag years, research and extension costs, market parameters (production, prices, elasticities) etc.

Here technology adoption is the extent to which technology is used by the beneficiaries and its benefits. The information related to technology adoption can be obtained through survey, sale of the technology (inputs like seed, fertilizer, pesticide etc.) or from secondary sources.

$$\Delta CS = P_0 Q_0 Z\ (1 + 0.5Z\eta)$$

$$\Delta PS = P_0 Q_0\ (K - Z)\ (1 + 0.5Z\eta)$$

$$\Delta TS = \Delta CS + \Delta PS = P_0 Q_0 K\ (1 + 0.5Z\eta)$$

Where $Z = K\ (\varepsilon|\varepsilon + \eta)$

ΔCS= Consumer Surplus

ΔPS = Producer Surplus

ΔTS= Total Surplus

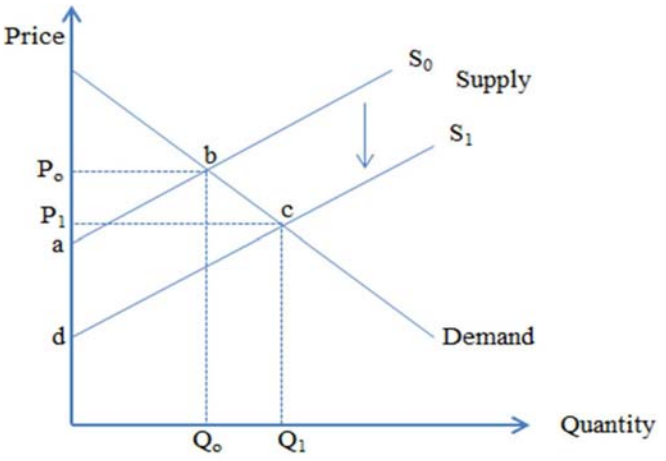
P_0 = Base Price of the commodity

Q_0 = Base Quantity

K= vertical shift in supply function as a proportion of initial price

η= Elasticity of demand (absolute)

ε= Elasticity of supply



Surplus and its distribution with parallel shift in supply curve

IX. Data collection and analysis

For impact assessment, there should be at least two rounds of data collection i.e. baseline survey and post-intervention survey. Beside these surveys, a pilot survey should also be conducted to check the validity of the questionnaire that has been developed. Questionnaire should include all the variables needed for the analysis, including, all the indicators required for assessing impact as well as control variables. Many a time we may have to ask a series of questions to measure a single variable. We should be clear with the usefulness of each question in the questionnaire and how they will be used in analysis. The pilot survey will help in identifying whether the questions are rightly interpreted or not by the respondents and whether all the variables that has to be covered is included or not in the questionnaire. The size of the pilot survey varies from project to project, but if our project is limited to a small area then survey of 25-30 beneficiaries will be sufficient.

The same questionnaire should be used in the baseline and follow-up survey. Any change in the questions may lead to changes in response of the beneficiary which may lead to faulty interpretations. In addition to collecting data, using questionnaire from the treated and control group, secondary information at the village or community level can also be collected.

The periodicity of data collection i.e. time between baseline and the follow-up surveys is also important. The key factor that influences the periodicity of data collection is the probable time that the project is expected to take to make an impact. For project interventions that will give an immediate or short-term effect (e.g. subsidies), follow survey after two years of baseline survey will be adequate. For project interventions that is expected to give a medium to long-term effect (e.g. technology transfers), to identify any impacts, the follow-up survey must be timed accordingly.

The data entry should be done as soon as possible after the data is collected. The collected data can be then analysed using suitable software's like SPSS or STATA.

Conclusion

Impact assessment of project or technologies is very important as it provides a proper feedback to research programmes. When a project intervention is done in a village or community, it will lead to many changes in the project area which may be intended or unintended. Thus, impact assessment is a systemic analysis of the intervention, related to its contribution to outcome and goal. It is used to ensure whether the project or intervention is economically viable, socially equitable and environmentally sustainable. There are many approaches to impact assessment and can be done at many levels. A series of steps have to be followed for doing impact assessment. For assessing impact, there is no single method that is appropriate. Therefore, depending upon what type of impact that we are expecting, the method should be also selected appropriately.

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