7 Institutionalisation of Research Prioritsation, Monitoring and Evaluation

P. K. Joshi and Cynthia S. Bantilan
International Crops Research Institute for the Semi-Arid Tropics
Patancheru, India

1. Introduction

Research priority setting, monitoring and evaluation (PME) have recently been introduced as research management tools to efficiently allocate scarce research resources to alternative choices. With squeezing agricultural research resources, research managers explore procedures to allocate available resources to meet the unprecedented challenges of increasing demand for additional food, and ever rising degradation of natural resources. An efficient and well prioritised research resource allocation is reckoned to make maximum contribution in improving the welfare gains of the society. To better allocate limited research resources among alternative researchable areas, it is now recognised the need to institutionalise the process of PME.

In the recent past, several national and international research organisations have institutionalised the research priority setting for resource allocation. Among others, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is one research organisation which has institutionalised the research priority setting and evaluation to develop its Medium Term Plan (MTP). Several approaches were suggested and used by different research organisations and authors for research priority setting (Davis et al., 1987; Alston et al., 1995). These approaches are: (i) congruence rule, (ii) economic surplus approach, (iii) mathematical programming approach, and (iv) scoring method. Each method was argued for some advantages and limitations. The ICRISAT adopted a multi-objective scoring approach, which provided strong basis for decision support system to allocate available research resources in the most transparent way.

The present paper briefly documents the framework implemented by the ICRISAT in this important area of research management and policy. It also suggests a mechanism to institutionalise PME in the Indian Council of Agricultural Research (ICAR) on a sustained basis. More specifically,

the paper deals with: (i) ICRISAT model on research priority framework, (ii) ICRISAT model on research evaluation and impact assessment, and (iii) lessons for the ICAR on adaptability of the ICRISAT model to institutionalise PME.

2. ICRISAT Research Priority Model

The ICRISAT's research focus is to enhance productivity and profitability of its five mandate crops (namely, chickpea, groundnut, pearl millet, pigeonpea and sorghum); improve the sustainability of soil and water resources; and uplift the living standard of poor depending on rainfed agriculture in the semi-arid tropics. Before 1994, the ICRISAT mandate was achieved through three programmes: Cereals Improvement Programme (including sorghum and pearl millet), Legumes Improvement Programme (including chickpea, groundnut and pigeonpea), and Resource Management Programme (including soils, agronomy and economics). Research resource allocation to these programmes was mostly informal and largely based on the scientific judgement of research managers. With declining research funds, an objective and transparent method of research priority setting and research resource allocation was strongly felt and initiated in 1992 to develop the MTP 1994-98. The main focus of the exercise was to eliminate those research areas which were of less relevance to the ICRISAT in a limited budget scenario. The method was regarded analytically rigorous with clear criteria for decision-making process (ICRISAT, 1992).

A multi-disciplinary Working Group was constituted consisting of scientists from various research programmes and groups. At the first instant, the Working Group defined the research domains. A research domain was defined as a homogenous eco-region, where the expected research outputs were relevant. These were delineated for each commodity on the basis of (a) production system characteristics (e.g., rainfall, soil type, cropping pattern); (b) major biotic and abiotic constraints in the production systems; and (c) location. Production constraints across locations in the semi-arid tropics were listed. Yield loss due to each constraint, and expected gains resulting from successful research were estimated. All the scientists were involved to assess yield losses and expected gains due to the research success. It also identified the strategy which was expected to alleviate specific constraint most effectively. To be more specific, the decision was made whether research should focus on genetic improvement or resource management or both to alleviate a given constraint in a specific research domain. In all, 110 research constraints were identified for research priority setting in the semi-arid tropics. Later, these constraints were termed as the research themes.

A multi-objective scoring model was developed for research priority setting in the semi-arid tropics. The multiple objectives were: (a) efficiency, which was measured as the net present value, the net benefit-cost ratio and the internal rate of return; (b) poverty, which was measured as number of poor in the research domain where the research theme was focused; (c) gender issues were included as number of illiterate female in the research domain; (d) internationality of the theme was computed as the Simpson Index of diversity; and (e) environment and sustainability contributions were given scores ranging from 1-5: 1, no contribution towards environment and sustainability, and 5, highest contribution. Poverty and gender issues were regarded proxy for equity considerations.

To measure efficiency of research investment, benefit-cost analysis was carried-out for each research theme in ex ante framework. A data-set (Details in chapter 3 of this volume) consisting of various quantitative variables relating to research, technology adoption, yield gains, and production and prices of commodities, was generated for each theme in all the research domains to estimate the net present value, net benefit-cost ratio and internal rate of return.

To combine the estimated values of multiple objectives, composite indices were computed for all research themes following the additive model by assigning equal weight to each criteria. All 110 researchable themes were sorted in descending order which provided a list of themes with highest composite index at the top and the lowest at the end. This indicated that the research theme attaining highest composite index should receive highest research priority, and vice versa for the constraint with lowest composite index. Research cost for each theme was also estimated, and cumulative research cost was computed according to the rank of the composite index. The methodology used in setting research priorities provided clear criteria for establishing choices among competing research activities, which was considered analytically rigorous, drew on scientists' empirical and intuitive knowledge base, and was transparent and interactive (Kelly et at., 1995).

Finally, top 92 research themes were selected to develop research projects as the funds were not available beyond that rating (Appendix I). All selected themes were finally used to develop 22 global research projects by combining themes of similar nature relevant to different crops, resource management, and socio-economic aspects.

Recently, the ICRISAT's new MTP 1998-2000 was developed following similar approach and criteria as used in 1994-98 plan but with slight change and updating of available information. The criteria consisted of: efficiency (calculated as in the last MTP), equity (including the new poverty modifier), internationally (including "alternative sources of supply" element, along with cross border consideration), and sustainability (including an explicit recognition of the importance of diversification of agricultural systems). The new criteria used in 1998-2000

MTP were new science opportunity, research relevance to the NARS priorities, and future trends in supply and demand that could change basic assumptions (ICRISAT, 1997).

3. Research Evaluation and Impact Assessment

It is always useful to regularly monitor and evaluate the research impact. There are three important benefits of monitoring and assessing the research impacts: (i) provide a basis for justifying research support, thereby leading to adequate investments in agricultural research; (ii) provide the basis for making a more efficient use of research resources, and (iii) provide the basis for making agricultural research a more effective contributor to agricultural development (Schuh and Tollini, 1979). To strengthen the research priority setting in a dynamic framework, the ICRISAT research management took a policy decision in 1994 to continuously monitor and evaluate research impacts. To adhere to this policy decision, a global research project on "Research Evaluation and Impact Assessment" (REIA) was initiated to document the benefits from research, use the information for research priority setting, and justify future funding. The project was designed to integrate ex post impact assessment with ex ante priority setting in dynamic framework adapted to suit the requirement of the ICRISAT. The main objectives of the project were: (a) develop methodologies, database, and ICRISAT/NARS capacity to support research evaluation, (b) quantify research benefits from ICRISAT/NARS research finished products, (c) estimate value of the ICRISAT germplasm/parental lines and other intermediate products, (d) establish a decision support system for research priority setting, and (e) institutionalise research evaluation process.

The first step to evaluate impact of ICRISAT/NARS technologies was development of an inventory of all research outputs. This was accomplished through an interactive approach with the agro-biological and social scientists. The objective was to identify technology components as a result of research investment, understand the research process of each technology, background of the technology development, and possible target domains of the technology. An inventory of research outputs was developed in three areas: (a) genetic enhancement of all the ICRISAT mandate commodities, (b) research information related to resource management technologies, and plant protection measures, and (c) socio-economic and policy research (Bantilan and Joshi, 1994). Under each area of research, technologies or research information were divided into two categories: (a) technologies successfully adopted by the farmers, and (b) technologies faced constraints in adoption. Technologies under the former category were selected for impact assessment, and the technologies listed under the second category were considered for constraint analysis. It was recognised that analysis on impact assessment and constraint analysis are important to effectively integrate these analysis with the research priority setting.

A systematic framework was designed to evaluate technologies for impact assessment (Bantilan, 1996). At the outset, number of impact indicators were identified for assessing impact at various stages. A list of these impact indicators is given below:

(a) Farm level impact indicators: Farm income, input saving, household food security, household poverty, risk and uncertainty, crop intensification, nutrition and health issues, gender related issues, and sustainability issues.

(b) Regional level impact indicators: Employment issues, food security issues, poverty, diversification and regional development, prices, and sustainability issues.

(c) Global level impact indicators: Efficiency, trade, commodity prices, spillover effects, and sustainability and environmental issues.

A number of methodologies are available to measure above mentioned impact indicators. Economic surplus approach, the most popular method for ex post impact assessment, was used for majority of the studies. This approach assumes the welfare effects of agricultural research in a conventional, comparative static, partial equilibrium model of supply and demand in a commodity market. Impact assessment of each technology was carried-out by a multidisciplinary team of scientists at the ICRISAT and NARSs. A database was jointly developed by the multidisciplinary team of scientists at the ICRISAT and NARS for quantifying impact of each technology. It included following set of information:

- Estimates of research cost including salary, operations, overheads, etc.
- Area and production of particular commodity at national, district and block level from official and published sources.
- Yield loss estimates due to the constraints.
- Research lag.
- Adoption tracking through:

    - Breeder seed distribution,
    - certified or truthfully labelled seed sale by seed companies, and
    - farmer-to-farmer seed distribution.

- Extent of adoption through informal and formal survey methods.
- Estimates on adoption ceiling levels.
- Estimates on on-farm gains due to adoption of improved technologies.
- Farm harvest prices of commodity under study.
- Supply and demand elasticities of commodity under study.

Research and adoption tag, ceiling level of adoption, and internal rate of returns of few technologies were estimated, and are given in Appendix II. It may be noted that efficiency criteria was used at the initial stage of impact assessment to justify the research investment in alleviating various constraints in the semi-arid tropics. Evaluation of other impacts like poverty, diversification, nutrition, spillover effects, is under progress at various stages for different technologies.

NARSs were effectively involved in quantifying the impact of various ICRISAT/NARS technologies. Training workshops and study programmes were organised to institutionalise the impact assessment of all collaborating programmes with NARS.

4. Integration of Research Prioritisation and Impact Assessment

The REIA project consists of a separate sub-project on research priority setting. The need was felt to integrate research evaluation with the research priority setting. A mechanism was developed to link the REIA project with all the global projects to institutionalise the research prioritisation and impact assessment.

Impact assessment studies provided more confidence among scientists in projecting research lags, research cost, extent of adoption, adoption ceiling and research gains. The adoption assessment and impact evaluation studies provided useful feedback for research priority setting while developing the 1998-2000 MTP of the ICRISAT. More reliable estimates derived from ex post studies were used for ex ante analysis for research priority setting. The ex post impact assessment studies also validated, in some cases, the research prioritisation and evaluation.

5. Adaptability of ICRISAT Model in ICAR

The apex organisation like the ICAR may encounter the problem of resource allocation to different research institutes/centres which are engaged in alleviating various production and socio-economic constraints. Once research resources are allocated, the research institutes/centres face the problem of distributing the available resources into different projects and research activities. Recently, few studies were initiated to prioritise agricultural research in India (Jha et al., 1995, and Ramasamy et al., 1997), making a good beginning in this area.

The ICRISAT model of research priority setting and impact assessment may be well suited at all the ICAR research institutes/centres, the State Agricultural Universities (SAUs), and their regional research stations to allocate resources up to the project and activity level. The problem may be encountered by the ICAR to allocate research resources to different research institutes. In the beginning, congruence rule may be applied at the ICAR level to allocate research resources to different research institutes/centres. Later, more rigorous analysis with multiple objectives may be used for each commodity, resource management, and socio-economic based research institutes/centres.

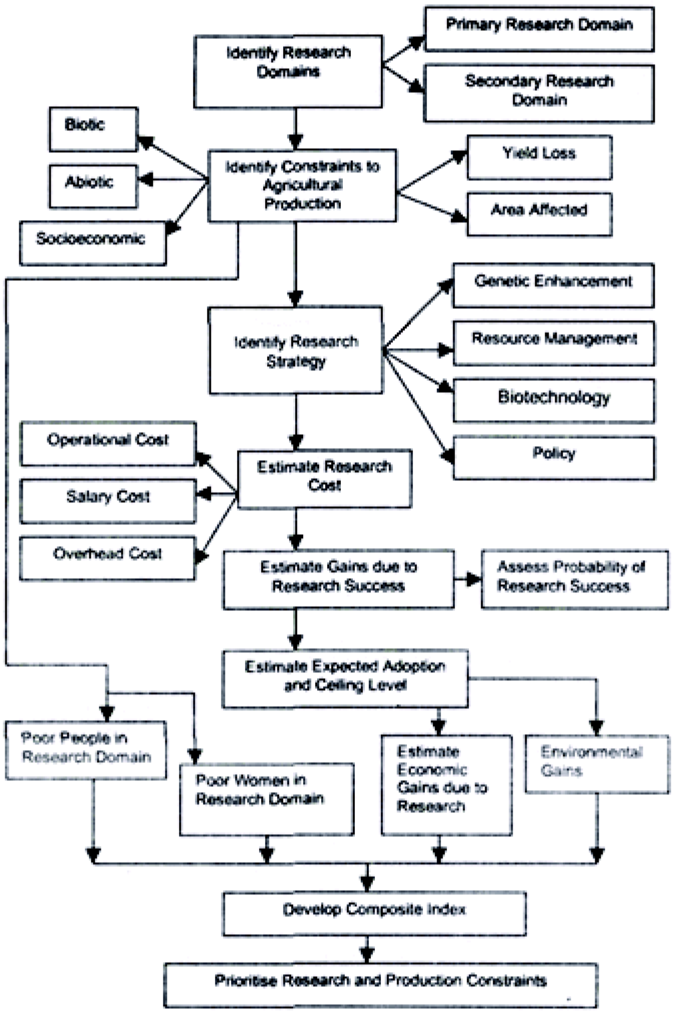
A simple procedure may be followed to prioritise research at each research institute/centre level. A framework for research prioritisation is given in Figure 7.1 which is summarised in following steps: Initially, above steps may be followed to prioritise research in each research institute/centre. Later, all themes from all research institutes/centres may be amalgamated and prioritised to allocate available research resources at ICAR level according to crops, agro-ecological regions, disciplines, research institutes/centres, and so on.

1. Clearly define the research domains. These may be delineated according to rainfall, soil, cropping pattern, socio-economic considerations, etc.
2. Identify production and socio-economic constraints in research domains with specific emphasis to the mandate of the research institute/centre. The production constraints may be abiotic, biotic and socio-economic. At this stage, it will be highly desirable to involve extension staff from the Training-and-Visit system of the department of agriculture and non-government organisations (NGOs).
3. Estimate yield loss due to each constraint, and delineate area affected due to the specific constraint.
4. Identify research strategy to alleviate production and socio-economic constraints. Research strategy may be one or a combination of genetic enhancement, resource management, biotechnology and policy research.
5. Estimate cost of each research strategy, and its probability of success. More discussions and interactions among scientists will yield better estimates on research cost and its probability of success. A low cost with high probability of research success will be the most preferred research strategy.
6. Measure gains due to research success in ex ante framework:

- Estimate expected adoption rate and adoption ceiling of the research output (a variety, or a research information on crop and resource management, or a policy).
- Estimate unit cost of production with and without research output. Compute reduction in unit cost of production due to the expected success of research output.
- Calculate total savings in production by multiplying the unit cost reduction with the base level of production of specific crop.
- Adjust total savings in production with probability of research success, adoption rate and adoption ceiling of research output, and develop a stream of benefits over a period of about 15 years.
- Compute net present worth, benefit-cost ratio and internal rate of return. Use stream of research costs and benefits for computing these efficiency indicators for each production constraints.
- Assign score to describe the contribution of each research success in improving environment and sustainability. Scores may range between 1-5: 1, no contribution; and 5, maximum contribution.

7. Use other indicators, like poverty and gender for research priority setting. Use number of poor people living below poverty line in the research domain to represent research focus to help poor women in the target area.
8. Develop a composite index for each production constraint by assigning equal weight to each indicator, namely, efficiency indicator (represented by net present worth), poverty, gender and sustainability. More number of indicators may be selected depending upon the national priority.
9. Rank the composite indices in descending order to prioritise production constraints.

Figure 7.1: A framework for research priority setting



6. Institutionalisation of Research Prioritisation in ICAR

For a sustained and continuous cycle of research priority setting and impact assessment, the concept of the All India Co-ordinated Research Project (AICRP) will provide an avenue for effective feedback and timely redirection of research. Implementation of a continuous and sustained effort involving database update, adoption/impact monitoring, and methodology adoption will promote a smooth implementation and achievement of a relevant, consistent, and objective set of defined priorities. These tasks can very well be taken-up by establishing an AICRP on 'Research Priority Setting and Impact Assessment'.

The AICRP should be responsible to collaborate and develop linkages with all the ICAR research institutes/centres and the SAUs. It will provide relevant updated database on important parameters, adapt uniform methodological framework across research institutes/centres and SAUs to compare results for better research resource allocation and targeting research agenda. Its role may also include to develop agricultural research policy in changing scenario. It should also organise training programmes to develop skills and capabilities of research scientists associated in research priority setting and impact assessment. To undertake the research priority setting uniformly by each research institute/centre, the project must have trained staff. Therefore, capacity building of the staff through training workshops should be viewed as prerequisite for its institutionalisation in the ICAR.

The AICRP may have its headquarters at the National Centre for Agricultural Economics and Policy Research. However, the project will be independent from various research institutes/centres and SAUs to avoid any kind of bias and influence, it may involve the stakeholders and its clients. It should develop a network by involving Agricultural Economics Division or Unit in each research institute/centre and SAD. The project may be horizontally linked with the Assistant Director-General (Economics, Statistics and Marketing), the Assistant Director-General (Project Planning and Monitoring), and the Director (Finance) to obtain relevant information from the ICAR headquarters.

7. Summing Up

The institutionalisation process on research priority setting and impact assessment should promote efficient research resource allocation, and provide a forum for decision support system in a dynamic framework. The ICRISAT model on research priority setting and impact assessment very well suits the needs of the ICAR, as this model is transparent and analytically rigorous for research priority setting and impact assessment. Also, the model encourages participation of scientists in multidisciplinary framework. An AICRP on research priority setting and impact assessment on ICRISAT model will be the most desirable policy decision to institutionalise research priority setting and evaluation in the ICAR institutes/centres and SAUs.

References

Alston, J.M., G.W. Norton, and P.G. Pardey (1995), Science Under Scarcity: Principles and Practices for Agricultural Research Evaluation and Priority Setting, Cornell University Press, Ithaca.

Bantilan, M.C.S. (1996), Issues on research evaluation framework, Paper presented at the Workshop on Joint Impact of ICRISAT/NARS Technologies, ICRISAT, Patancheru, 2-4 Dec 1996.

Bantilan, M.C.S. and P.K. Joshi (1994), ICRISAT Research Impact, International Crops Research Institute for the Semi-Arid Tropics, Patancheru.

Davis, J.S., P.A. Oram, and J.G. Ryan (1987), Assessment of Agricultural Research Prioritise: An International Perspective, ACIAR, Canberra

ICRISAT (1992), ICRISAT Medium Term Plan 1994-98, Volume I, International Crops Research Institute for the Semi-Arid Tropics, Patancheru.

ICRISAT (1997), Shaping a Food-Secure Future, ICRISAT Medium Term Plan 1998-2000, International Crops Research Institute for the Semi-Arid Tropics, Patancheru.

Jha, Dayanatha, P. Kumar, Mruthyunjaya, Suresh Pal, S. Selvarajan, and Alka Singh (1995), Research Priorities in Indian Agriculture, NCAP Policy Paper 3, New Delhi.

Kelley, T.G., J.G. Ryan, and B.K. Patel (1995), Applied participatory priority setting in international agricultural research: making trade-offs transparent and explicit, Agricultural Systems, 49, pp. 177-216.

Ramasamy, C., T.R. Shanmugam, and C. Pray (1997), Priority setting for rice research in southern Indian: ex ante approach, Indian Journal of Agricultural Economics, 52(1), pp. 101-113.

Schuh, G. Edward and H. Tollini (1979), Cost and benefits of agricultural research: the state of the arts, Staff Working Paper No. 360, The World Bank, Washington, D.C.

TAG Secretariat (1996), Report of the Fourth External Program and Management Review of the ICRISAT, December 1996, pp. 56- 59.

Appendix I. ICRISAT's protfolio of ranked research themes

Rank	Programme	Constraint/ theme	Efficiency Net B/C ratio	Res. cost first year ($m)	Equity		Inter nationality	Sustaina Bility	Composite index ($m)	Cumul ative cost
					Poverty million poor	Gender million fem ill				
1	GRU	Germplasm evaluation	101.9	0.19	397.0	378.0	1.00	4	5.21	0.19
2	GRU	Germplasm collection	40.7	0.14	397.0	378.0	.100	5	4.24	0.33
3	LGM	Drought-CP	113.7	0.48	60.0	119.5	0.55	3	3.64	0.81
4	GRU	Germplasm maintenance	35.5	0.10	397.0	378.0	1.00	3	3.63	0.91
5	LGM	Ascochyta bligh-CP	134.7	0.14	31.1	94.4	057	1	3.48	1.05
6	LGM	Rust-GN	47.9	0.33	337.0	310.0	070	3	3.35	1.38
7	LGM	Aflatoxin-GN	23.1	0.05	248.2	298.6	082	5	3.28	1.43
8	LGM	Late leaf spot-GN	12.4	0.43	329.0	302.0	084	4	3.00	1.86
9	LGM	Alatoxin (MGT) GN	6.4	0.56	360.0	308.0	060	5	2.96	2.42
10	LGM	Insect damage-CP	78.5	0.25	88.2	107.9	026	4	2.94	2.67
11	LGM	Wilt-CP	114.2	0.14	88.2	107.9	026	1	2.90	2.81
12	RMP	Adopt Asses/ imp/.evl.	-	0.62	75.9	114.1	000	3	-	3.43
13	RMP	Res. Resource alloc'n	-	0.21	397.0	378.0	1 00	4	-	3.64
14	RMP	Soil nutrients	35.9	0.54	167.9	162.2	049	5	2.81	4.18
15	LGM	Early leaf spot-GN	4.4	0.46	345.0	313.0	070	4	2.75	4.63
16	LGM	Genetic poten'l yield-PP	63.5	0.13	125.2	168.2	023	3	2.53	4.76
17	LGM	Yield potential GN	12.3	0.44	234.2	363.4	071	3	2.53	5.20
18	CRL	Striga-SG	41.4	0.28	31.5	43.8	080	4	2.51	5.48

19	LGM	Drought-GN	5.2	0.50	331.8	326.0	062	3	2.43	5.98
20	LGM	Root rots-CP	70.3	0.14	88.2	107.9	033	2	2.34	6.12
21	LGM	Bud necrosis virus-GN	1.2	0.13	298.9	328.1	066	3	2.33	6.25
22	CRL	Grain & stover yield.- SG	16.6	0.68	180.8	169.2	085	3	2.33	6.93
23	RMP	Soil fertility	21.1	0.58	16.8	37.9	076	5	2.28	7.51
24	LGM	St mosaic/Fu Wilt-PP	40.4	0.21	125.2	168.2	012	4	2.21	7.72
25	RMP	Soil structure	5.9	0.74	167.9	162.2	046	5	2.18	8.46
26	LGM	Leaf miner-GN	6.0	0.19	195.7	268.6	046	4	2.17	8.65
27	LGM	Biolog N fixation-CP	16.6	0.10	88.2	133.7	043	5	2.16	8.75
28	LGM	Leaf miner (MGT)-GN	4.5	0.23	195.7	268.6	046	4	2.14	8.98
29	RMP	Water deficit	19.1	0.95	154.4	151.4	034	4	2.03	9.93
30	LGM	Spondoptera-GN	0.9	0.14	174.7	247.6	040	4	1.93	I0.07
31	LGM	Peanut clump virus GN	4.9	0.23	114.3	124.0	084	3	1.87	10.30
32	LGM	Rosette virus-GN	8.6	0.53	71.9	71.4	089	3	1.82	10.83
33	LGM	Hilicoverpa (MGT)-PP	23.8	0.17	98.2	136.4	017	4	1.82	11.00
34	CRL	Stem borer-SG	1.6	0.76	232.7	191.2	075	2	1.82	11.76
35	CRL	Grain mold-SG	21.5	0.45	51.2	57.2	068	3	1.81	12.21
36	LGM	Millipedes-GN	8.0	0.04	27.3	37.2	077	4	1.80	12.25
37	RMP	Water deficit-PM. SG. GN	3.9	0.83	24.1	42.6	076	4	1.71	13.08
38	RMP	Tech Adopt/ Imp Eval.	-	0.29	24.1	42.6	083	2		13.37
39	RMP	Agro-forsestry	3.5	0.60	24.1	42.6	076	4	1.70	13.97
40	RMP	Char'n of prod'n emit	-	0.72	24.1	426	0.76	3	-	14.69
41	LGM	Nematodes-GN, PP, CP	5.9	0.41	179.7	263.9	6.27	3	1.69	15.10
42	LGM	Termites-GN	24	0.11	273	37.2	077	4	1.68	15.21

43	LGM	Sub-optimal yield-CP	0.5	0.25	882	133.7	0.52	4	1.68	15.46
44	CRL	Low temperature-SG	9.6	0.19	32.7	11.8	060	4	1.63	15.65
45	LGM	While grubs-GN	1.6	0.11	27.3	37.2	0.72	4	1.62	15.76
46	CRL	Head bug-SG	7.1	0.27	43.2	74.8	076	3	1.61	16.03
47	LGM	Drought-PP	77	0.41	98.2	136.4	0.28	4	1.61	16.44
48	CRL	Anthracnose-SG	46	0.43	126.7	110.8	0.82	2	1.60	16.87
49	CRL	Midge-SG	4.1	0.52	566	47.1	0.82	3	1.59	17.39
50	RMP	Chaf'zation of environ.		0.25	75.9	114.1	0,00	3		17.64
51	RMP	Microecon studies	-	-	-	-	-	-	-	18.05
52	RMP	Natural resources		0.60	75.9	114.1	0,00	5	-	18.65
53	RMP	Supply & demand		021	75.9	114.1	0.00	4	-	18.86
54	RMP	Farmers' preferences		0.14	759	114.1	0.00	3	-	19.00
55	RMP	Beneficial organisms	11.3	0.41	624	104.9	0.27	4	1.55	19.41
56	RMP	Plant nutr'n-SG/ PM/FM	13.0	0.08	32.1	12.4	0.70	3	1.54	19.49
57	LGM	Peanut mottle virus-GN	3.5	0.21	147.3	138.7	0.91	1	1.51	19.70
58	RMP	Cons /demand studies		0.21	24.1	42.6	0.78	2	-	19.91
59	CRL	Drought-PM	8.9	0.56	65.3	116.7	0.48	3	1.48	20.47
60	GIP	Adaptability-GN	33.9	0.08	12.9	12.4	0.75	1	1.47	20.55
61	CRL	Adapt, to acid soils-SG	9.1	0.19	48.9	205	064	3	1.45	20.74
62	LGM	Peanut stripe virus-GN	4.3	0.18	97.1	47.1	0.54	3	1.40	20.92
63	RMP	Drought-SG/ PM/FM	8.1	0.14	32.1	12.4	0.65	3	1.40	21.06
64	CRL	Downy mildew-	168	1.12	64.1	114.6	023	3	1.39	22.18

		PM								
65	CRL	Drought-SG	8.6	0.85	31.4	229.7	0.76	1	138	23.03
66	CRL	Leaf blight-SG	50	033	37.4	52.0	0.86	2	1.37	23.36
67	CRL	Blast disease-FM	13.8	0.33	60.0	23.1	0.68	2	1.36	23.69
68	CRL	Striga-PM	4.8	0.33	10.7	31.1	0.66	3	1.33	24.02
69	CRL	Low grain yld-PM	10.5	0.87	55.4	93.6	0.32	3	1.30	24.89
70	LGM	Phyto. Bligh (MGT)-PP	15.9	0.12	103.9	147.4	0.01	3	128	25.01
71	LGM	Helicoverpa-PP	0.8	0.32	98.2	136.4	0.08	4	1.27	25.33
72	CRL	Foliar disease res.-SG	3.3	0.41	71.9	23.3	050	3	1.25	25.74
73	SMIP	Impr. of grain yield-FM	5.6	0.21	13.1	6.8	0.55	3	1.20	25.95
74	ECO	Res. Impact-SG/ PM/FM		0.12	11.9	4.6	0.48	1	-	26.19
75	ECO	Policy analysis-SG/PM/FM		0.12	85.7	34.4	076	1	-	26.46
76	CRL	Shoot fly-SG	12.4	0.27	45.6	67.3	0.49	2	1.19	26.46
77	CRL	Lack of adapt. (arid)-PM	9.9	0.66	20.5	68.7	033	3	1.18	27.12
78	LGM	Maruca-PP	1.9	0.06	52.5	102.4	0.11	4	1.17	27.18
79	LGM	Stunt virus-CP	1.1	0.10	88.2	107.9	0.25	3	1.13	27.28
80	LGM	Podfly (MGT)-PP	8.0	014	70.4	130.0	0.08	3	1.10	27.42
81	LGM	Water logging-PP	7.0	0.30	89.4	125.7	0.05	3	1.08	27.72
82	CRL	Podfly-PP	0.5	0.14	70.4	130.0	008	3	1.07	27.86
83	CRL	Head catepillars-PM	4.0	0.30	10.3	27.5	0.59	2	0.99	28.16
84	CRL	High temperature-PM	5.9	0.50	588	113.6	0.29	2	0.96	28.66
85	LGM	Cold tolerance-CP	7.6	0.23	20.2	66.1	0.03	3	083	28.89
86	CRL	Forage	99	0.25	842	72.3	0.28	1	077	29.14

		sorghum-SG								
87	CRL	Stem borers-PM	1.1	029	2.5	23.8	0.44	2	0.76	29.43
88	LGM	Botrytis gray mold-CP	29	0.19	30.1	82.8	0.48	1	0.74	29.62
89	ECO	Seed d'bution' SG/PM/FM	-	0.19	14.8	5.5	065	2	-	29.81
90	ECO	Seed d'bution-SG/PM/FM	-	0.17	205	10.5	0.72	1	-	29.98
91	RMP	Inst'l & human res'rces	-	0.12	75.9	114.1	0.00	4	-	30.10
92	RMP	Input markets	-	0.08	75.9	114.1	0.00	2	-	30.18
Complementary funding										
93	CQU	Quality/ Utilization-SG	36.9	0.13	185.7	169.2	0.79	3	2.68	30.31
94	RMP	Weeds	6.5	0.33	24.1	426	0.76	3	1.51	30.64
95	RMP	Weed (MGT) - SG, PM. FM	10.0	0.21	32.1	12.4	0.72	3	1.50	30.85
96	CRL	Acid soil adaption-SG	9.1	0.19	48.9	20.5	0.64	3	1.45	31.08
97	LGM	Aphids-GN	0.1	018	273	37.2	0.77	3	1.39	31.26
98	RMP	Nematodes-SG	2.2	0.09	5.8	1.6	0.53	4	1.34	31.35
99	LGM	Crop improvement-PP	2.2	0.83	230	14.5	073	3	1.34	32.17
100	CRL	Sooty stripe-SG	0.2	0.17	22.9	406	0.78	2	1.15	32.34
101	CRL	Long smut-SG	47	0.17	4.4	7.9	0.71	2	1.08	32.51
102	SMIP	Storage pests* SG.PM	0.1	0.12	17.3	9.7	0.48	3	1.03	32.63
103	CRL	Low grain yield-PM	5.5	0.21	11.5	296	0.32	3	1.00	32.84
104	SMIP	Ergot-SG	4.0	0.18	13.7	5.5	0.68	1	080	33.02
105	GIP	Imp. C' vars confec.-GN	8.2	0.17	3.9	3.0	0.55	1	0.73	33.19
106	SMIP	Photosensitive-PM	3.0	0.08	2.0	3.8	0.00	3	0.57	33.27
107	SMIP	Photosensitive-	3.9	0.02	3.6	3.8	0.30	1	0.39	33.29

		SG								
108	CQU	Qlty. Scre'ing-SG/PM/FM	-	0.17	173	7.1	0.54	1	-	33.46
109	COU	Q'lty imp'ment-SG/PM/FM	-	0.05	173	7.1	0.54	3	-	33.51
110	CQU	Sweet stern sorghum-SG	-	0.14	15.9	6.9	0.44	4	-	33.85

Appendix II. Illustrative sample of results of adoption/impact studies

Country	Crop	Variety	Region	Adop-tion (% area)	Impact
Botswana	Sorghum	SDS 3220 (Phofu)	National	14	Survey results indicate broad acceptability of variety for early maturity, large head and large white grain and strong stem resistant to lodging.
Cameroon	Sorghum	S35	Mayo Sava Diamare Mayo Danay	49 14 12	Yield gain (500 kg) maximum during drought years when yields of land races are almost nil. Widely adopted for early maturity.
Chad	Sorghum	S35	Guera Diamare Mayo Danay	38 27 24	51% yield gain; widely accepted for early maturity and food/fodder quality. Income generated through marketable surplus provides farmers means to invest in land conservation and improvement techniques.
India	Pearl millet	Improved cultivars	Maharashtra	92	
		ICTP 8203		34	50% yield gain; seed widely available via public seed sector; widely accepted for its downy mildew resistance.
		MLBH 104		23	61% yield gain; Rs 1,416 per unit cost reduction over local cultivars; Rs 2,670 per ha net returns.
			Gujarat	99	

		MH 169		33	Widely adopted due to
		MH 179		25	disease resistance, short
		Nandi 18		14	duration and high grain and fodder yield.
			Tamil Nadu	77	
		ICMS- 7703		6	Wide adoption due to high yield, drought resistance and seed availability.
		ICMV- **221**		5	
		WC-C75		12	
		Pioneer		29	
India	Pigeon pea	ICP 8866	Kamataka	59	IRR: 65%
			AP Border	52	US$ 62 m net present value of res. Benefits.
		ICPL 87	Maharashtra border	59	43% yield gains.
			Eastern Maharashtra	18	42% unit cost reduction.
			Western Maharashtra	57	Two main reasons for widespread adoption are: a) Short duration allows double cropping; and b) crop rotation with pigeonpea helps maintain soil fertility.
	Chick Pea	ICCV2	A.P.	17	IRR: 17.5-21 .2%
			Maharashtra	10	
			M.P	13	Gender: 11% higher employment. Sustainability: occupied rabi fallow land; (a) double cropping, (b) controls soil erosion, (c) improves soil fertility.
		ICC 37	A.P.	9	Yield increase: 111%
			Maharashtra	18	Gender: 8% higher employment.
		ICCV4	Gujarat (Jamnagar)	25	Yield increase: 67% Cost saving: 32%
	Ground Nut	Raised-bed & furrow	Maharashtra	31	IRR: 25.3%

	Prod-uction	Improved varieties		84	Gender: higher labour productivity; and easy weeding and harvesting.
	Tech.	Single super phosphate		69	Sustainability: moisture conservation and improve drainage.
		Zinc sulphate		14	
		FeSO4		6	
		Gypsum		42	
		Seed dressing		46	
		sprinkler		4	
India	Verti Sol Tech	Summer cultivation	Vidharbha, Maharashtra	75	Dry seeding: Cotton:
	.	Dry seeding Double		40	Yield increase: 27% Income increase: 55.7%
		cropping Improved		56	Cost saving: 17%
		Varieties Fertilizer		43	Sorghum: Yield increase: 38.45% Income increase: 98.5%
		Application (% farmers)		97	Employment increase: 13.6%
		Seed& fertilizer placement (% farmers)		95	Cost saving: 17.15
		Plant protection (% farmers)			
Malawi	Sorghum	SPV 351	National	10	Widely accepted for early maturity.
Mali	Peart millet	Improved cultivars	Segou	29	Stable yield improved food security.
			Koulikoro	20	65% yield gain
			Mopti	17	52% yield gain
	Sor-ghum	Improved	Segou	29	
		cultivars	Koulikoro	30	
			Mopti	33	

Mozam-bique	Sorghum	ICSV 88060	National	5	Drought relief programme distribution
Namibio	Pearl millet	ICTP 88908	National	31	Broadly accepted for early maturity, bold grain; basis for start of national seed industry.
Zambia	Sorghum	IS 23520 MR4/460 T11	National	35	IRR 11-15%, broadly accepted for early maturity and bold grain.
Zimbab we	Sorghum	ICSV 88060	National	36	IRR 22%, widely accepted for early maturity, late senescence, processing ease.
	Pearl millet	SDMV 89004	National	16	IRR 44%; widely accepted for early maturity and bold grain.

Source: TAG Secretariat (1996).