NATP PME notes 12

Task Force on Prioritization, Monitoring & Evaluation

भाकृअनुप ICAR

Impact Assessment of Agricultural Research - *Concepts and Measurement*

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Need for impact assessment

Agricultural research is an economic activity. Like any other investment propositions, resource allocation to agricultural research needs to be justified. The society or the donors are always interested to know what happened to the money invested in agricultural research. It is important to document the returns and/ or benefits accrued from the research investment. Objective assessment of research investment helps in making decision and allocating resources in high returns research portfolio. It also helps to know which research areas and programs benefit the poor and regions. In the paradigm shift, the donors are seeking evidences on impact of past funding as a basis for future financial support. Systematic impact assessment forms the basis for efficient resource allocation in alternative research programs competing for financial support. Research programs demonstrate better historical performance, in terms of benefits generated for the society, are rated higher for attracting required research resources. Impact assessment studies are also getting more prominence as the international environment is rapidly changing due to many emerging complex problems. Socioeconomic and environmental problems, like poverty, international trade, degradation of natural resources, are growing fast and the donors are looking for the research programs, which can overcome these challenges. Therefore, systematic impact assessment studies would form a strong base for higher research funding to overcome many regional, national and global problems.

Impact assessment of research is not a new phenomenon. Earlier, it was based on some partial evidences. Some times the changes in production, area and productivity enhancement were used as a proxy for contribution of research at regional or national levels. Other proxies used were increased export, import substitution, employment generation, and contribution towards improving nutritional security and conservation of soil and water resources. Such proxies were often questioned, as such changes were the result of numerous forces, including the research contribution.

Framework for research impact assessment

The framework for research impact assessment is shown in Figure 1. Impact assessment is undertaken at three levels. First, ex-ante assessment, which is done to objectively assess the research portfolio and prioritize the research agenda. This is done to justify funding in different research options. In the figure, it is allocating resources in R&D for generating research outputs. The second is the concurrent evaluation, which is done to identify the impediments for larger adoption of the research outputs. The purpose is to correct the gaps and provide feedback for refining and tuning the technology as per the stakeholders' requirements. Often it is known as constraint analysis. In the figure, four circles are being shown. These are technology traits (e.g. duration, quality, etc.), policy environment (e.g. price support, procurement, etc.), institutional arrangements (e.g. seed sector, credit availability, etc.), and infrastructure (e.g. markets, roads, power, processing facilities, etc.). All these four components determine the adoption of any technology. It is just like four wheels of a vehicle. When all the wheels have optimum air, pressing accelerator will pick-up the

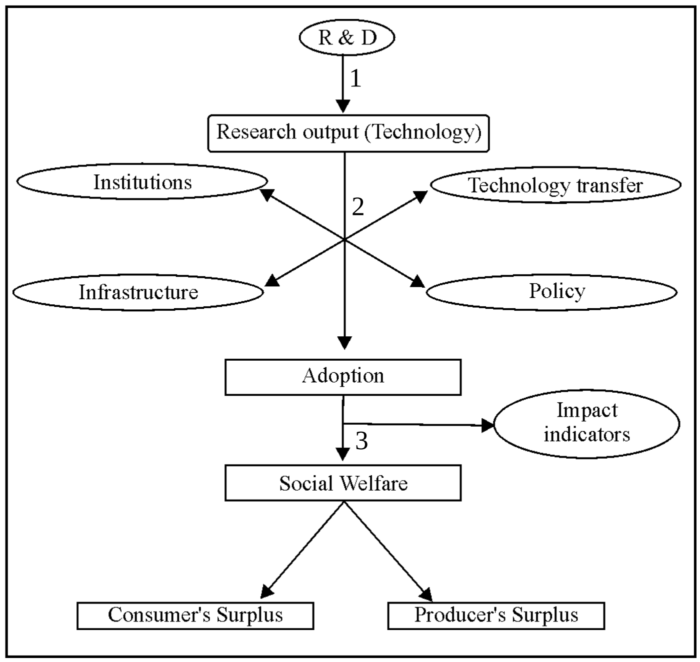

Figure 1 : Framework for assessing research impact

speed of the vehicle at desired speed. Less air even in one wheel will limit the speed. If one wheel is flat, the vehicle has to be dragged by other means. The same is true for adoption of research outputs or improved technologies. During the green revolution period, all the four circles were favorable, which resulted in fast adoption of improved technologies. It was also true during the Oilseed Mission. On the contrary, the other promising technologies like watershed development, salinity management, Integrated Pest Management were finding difficult to be largely adopted despite

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of favorable policy environment and infrastructure. The absence of appropriate institutional arrangement is hindering the speed of these promising technologies. Therefore, determining constraints for larger adoption forms a part of the impact assessment. Such studies are characterized as part of the early impact assessment. These provide useful information on conditions for larger returns and benefits of research investment.

The third stage of impact assessment is known as *ex-post* assessment, which is done to validate past funding on research. These studies are being undertaken when the research outputs and technologies are largely adopted in the target domain, and assess their contribution to social welfare, resource conservation, trade, sharing of benefits of research outputs among different stakeholders (e.g. producers, consumers, industry), etc.

Impact indicators

Impact indicators vary with technology and level of assessment. There are two types of benefits of research outputs: (i) tangible benefits are those which can be assigned monetary values, and (ii) intangible benefits are those which can not be assigned monetary values but are important for the society. Examples for the later type are improvement of environment, better health, reduction in infant mortality, national defense, etc. These are important but difficult to assign any monetary value. These must be documented at least in physical terms.

Box 1: Farm-level impact Indicators

- Efficiency
  - Income augmentation
  - Unit cost reduction
- Household food security
  - Nutritional security
- Poverty reduction
- Risk management
  - Improving yield or income stability in the absence of insurance
- Cropping intensity
- Gender related issues
- Natural resource conservation

The impact indicators will be different at farm, regional, national and global level. At the farm level, the direct beneficiaries are affected by adopting the technologies. At higher level, the society and the environment are being influenced and measured. Important farm-level and regional/ national-level indicators are listed in Box 1 and 2.

The emphasis of the listed indicators would vary with the type of research outputs. It is not necessary that all indicators would be applicable for any kind of technological change.

Box 2: Regional/ National-level impact indicators

- Agricultural production
- Food self-sufficiency
- Employment generation
- Equity issues
  - Inter-regional
  - Inter-personal
- Poverty
- Trade
  - Prices
  - Export and/or import substitution
- Inter-sectoral linkages
  - Forward linkages(like markets, transport, processing, etc)
  - Backward linkages (like seed sector, fertilizer industry, pesticide industry, farm machinery, etc.)
- Sustainability of natural resources

Measuring efficiency indicator

Following are the important methods for assessing the efficiency benefits of research impact:

Benefit cost analysis: The method compares the stream of benefits with that of stream of research cost. Following are the indicators for the benefit-cost analysis:

Benefit-cost ratio: It is the ratio of present worth of benefits stream and the present worth of cost stream.

Net present value: It is the present worth of the incremental net benefit stream.

Internal rate of return: It is the discount rate when net present worth of benefit and costs equal to zero.

Pay-back period: It is the period during which the entire research cost is recovered after the benefits are accrued.

Econometric approach: The approach assesses the changes in marginal productivity of research investment at macro-level. The econometric methods are powerful that can discern the contribution of research and other determinants in total change in output.

Total factor productivity: It is the ratio of total output and the whole set of inputs. It shows the residual left after incorporating the contribution of input quantities. The total factor productivity can be decomposed into the contribution of research resource allocation and other qualitative determinants.

Economic surplus approach: The approach estimates the economic surplus generated as a consequence of research outputs. The benefits can be decomposed into changes in the economic surplus to consumers and producers as a result of research success. The information derived through economic surplus approach is also

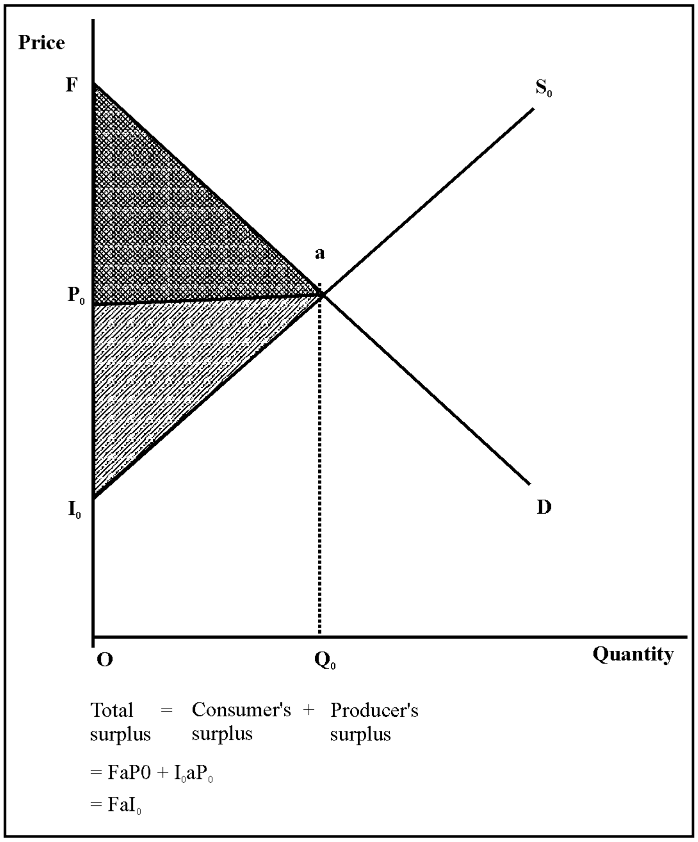

Figure 2: Total economic surplus

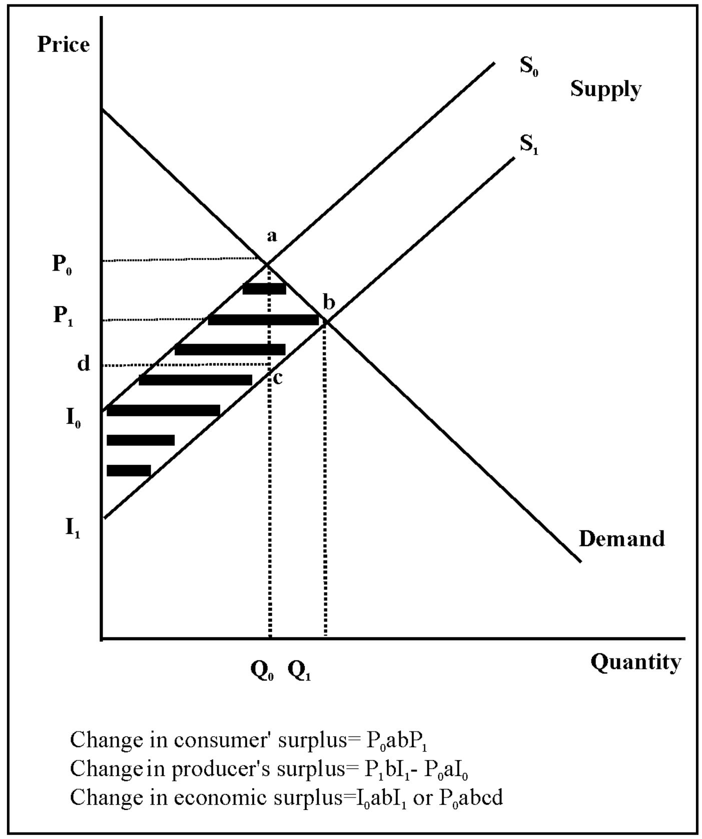

Figure 3: Assessment of economic surplus

be used to estimate benefit-cost ratio, internal rate of returns and net present value of research outputs.

In the Figure 2, the consumers' surplus as a result of fall in prices from F to P_0 is the area beneath the demand curve (dd) less cost of consumption. It is $FP_0a = FaQ_0O\text{-}P_0aQ_0O$.

The producers' surplus as a consequence of increase in prices from I_0 to P_0 is the area P_0aI_0. It is total revenue (P_0aQ_0O) less total cost of production (I_0aQ_0O).

The impact of research outputs or technological change is reflected by either unit cost reduction or yield enhancement. Cost reduction and adoption of technology would shift the supply function (from I_0S_0 to I_1S_1), which would form a new equilibrium price (from P_0 to P_1) and quantity (from Q_0 to Q_1) demanded and supplied. Figure 3 shows these shifts. The surplus generated as a result of shift in supply due to technological change will be as follows:

Change in consumers' surplus	=	P_0abP_1
Change in producers' surplus	=	$P_1bI_1 - P_0aI_0$
Change in economic surplus	=	I_0abI_1 or P_0abcd

Research cost

To develop the stream of cost, the research expenditure in developing specific technology need to be estimated. Under project-based budgeting, it is easy to have information on research cost. In the absence of such provisions, the research cost is to be estimated by consulting the scientists involved in the research. Important elements of the research process, like (i) year of initiation of research, (ii) year when the final research output was identified, and (iii) year when the research output (or technology) was released. The time difference between starting year and research output release is known as the research lag. Shorter the research lag, early the research benefits reach the clients and vice-versa. In addition, the expenses incurred during the research lag period need to be estimated. These include the expenses on salary, operations, travel, equipment and overhead.

Another important component is the adoption of research outputs. At farm-level, adoption is the acceptance of new technology when farmer has full knowledge about its potential benefits. At aggregate-level, adoption is the process of spread of a new technology within a region. Estimates are needed on (i) year when the research output was adopted first time, (ii) the extent of adoption, and (iii) year when adoption reached to ceiling or maximum limit.

Figure 4 shows the research continuum, starting from research until the adoption started ceasing. Often, the agricultural technologies follow a sigmoid nature of adoption. Initially the technology is adopted at a slow pace, and then increases with increasing rate and finally reaches to ceiling (or maximum) level. After that when some new technology replaces the old one it starts descending.

To develop the benefit stream, the change in economic surplus derived in Figure 3 is multiplied by the annual extent of adoption of the technology. The stream of benefits and stream of costs are

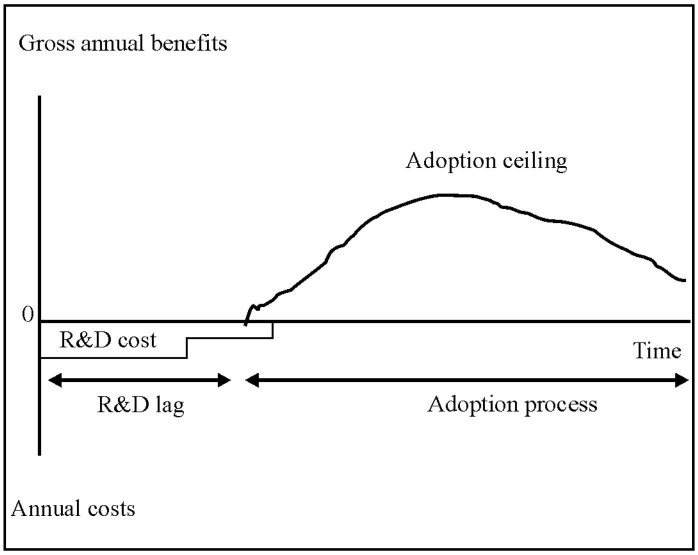

Figure 4: Research continuum: research lag and adoption process

used to estimate the internal rate of returns or discounted for computing the net present worth or benefit-cost ratio.

An illustration

A case study in *ex-post* framework *is* demonstrated to assess the returns of research investment on wilt resistance in pigeonpea. This is the case of developing a wilt resistance pigeonpea variety (ICP 8863) to overcome the problem in the pigeonpea granary of India, where the disease has disastrous implications. The variety was targeted for Andhra Pradesh, Karnataka and Maharashtra. The minimum data required for estimating the economic returns are given in Box 3 and results in Box 4.

Box 3: Case Study: Ex-post Assessment

Returns to research investment on wilt resistance in pigeonpea

Variety: ICP 8863

Target domain: Karnataka, Andhra Pradesh and Maharashtra

Minimum data:

Base production (1986-88 average)	120835 t
Base year prices	Rs. 5468/t
Supply elasticity	0.2
Demand Elasticity	-0.5
Discount rate	0.08
Unit cost reduction	Rs. 3820/t (42%)
With ICP 8863	Rs. 5234/t
With local	Rs. 9054/t

The cost of developing the wilt resistance variety was estimated at Rs. 5 million. The unit cost reduction as a result of adoption of ICP 8863 as compared to local varieties was 42%. The adoption ceiling in the target domains varied due to institutional constraints. The large-scale adoption of the variety generated Rs. 1850 million surplus, with a high internal rate of return (65%). The producers' shared larger benefits (72%) than the consumers' (28%).

Besides generating economic surplus and high rate of returns, the adoption of wilt resistant variety generated employment opportunities and contributed in conservation of soil and water resources.

Box 4: Research cost, adoption and returns

Research cost

PV of research cost	Rs. 5 million

Adoption ceilings (%)

Karnataka	60
Andhra Pradesh	55
Maharashtra	55
E. Maharashtra	10

Economic surplus

Net present value	Rs. 1850 million
IRR	65%
Consumer's share	28%
Producer's share	72%

Selected readings

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