ICAR	NATP *Task Force on Prioritization, Monitoring & Evaluation*	**PME NOTES 10**

Resources Allocation in Agriculture Research using Mathematical Programming

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Decision-makers have to rationalize resource allocation in terms of priorities to achieve overall and broad research goals like efficiency, equity, sustainability, export promotion etc. This has become necessary on account of changes in the context and environment confronting agricultural sector. For more details on these aspects, refer earlier PME notes.

Resource Allocation Analysis: Mathematical Programming

While allocating scarce research resources, the research managers are called upon to evaluate the consequences of alternate allocation decisions. This calls for building up detailed information base. Several methods like scoring technique, congruence approach, economic surplus method, maihematical programming approach and simulation techniques are used in resource allocation analysis. Among them, mathematical programming approach offer scope for evaluating the tradeoffs between multiple goals of agricultural research while allocating the scarce resources. The usefulness of this approach is illustrated by applying it to a sub-set of a regional research station's research portfolio.

Illustration of Mathematical Programming

Agricultural research system database generated from Zonal Fruit Research Station (ZFRS), Mahatma Phule Krishi Vidyapeeth, Ganeshkhind, Pune; Maharashtra is used for the illustration. Nine research programmes (Table 1) are developed from 69 research projects identified for the western Maharashtra plain zone through a decentralized agricultural research priority setting exercise involving multiple stakeholders in a bottom up approach. The data were generated from secondary sources, rapid rural appraisals, workshops, group discussions and interactions with scientists, NGOs, extensionists, farmers and policy makers in the region.

Research Impact Estimation

The database generated covered the following aspects: Information on expected recurring and non-recurring cost of research programme, duration, yield/cost impact of research, probability of research success, expected adoption pattern, adoption lag, spatial spread of research impact, ceiling rate of adoption, technology degeneration, contraction/ expansion of area and expected impact of technology on natural resource base.

Using discount rate of 10%, the benefit and cost stream for each programme was discounted and net present value (NPV) for each research programme was estimated using economic surplus method. Cumulative total cost, NPV and estimated

Table 1
Research programmes for ZFRS, Pune

WHTDE	Thermoinsensitive&early maturing wheat varieties
PULIPM	Integrated pest management in pulses
SORDE	Developing early maturing sorghum varieties
FEVEG	Fertigation studies in vegetables
EXVEG	Standardizing chemical residues in vegetables

OFVEG	Organic farming & vermi-compost in vegetables
GRIPM	Integrated pest management in grapes
VARF1G	Varietal development for high yields in fig
CUSTD	Technology standardization in custard apple

number of small and marginal farms cultivating the respective crops are given in Table 2.

Scientific Manpower Requirement

Scientific manpower required for implementing each research programme as ascertained during the research programming discussions is also given in Table 2. All projects require multidisciplinary expertise involving two to four subject matter disciplines.

Research Goal Dimensions

Agricultural research programmes have objectives directed towards producing outputs, the effects of which will lead to one or more relatively independent dimensions of improvements in the welfare of individuals within the society. Two such dimensions namely efficiency and equity are considered here with the nine research programmes. Efficiency dimension can be targeted by maximising the returns per unit of research investment. Equity dimension can be achieved by maximising the benefits to the small and marginal farms. These dimensions are criteria that form the basis for research programme evaluation and selection.

Mathematical programming models help select research programmes on the basis of their contributions to the criteria of evaluation subject to a set of resource and manpower constraints. The value of the objective function is a measure of the utility of the total research programme, and is defined as the weighted sum of the dimension scores. The more goal dimensions toward which a research programme contributes, the more it will contribute to the objective function and hence the more likely it will be selected. The optimal solution will be a set of research programmes, which maximises the expected utility of the research portfolio.

Selected Research Portfolio

The optimal research portfolio for an available budget of Rs 20.2 million is highlighted in Table 3.

Table 2
Expected Research Impact and Scientific Manpower Requirement

Particulars	Unit	WHTDE	PULIPM	SORDE	FEVEG	EXVEG	OFVEG	GRIPM	VARFIG	CUSTD
Net present value	Million Rs	44	22 0.20	30	510	2394	495	144	204	168
SF and MF benefited	Million No.	0.20		0.40	0.05	0.07	0.08	0.10	0.12	0.15
Project cost	Million Rs	2.0	2.0	3.0	2.5	3.0	2.5	1.6	1.2	2.4
Agronomist	Percent	20		20				10	10	15
Breeder	Percent	50		40						
Pathologist	Percent	20	50	25		10		30		20
Entomologist	Percent		50		60	20	15	15	10	20

Horticulturist	Percent				60	20	25	15	50	60
Chemist	Percent					50				
Microbiologist	Percent						15			

SF : Small farms;
MF: Marginal farms

With the availability of full budget of Rs 20.2 million, all nine research projects can be taken up and they generate total discounted returns of Rs 4011 million benefiting 1.37 million small and marginal farms. If research budget were reduced by half to Rs 10.1 million, what would happen to returns and impact on poor farmers ? To examine this, we consider efficiency and equity dimensions independently as well as together.

Table 3
Resource Allocation & Research Portfolio

	Full budget	**Efficiency**	**Equity**	**Efficiency & Equity**
Budget (million Rs)	20.2	10.1	10.1	10.1
NPV (million Rs]	4011	3684	477	2680
SF *& MF* (million No.)	1.37	0.376	1.038	0.880
WHTDE				
PULIPM				
SORDE				
FEVEG				
EXVEG				
OFVEG				
GRIPM				
VAFIG				
CUSTD				
Budget shadow price (million Rs)	0	90	1231	1037

First, if efficiency is to be targeted, then five out of six research programmes covering fruits and vegetables are selected for full-scale implementation. Only the project on integrated pest management in grapes is selected with reduced budget allocation. None of the cereal and pulse programmes enter into the research portfolio. The returns to this research portfolio marginally come down by 8% to Rs 3684 million. But equity dimension got adversely impacted with a substantial reduction by 73% in the number of small and marginal farm beneficiaries.

Next, if equity is to be targeted, we find that with a research budget ofRs 10.1 million, all the three cereals and two fruits based research programmes are preferred to provide a total return of Rs 477 million benefiting 1.04 million small and marginal farms. In this case, the returns come down substantially by 38% but small and marginal farm beneficiaries come down only by 24% as compared to the research portfolio that can be supported by full research budget of Rs 20.2 million.

When both efficiency and equity dimensions are considered together, the research portfolio gets more diversified. Two cereals and one each in fruits and vegetables based research programmes are selected. The returns to this research portfolio is Rs 2680 million benefiting 0.880 million small and marginal farms. In this case, both the returns and number of small and marginal farm beneficiaries come down by around l/3rd as compared to the research portfolio that can be supported by full research budget of Rs 20.2 million.

While pursuing both efficiency and equity dimensions, with reduced budgetary allocation for research, sharp conflict between efficiency and equity objectives could be observed. This tradeoff between equity and efficiency objectives is affected by the available research budget. Promoting equity objective while allocating scarce research resources will entail selection of cereals, pulses and fruits based research portfolio while pursuing efficiency objective will entail selection of vegetables and fruits based research portfolio for implementation. This illustration also highlights that cereals and pulses research has equity orientation; vegetables research has efficiency orientation; and fruits research contributed to promoting both efficiency and equity concerns. Such an analysis can also be extended to consider different weighting schemes for different objectives and their impact on the research portfolio and resource allocation decisions.

With restricted budget of Rs 10.1 million, shadow price for the budget shows Rs 90 million for efficiency dimension. This means that attracting one more million Rs for agricultural research for this region would increase the returns from agricultural research by Rs 90 million. This would aid the research managers to argue for higher research budget. The above illustration shows the potential use of mathematical programming in generating information useful to decision makers in allocating resources, arguing for research resources etc. Of course, such decision-aiding information can be generated only when project level data is systematically documented right from the stage of project proposal formulation through implementation and completion. All research project formats will have to be tuned to document the minimum data set needed for conducting such rigorous resource allocation decision analysis. As illustrated, however, such efforts have rich dividends.

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