Priority Setting

Training Document

Draft Version 3.2

November 1989

Manual for

METHODS OF PRIORITY SETTING IN AGRICULTURAL RESEARCH AND THEIR APPLICATION

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Foreword to:

Methods of Priority Setting in Agricultural Research and Their Application

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In this manual five methods for research priority setting are discussed, with illustrations of their applications. The manual focuses on priority setting among lines of research within research institutes or programs. This is referred to as "project level" priority setting. Other ISNAR staff are working on methodology development and training materials for strategic level priority setting.

The manual is based on ISNAR Working Paper No. 10, Priority Setting in Agricultural Research, May 1988, by the same authors. It is designed to accomplish two objectives.

To familiarize those concerned with making decisions in agricultural research with some of the more widely used methods of priority setting, and

To give them an idea of how these methods are applied.

The presentation in this version of the manual, Draft version 3.2, has been substantially reoriented with the assistance of Doyle Baker[1]. An attempt has been made to more clearly distinguish the overview of methods (many of which can be applied to both strategic and project level priority setting) from the project level applications. A second goal has been to further highlight various critical factors which influence priority setting at the project level, regardless of what method is used.

Robert Raab, ISNAR Research Associate for Training, has put this manual in its training-oriented format.

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1. Introduction

Priority setting in agricultural research has traditionally been an experience-based, informal process. As expenditures rise and as public demand for accountability increases, research managers have come to realize that they need more objective, formal, and systematic methods for assessing research needs and, eventually, allocating resources. Practice in this respect varies widely and is evolving.

Most recent organized experiences of priority setting in national agricultural research systems (NARS) have had three key features in common.

- Priority setting has ceased to be an exercise which scientists do by themselves. It is now recognized for what it is, a joint scientific and political exercise. In order to be effective, priorities must be legitimized at all levels, from the policy-makers down to those who will implement the decisions. Priorities must also be legitimized among clients and sponsors.

- While decisions have always been based on relevant criteria and indicators or measures, these are now made more explicit.

- Research managers have additional agenda items in mind: the exercise is seen as a vehicle for justifying the use of existing resources and laying further claim to more, as well as one of rallying and mobilizing members of the organization to the attainment of institutional goals.

Present informal practices fulfil these needs for the most part. But they provide little systematic guidance to resource allocation, do not furnish measures to compare investments in research to alternative uses of resources, and they are not able to respond to questions related to vulnerable sectors of the population, an issue which is increasingly raised by governments.

Techniques in economics are now being adopted to assist in research priority setting. The approaches differ. Each of the techniques has special information requirements, specific applications, and limitations.

This paper is designed to accomplish two objectives.

- To familiarize those concerned with making decisions in agricultural research with some of the more widely used methods of priority setting.

- To give them an idea of how these methods are applied in determining priorities, emphasizing the research project level.

The paper begins with an overview of priority setting methods. Following this, eight critical factors are identified which affect priority setting at a research program and project level. Applications to priority setting at the project level are then discussed and illustrated. The paper concludes with comments on the practicality of the various methods.

2. Overview of Research Priority Setting

To end up with a research program that is in the best national interest, a wide range of possible research areas should initially be considered, among which priorities must be determined regardless of the current composition of resources. In determining priorities, the planner's aim is to get the highest value for money. This means that priority setting is based on informal or formal assessments of the benefits from research relative to costs.

In the planning process, it nearly always is found that available resources do not accord with desired ends. For instance, land and buildings usually already exist, and so do research staff with their specific levels of training and skills. Nevertheless, certain new research activities might require retraining of staff, seeking specific kinds of technical cooperation, or constructing a new building. In this case, the planner's ideal must be modified to take account of the time and resources it takes to move toward the desired ends. Thus, in practice, planning and priority setting are based on "what is" as well as "what should be". Priority setting is also affected by existing commitments to various research programs and the reality that the scope for change from one year to the next is limited.

Priority Setting at Different Levels

At the highest level of decision-making in agricultural research an allocation of research funds is made on a broad basis to commodities or groups of commodities (coffee, livestock, cereals...) and to broad problem areas (say erosion control) or factors of the natural resource base (soils, water, etc.). Priority setting at this level of decision making is often referred to as "strategic" priority setting. Both economic and social criteria are important in strategic priority setting. Political processes often dominate at this level, but priority-setting methods can be used to provide politicians and planners with information on the likely costs and benefits of alternative research investments.

Strategic priority setting is not sufficient for agricultural research planning. Within research institutes or programs, broad funding allocations are converted into financial, human, and physical resources for specific lines of research. Thus, priority-setting methods are also needed for planning and resource allocation decisions within research institutes and programs. In this manual this is called research priority setting at the project level.

Research Priority Setting Methods

There are many priority setting methods, some of which are quite theoretical and have never been applied in practice. Five methods which appear to have the greatest relevance for practical application are described in this section. The five methods discussed here are:

- **Congruence**
- **Domestic Resource Cost (DRC) Ratios**
- **Checklists**
- **Scoring or Weighted Criteria Models**
- **Benefit/Cost Analysis**

The congruence and domestic resource cost ratio methods are applicable only at a high level of aggregation for strategic priority setting. Scoring models, checklists and benefit/cost analysis can be used for an initial determination of priorities at the strategic level and for setting priorities at the project level, i.e. between different lines of research within an institute or program. In this manual, only versions amenable to priority setting at a research project level are discussed in any detail. However, illustrations of the use of congruence and DRC ratios are given in Annex1.

Of all the methods identified in this manual, only congruence directly answers the question of how resources should be distributed among different research programs. For the other methods, the determination of priorities does not by itself answer the question of resource allocation: the two are not synonymous. From the outset, there has to be some judgement of what constitutes a promising and reasonable program and what resources it requires. Resources, notably people's time and funds, are then allocated to research programs in accordance with the priorities, going down the priority list until the budget is exhausted.

Congruence

Congruence in agricultural research simply means that, assuming other things are equal, total available research funds should be allocated to commodities in the same proportion as their existing contribution to the agricultural gross domestic product (AGDP). Imports minus re-exports (net imports) may also be added if the commodity in question is being produced competitively at home, or might be, given a successful research program.

The main advantage of congruence is that it does provide a basis for comparing the existing allocation of resources to research on different commodities with the importance of those commodities' contribution to the national income. If there are wide discrepancies in this respect, these should be looked at, and justified if they are allowed to persist.

Congruence provides a conceptually simple method of setting priorities, or rather of allocating resources. It only requires a comparison of national agricultural income and perhaps trade statistics, with agricultural research budgets by commodity. However, many research institutions do not budget by commodity or do so incompletely, and in such cases the needed figures may be difficult to extract. In fact, intended use of the congruence method implies the need for commodity-by-commodity budgeting.

The congruence method has two major shortcomings. First, by definition, it tends to maintain the status quo: today's most important commodities get the most research funds, and commodities currently not produced get none, however high their potential interest. Second, congruence cannot be used to set relative priorities between commodity research and research that is not directly related to commodities. For example, while congruence could be applied to research on natural resources (land, water) or to what may be called "vertical stages of value added" (production, storage, processing ...) if the GDP data are arranged accordingly, it is impossible to arrange the GDP simultaneously in multiple ways in a single analysis. Consequently, one cannot compare resource percentages of AGDP to commodity percentages of AGDP.

Despite its limitations, the congruence method may be useful for initial fund allocation decisions at the strategic level. Moreover, there is no reason why funds must be allocated in strict conformity with the congruence rule. Adjustments can take place subsequently on the basis of information from the research system as a whole flowing up and down the decision-making hierarchy, between the strategic and project priority setting levels.

Domestic Resource Cost (DRC) Ratios

DRC ratios indicate where a country's comparative advantage over other producers in the world market lies. They show how the costs of domestic inputs (including labor, land and annualized capital values) into the production of a commodity compare with the foreign exchange cost of importing the commodity (case of imported commodities) or the foreign exchange value of exports (case of exported commodities). A simple DRC ratio can be calculated using the formula below.

$$\text{DRC Ratio} = \frac{A}{B - C}$$

Where:

A = Current cost of domestic resources per unit of the commodity produced locally.

B = Import costs (c.i.f.) of a unit of the commodity of equivalent quality produced abroad for imported commodities, or export value (f.o.b.) for exported commodities.

C = Costs of imported inputs needed to produce a unit of the commodity domestically.

As can be seen from the formula, if the costs of domestic inputs (those which are not imported) into a tonne of locally produced maize -- for example -- are below those of the equivalent inputs in foreign-produced maize, the DRC ratio for maize will be less than one. Thus, a DRC ratio of less than one shows a comparative advantage in the production of a commodity, a ratio of more than one shows the opposite. The lower the DRC ratio, the greater is the country's international comparative advantage in producing maize and the more resources it should then allocate to maize research. The above assumes that current domestic and foreign production costs can be used to determine research priorities. They do, in fact, provide some indication in this respect, as they show what a country is already good at, and the inference is that success should be built on. But the real issue is: where will comparative advantage lie once the research in question has been undertaken and the results adopted. Ideally, therefore, the components of the analysis should be expressed in anticipated post-research terms. Moreover, these post-research-and-adoption DRC ratios should be "time-valued" through discounting. This is because research results are achieved and adopted at some time in the future, so that monetary values must be discounted to express them in present values. But if these complications are introduced, the DRC ratios lose their relative simplicity and may then no longer be attractive by comparison with the more revealing benefit/cost analysis.

Like congruence, DRC ratios can only be used for determining priorities at the strategic level where commodities as a whole are under review, not among individual lines of research within commodity programs. A set of DRC ratios might, for example, indicate that maize research deserves priority over that on coffee. But if an analysis at a research project level shows that a particular project on coffee holds more promise than the most promising line of research which might be conducted on maize, then the initial decision to favor maize at the strategic level will have to be modified as this more detailed information is fed back up through the decision-making system. Provided the need for subsequent adjustment is well accepted, the DRC ratio method provides a reasonable technique for the preliminary broad allocation of research priorities on a commodity-by-commodity basis.

In contrast to congruence, using the DRC method by itself does not tell the planner how much money should be allocated to each commodity.

Clearly, DRC ratios cannot be used for priority setting in non-commodity research.

Checklists

Checklists pose questions under different criteria which must be borne in mind in determining which research programs or lines of investigation deserve priority and which do not. Checklist design varies considerably, often reflecting the planner's personal view of what are important issues. (But this tendency can be reduced to some extent by basing the checklist on the same criteria as those involved in a benefit/cost analysis, as is shown below.)

A research planner can use a checklist to evaluate and compare entire research programs at the national level: maize, soils, cassava, coffee, dairy research, and so on. To do this well, he needs a good underlying insight into the range and potential success of all lines of research which each program might comprise: varietal improvement, research on fertilizer, pest control, storage techniques, etcetera. In this he will be aided by any information which he has been able to obtain from research staff at the station level.

The checklist method is also applicable to priority setting at the research institute or station level. In this case it deals with the different research lines of research within each major program. For example, for maize research, separate projects could be: breeding hybrid varieties for yield, improvement of rainfall efficacy, cultural techniques to reduce the incidence of disease, etc. Similarly, under the broad heading of soils research, there could be separate research projects on, for instance, utilization of rock phosphate on acid soils, and drainage of valley bottoms. But here the research is not directly related to a commodity. Its outcome must be translated into its effect upon whatever range of commodities may be concerned if the analysis is to be conducted in terms of the underlying concepts of costs and benefits.

The checklist technique is particularly useful where a project identification process presents a large number of alternative lines of research. Checklists, or the scoring models which follow, can then be used to eliminate most of these without the need to undertake elaborate benefit/cost analyses.

The main problem with checklists is that checklist criteria do not tell us precisely what the relative significance of one criterion or issue is against another: for example, probability of research success versus anticipated rate of on-farm adoption. Furthermore, the expression of answers in words, characteristic of checklists, is cumbersome and imprecise, and does not facilitate comparisons. The manner in which the checklist is used in this manual tries to overcome these difficulties to some extent.

Scoring or Weighted Criteria Models

The scoring technique for setting research priorities is much like the checklist method, except that numerical weights are used to express the relative significance of each criterion and scores are allocated in place of the highs, mediums and lows often employed in checklists. Numerically weighted criteria give a clearer picture of their relative importance, provided of course that such numbers carry conviction. Moreover, scoring is no more difficult to apply than is the checklist method. But the sense of precision which it imparts may, perhaps, be misleading, in which event it may be better to recognize this and confine oneself to the less ambitious checklists.

In some scoring models, the criteria are expressed in terms of national objectives, such as the desire to increase employment, foreign exchange earnings, and the like. The model described in section 4 uses eight critical factors which were derived from a benefit/cost analysis.

The scoring method is frequently applied at the strategic level, i.e. for commodities or research programs in the aggregate. In this manual it is applied at the level of individual lines of research, where the research planner's notion of expected costs and anticipated benefits can be more specific.

In the simplest form of the scoring technique, weights are subjectively determined; that is to say from the opinions of the persons applying the method rather than from an analysis of actual data. A somewhat more complicated method derives weights from sensitivity tests conducted on social benefit/cost analyses for a number of research projects, as will be explained later.

Researchers accept the scoring method easily. It is relatively simple to understand and apply, as it is no more than a logical extension of the checklist. Moreover, it does have the merit of forcing the planners to be specific about the relative significance, or "weight", which they accord to the various criteria.

Benefit/Cost Analysis

In benefit/cost analysis all costs of producing, delivering and adopting a technology are compared to producer and consumer benefits, expressed separately or together. These benefits and costs are expressed in money terms, taking into account the years in which they occur. The basic principle in assessing these money values is that a dollar earned in the future is worth less than a dollar now. This is because a dollar now can be invested at the going rate of interest so that it will be worth more in the future. Future costs and benefits must therefore be discounted (the reverse of compounding), as shown in Figure 1. Annex 2 gives the discount factors for 1 to 40 years at annual discount rates from 1 to 60 percent.)

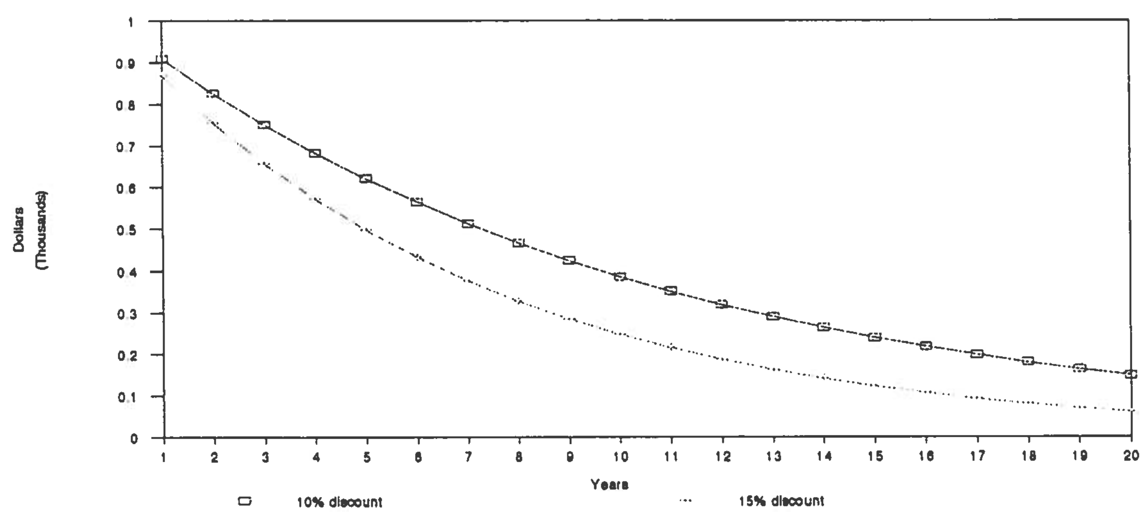

Figure 1. Present value of a stream of costs and/or benefits of 1000 a year over 20 years.

The anticipated streams of costs and benefits, represented in discounted terms, can be used to express the expected worth of a research project in terms of the net present value (NPV), the internal rate of return (IRR), or the benefit/cost ratio (B/C ratio). Net present values are used for sensitivity testing as will be shown later. The internal rate of return is the calculated rate of interest in the project as a whole at which the net present value would be exactly zero. This indicator is commonly used to assess the economic attractiveness of investments in infrastructural development projects, but it can also be used for ranking research projects. The benefit/cost ratio is the ratio of total gross benefits to total costs, both expressed in present value terms.

Also benefit/cost ratios can be used to rank research programs or projects in most cases. Rankings obtained with B/C ratios may differ from those obtained with IRRs, and economists are not unanimous about the relative merits of these two indicators.

Thorough use of opportunity costs (expressing the opportunities which society foregoes when choosing to produce a given commodity instead of others), will remove any distorting effects of national economic policy on the above indicators. Foreign exchange earnings or expenditures should be represented in terms of the free market or parallel rate of exchange as this is likely to be closer to their real opportunity cost than is the official exchange rate. Wages may be represented at their pre-innovation value as this is a good proxy for the opportunity cost of labor under the expected future cropping pattern or other new technology.

If this policy places ceilings on domestic prices below international prices, but does not at the same time subsidize production inputs such as fertilizer in a fully compensatory way, then farmers may produce less than is in the national interest, no matter how productive a new technology may appear to be in opportunity cost terms. In that event, technologies depending on fertilizer use may not merit priority in research allocations until government policy is changed, even where opportunity costing indicates that they should.

Benefit/cost analysis is the only one of the methods discussed here which attempts to quantify the anticipated pattern of events over time in a more or less precise way. A good understanding of the importance of discounting costs and benefits is essential .

One must also be able to demonstrate what will happen if the guesstimates which go into this analysis are wrong to a certain degree. This is done by showing the effect of variations in assumptions on the net present value (NPV) of a project by means of what is called sensitivity testing. Such tests can be carried out for variations in each critical factor affecting benefits and costs. The results of these sensitivity tests indicate whether a factor is likely to prove of greater or lesser significance when it comes to the estimation of the net gains to society (i.e., NPV) from different kinds of research.

While benefit/cost analysis is presented as a tool in priority setting, its most immediate benefit is to introduce the thought processes involved into the minds of decision-makers at every level. This greater understanding should also lead to improved use of scoring techniques and checklists. It is worth repeating that, if a reasonably large sample of research programs can be analyzed in benefit/cost terms -- preferably ex-post i.e. using real data -- this will throw light on how the critical factors affecting benefits and costs behave in differing circumstances. In particular, it will provide evidence on the magnitude of weights and scores which should be used in a scoring model. It may also provide further insights into the nature of the questions to be included in a checklist, and into the significance of the answers to these questions.

The economic surplus model of benefit/cost analysis (not covered in this manual) is used at a strategic level of priority setting. This model takes account of the fact that all but the last, or "marginal", consumer would have been willing to pay more for a unit of a particular product than he or she actually has to pay (consumer surplus). It also recognizes that all but the last or marginal producer would have been willing and able to produce it for less than he or she receives for it (producer surplus). The economic surplus model shows to what extent research-induced reductions in production costs may reduce market prices, and thus change the distribution of benefits between consumers and/or producers of a commodity in a way which simpler versions of benefit/cost analysis do not. Moreover, analysis in economic surplus terms can be used to show how economic policy interventions, such as commodity price ceilings, over-valued exchange rates, and/or subsidies and taxes, distort or even eliminate the welfare gains which might otherwise have been obtained from research. The logic involved in the economic surplus benefit/cost model requires some knowledge of elementary economic theory, and application is hampered by several difficulties including that of obtaining the necessary data on elasticities of supply and demand.

The model of benefit/cost analysis described in this manual is applied to individual research projects, rather than at the level of programs in the aggregate. Using benefit/cost analysis at the level of research projects has the advantage of involving the individual researchers themselves in planning. However, it also raises feasibility problems: most national agricultural research systems will have a hundred or more different lines of research. Applying benefit/cost techniques to all of these would be an extremely elaborate exercise, even though simple computer programs can greatly facilitate the calculations. The problem is smaller than it seems, because rough calculations in checklist or scoring model terms will usually suffice in practice to weed out many unpromising research projects. Benefit/cost analysis can thus be restricted to a much smaller number of projects.

As stated above, research-induced increases in supply may cause prices to fall. Nevertheless, in the model of benefit/cost analysis detailed in this manual prices are assumed to remain constant. The constant-price assumption is useful for practical purposes, as the effect of these price consists for the greater part of a transfer of welfare from the producer to the consumer. Price falls may, of course, reduce the rate and ceiling of technology adoption, and this can have a substantial impact on the ratio of benefits to costs.

3. Critical Factors in Project Level Priority Setting.

Success in priority setting at the research project level vitally depends on the range of factors taken into account, regardless of which priority setting method is used. In practice, there has been little consistency in the number and types of factors taken into account by research planners. Thus, critical determinants of research priorities have not always been systematically considered even when more formal methods of priority setting have been used. While it is important to include all important factors in priority setting, the number of possible elements or considerations is very large.

Fortunately, it is possible to identify eight "critical factors," each of which is composed of a number of underlying elements or considerations, which incorporate all the information needed for priority setting. These eight critical factors are described one by one below as they apply to agricultural research.

1) Annual Research Costs

Sensitivity tests carried out in benefit/cost analyses show that this factor has little influence on a research project's net gain to society -- its net present value (NPV) -- apart of course from any effect it may have on any other critical factor, for example research duration or probability of research success. This factor is therefore shown as little significant in a checklist, and has a low weight in the scoring model. Considerations which bear upon this factor for any given research project are:

- Additional annualized capital and land costs (if any)
- Labor costs
- Personnel charges for professional staff
- Materials

2) Duration of research in years

Sensitivity tests indicate that on average this factor is somewhat more significant than the previous one, but still of relatively little significance. Important underlying considerations are:

- Complexity of the research in question
- Foreign research linkages benefiting the research
- Relationship to existing domestic research programs

- Suitability of research staff (qualifications, area of specialization, experience)
- Motivation of research staff
- Physical research capacity
- Size and consistency of funding

3) Probability of research success

In contrast to most other factors, the significance of probability of research success is highly dependent upon its level. When the probability is high (say over 70%) the significance of this factor is low, when it is in the low range, say below 25%, its significance is very high. On average it may be assessed as medium in significance. The considerations bearing upon this criterion are **the same as those affecting duration of research and in addition:**

- Yield gap between local and foreign research

4) Costs of adoption

Society may lose part of what it gains from an innovation in the form of added costs per hectare (or per tree, or animal) of implementing that innovation. Costs may also be incurred by certain general provisions (extra extension efforts, subsidized initial seed multiplication, input distribution infrastructure...) that are needed to make adoption of the innovation possible. These costs, or part of them if they also provide wider benefits, must be attributed under this heading. Sensitivity tests indicate, as one might expect, that this factor is moderately to very significant in its bearing upon research priorities. As costs of adoption are negative, this factor carries a - sign in a scoring model or checklist. Note, however, that if the innovation is expected to lead to cost <u>reduction</u>, the score or rating for this factor will have a + sign. Elements to be taken in to consideration include:

- Increase or decrease in financial costs to producers
- Increase or decrease in foreign exchange component of costs
- Increase or decrease in employment
- Increase in costs of extension (insofar as these are not reflected in costs to producers or consumers)
- Correction for input subsidies
- Correction for taxes on inputs

All but the first of these must be expressed in terms of efficiency prices.

5) Benefits of adoption

The gross benefits per hectare (or animal, or tree) which are expected to arise from adoption of the innovation constitute the single most important factor in setting priorities. Gross benefits (over and above the situation without adoption) are generally positive, but note that an innovation having low or zero (or even somewhat negative) gross benefits can be attractive if it is characterized by an important reduction in costs (i.e. a + rating for the previous factor). The following elements must be considered when evaluating this criterion:

- Increase or decrease in gross financial benefits per hectare (or tree, or animal) to producers
- Financial benefits to consumers
- Additional foreign exchange earnings or savings
- Corrections for price supports or price controls and taxes on production
- Increase or decrease in yield variability and/or price risk
- Effects on equity (gains to poor vs. rich farmers)
- Effects on food security
- Additional processing opportunities

All but the first two of these elements must be expressed in terms of efficiency prices.

6) Adoption period

Contrary perhaps to expectation, the time it takes for an innovation to reach its adoption ceiling often turns out to be a factor of rather low significance. Any adoption delay is negative, so this factor carries a - sign in a scoring model or checklist. Considerations in evaluating this factor are:

- Net financial benefits per hectare (= gross benefits from adoption minus costs of adoption)
- Increase or decrease in outlays required
- Technical ease or difficulty of implementation
- Availability of credit and associated inputs
- Increase or decrease in yield variability and/or price risk
- Farmer receptivity to innovation
- Population pressure

7) Ceiling on adoption

Sensitivity tests show that generally this factor only moderately influences the net present value of a research project . This is understood if one remembers that benefits and costs in the relatively distant future are heavily discounted. This factor is influenced by **the same elements as those affecting adoption period, but also:**

- Existing area of cultivation (or number of animals)

8) Life of the innovation

According to sensitivity tests, this factor is often of moderate, sometimes of low significance. The following considerations should go into an evaluation of this factor:

- Genetic and other elements of stability in the innovation
- Probability of displacement by further innovation.

Lastly, it is worth noting that, speaking generally, anticipated changes in the external environment must always be taken into consideration, because in different ways they can influence any and all of these eight critical factors.

4. Applications to Project Level Priority Setting

The eight critical factors just discussed govern the application at project level of all three priority-setting methods outlined in this section: checklists, scoring models, and benefit/cost analysis.

Application of the Checklist Method

Step 1. Construct a table similar to Table 1. Across the top of the table, as column heads, write down the criteria to be used. For the reasons given earlier, the chosen criteria are the eight critical factors itemized above. Other criteria may be added if the situation warrants; for example, equality of income distribution, or foreign exchange earning potentia, although such criteria often can be subsumed under benefits and costs of adoption.

Give some indication of the relative significance of each criterion in terms of its impact on the returns to society from the research in question. In Table 1, this has been done by designating the criteria as **VS, MS** and **LS,** for very significant, moderately significant, and less significant. These factor weightings are tentatively based on a sampling of recent benefit/cost analyses, as has been discussed earlier.

Also indicate the kind of effect: positive sign for criteria that are increasingly beneficial as they grow in magnitude,

Table 1. Example of priority setting in agricultural research using a checklist.

(1) Types of Research	(2)	(3)	(4)	(5)	(6) Criteria	(7)	(8)	(9)	(10)
	Annual research costs (LS) (-)	Duration of research in years (LS) (-)	Probability of research success (MS) (+)	Costs of adoption (VS) (- or +)*	Benefits of adoption (VS) (+ or -)**	Adoption period (LS) (-)	Ceiling on adoption (MS) (+)	Life of the innovation (MS) (+)	Rank order
Maize selection	-M	-M	M	-M	M	-M	M	M	3
Soil acidity	-M	-H	M	-M	H	-M	H	H	2
Cassava pests	-M	-L	H	0	H	-L	H	H	1
Coffee quality									
Dairy husbandry									
Sorghum diseases									

Examples of scales used in assessing each criterion:

1) Annual research costs:	High (> $800,000) Medium ($200,000-$800,000) Low (< $200,000)
2) Duration of research:	High (> 8 years) Medium (4-8 years) Low (< 4 years)
3) Probability of research success:	High (> 75%) Medium (25-75%) Low (< 25%)
4) Costs of adoption:	High (> $12/ha) Medium ($4-12/ha) Low (< $4/ha)
5) Benefits of adoption:	High (> $30/ha) Medium ($14-30/ha) Low (< $14/ha)
6) Adoption period:	High (> 18 years) Medium (8-18 years) Low (< 8 years)
7) Ceiling on adoption:	High (> 75% of existing area) Medium (25-75% of existing area) Low (< 25% of existing area)
8) Life of innovation	High (> 15 years) Medium (5-15 years) Low (< 5 years)

* Innovations usually increase costs per hectare, tree or animal (-) through intensification, but sometimes they reduce them (+).

** Normally, an innovation increases benefits (+), but with cost reducing innovations benefits may stay constant or decrease (-) and still be attractive.

and minus sign for those that work in the opposite direction. These signs will be attached to the ratings given in step 4.

Step 2. Define the ranges which will be used for each of the criteria, in money, year or percentage terms, to ensure that all research projects are evaluated by the same standards. An example is given in the bottom half of Table 1.

Step 3. In the first column of the table, list all the research projects under review.

Step 4. Rate every research project under each criterion. Perhaps the simplest method, as shown in Table 1, is to use a scale of **0**, **(L)**ow, **(M)**edium and **(H)**igh.

The appropriate plus or minus sign must be attached to each rating. This sign then applies to all research projects. In columns 5 and 6 (costs of adoption and benefits of adoption, per hectare or per tree or per animal) the sign may vary. Costs of adoption per hectare or tree or animal (column 5) will carry a minus (-) sign, except if adoption costs are actually reduced with the new technology, when the sign will be positive (+). Similarly, gross benefits of adoption may have a + or a - sign, depending on whether these benefits are higher or lower than before as a result of the new technology

Step 5 Rank each research project on the basis of an examination of the ratings under the various criteria, combined with an assessment of their relative significance at the head of each column. For example, the Cassava Pests project in Table 1 is expected to have high gross benefits (column 5), and the importance of this is enhanced by the fact that this criterion is judged to be very significant (VS). By contrast, the duration of the research (column 1) is expected to be low, with a corresponding minimal negative effect (-L). Furthermore, the importance of this in the overall assessment is relatively small (LS). It is the combination of these and the other column-by-column judgements which persuades us to rank this project highly (column 10).

The following will help to illustrate how the various ratings were assigned in Table 1.

Maize selection: The costs of this research was expected to be $300,000 per year; a moderate amount. Experience has shown that it takes about seven years to select a usable hybrid variety; a more or less average period in the research scale. Success is reasonably likely, but by no means certain. Additional on-farm costs associated with adoption are about $8 per hectare and additional on-farm benefits should be about $24 per hectare (no other costs of adoption are assumed here); neither of these is a large amount but both are significant enough. Farmers are expected to adopt at a reasonable rate, the area over which hybrids can be grown is moderately large (250,000 hectares), and the normal life of a hybrid is about ten years, which is about average for a new variety. Maize selection was therefore rated as medium (M) for all criteria.

Soil acidity: The ratings for soil acidity research show a somewhat different pattern. It was rated M for four criteria: research costs, probability of success, costs of adoption, and adoption rate.

However, such research typically takes a long time to produce usable technologies. On the other hand, the payoffs are high: technologies produced may increase yield levels across the board, be appealing to many farmers, and are likely to remain appropriate over many years. All of these criteria were rated high (H).

Cassava pests. Ratings for this research also reveal differences. In this case, we know, based on results from neighboring countries, that the mass rearing and release of a biological control agent (a predatory insect which destroys the pest in question) is likely to have a tremendously positive effect on on-farm benefits. In addition, the probability of success is almost 100 percent. Due to the nature of the technology (natural multiplication of the predator), the ceiling on adoption equals 100 percent of the existing cassava area, and the life of the innovation will be for as long as the predator survives through its various generations. All of these criteria are therefore rated H. Additional on-farm costs will be nil. Adoption is rapid as the predator spreads quickly, so that the adoption period is rated as Low (L). Duration of research is only three years (L), after which time a small predator maintenance and dissemination program is all that is needed.

A comparison of the ratings for these three projects evaluated in Table 1 (taking account of the different relative significance of the various criteria) suggests, but does not empirically verify, that cassava pest research merits the highest priority, soil acidity research the second, and maize selection the third.

Application of the Scoring Method

Step 1. Construct a table along the lines of Table 2. As with the checklist method, write down the criteria to be used across the top of the form as column heads. The eight critical factors provide these criteria. As with checklists, other criteria can be added if the situation warrants.

Step 2. Assign weights to all criteria (points adding up to 100, or if preferred, decimal points adding up to 1). These weights show the relative importance which each criterion receives in the priority setting process. For the method to work, the weight for a given criterion must be uniformly applied to all the research projects under consideration. As indicated earlier, the weights assigned to the different criteria are derived from sensitivity tests on a number of benefit/cost analyses. Assigning weights in this manner is likely to be much better than the current practice of subjective assignment of weights, but it requires a substantial sample of relevant sensitivity tests to be carried out, preferably using ex-post data.

Step 3. List the research projects in column 1.

Step 4. Apply a score to each of the weighted criteria for each research project, attaching the appropriate plus or minus sign to each score, as was done with the checklist. Scores may run from 0 to 10, but this suggests a precision which is often difficult to justify. Perhaps the simplest method is to use a modified version of the scale developed

Table 2. Example of priority-setting in agricultural research using a scoring technique.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Types of Research	Criteria (weighted in points, totalling 100)									
	Annual research costs	Duration of research in years	Probability of research success	Costs of adoption	Benefits of adoption	Adoption period	Ceiling on adoption	Life of the innovation	Total score	Rank order
	(1) (-)	(8) (-)	(12) (+)	(21) (- or +)*	(32) (+ or -)**	(3) (-)	(12) (+)	(11) (+)	(100)	
Maize selection	-2x1=-2	-2x8=-16	2x12=24	-2x21=-42	2x32=64	-2x3=-6	2x12=24	2x11=22	68	3
Soil acidity	-2x1=-2	-3x8=-24	2x12=24	-2x21=-42	3x32=96	-2x3=-6	3x12=36	3x11=33	115	2
Cassava pests	-2x1=-2	-3x8=-8	3x12=36	0x21=0	3x32=96	-1x3=-3	3x12=36	3x11=33	188	1
Coffee quality										
Dairy husbandry										
Sorghum diseases										

* Innovations usually increase costs per hectare, tree or animal (-) through intensification, but sometimes they reduce them (+).

** Normally, an innovation increases benefits (+), but with cost reducing innovations benefits may stay constant or decrease (-) and still be attractive.

for the checklist in Table 1. Instead of using 0, Low, Medium and High, one may use their numerical equivalents 0, 1, 2 and 3. For instance, if "duration of research" (column 3) is high for a given research project, say soil acidity research, then the activity will score 3 under this criterion. This has been done in constructing Table 2.

Step 5. To produce "weighted scores" for each research project, multiply the scores obtained in step 4 by the corresponding column weights, taking care to add the appropriate - or + sign. For example, because duration of research has been given a weight of 6 and carries a minus sign, the expected long duration of the soil acidity research project leads to a weighted score of -3x6= -18 points. This weighted score of -18 represents the effect which research duration is expected to have on the total score for this particular project. Because it is negative, it must be subtracted from whatever positive weighted scores are obtained under other criteria to determine the total score in column 10.

Step 6. Sum the weighted scores per research project along the rows.

Step 7. Rank the research projects on the basis of the total scores obtained in step 6. The higher the total score, the higher the priority which the research project in question should receive.

Step 8. Remember that this priority ranking is not synonymous with budgetary allocation: a high-priority project may have a low annual cost and vice versa. As with the checklist, one has already envisaged a particular research undertaking complete with costs, anticipated results, and their adoption by farmers at the outset. This means that the annual research costs for each project have already been more or less specified. These costs must now be set against the projects in their rank order until the budget is exhausted. Projects which fall outside the budgetary allocation will not be executed, unless additional funds can be found.

Weighted scoring does not do justice to situations where one criterion assumes a dominant influence in a particular project. This is true especially for probability of research success. The weight of this criterion depends quite heavily on the probability level and the weight assigned in Table 2 (9 points out of 100) is merely an average. Therefore, it is not representative of extremes in the probability range. If the probability of research success is very low, say below 25 percent, then the priority given to the research project in question should normally also be low, no matter what the total score. Here as elsewhere, the method must be applied with discrimination.

Application of Benefit/Cost Analysis

Benefit/Cost Analysis in research priority setting involves three stages of analysis, each comprising several steps.

In Stage 1 the planner values costs and benefits for the research projects among which priorities are to be set. This analysis will yield three indicators of the expected value of each research project: the net present value (NPV), the internal rate of return (IRR), and the benefit/cost ratio (B/C ratio).

In Stage 2, the different research projects are compared and then ranked on the basis of internal rate of return or benefit/cost ratio.

Stage 3 involves the sensitivity testing of each one of the eight critical factors in the benefit/cost analysis. These factors are varied separately in order to determine what will happen to the net present value of the project in question if the factor estimate would be wrong to varying degrees. This technique is not developed in this manual, but the manner in which the results can be utilized is treated in section 5.

Stage 1. Analysis of Costs and Benefits

Step 1. Construct for each research project a table similar to Table 3.

Step 2. This table embodies estimated values for the same eight critical factors as used with the checklist and the scoring models . Here, however, these factors are not shown explicitly, but are subsumed under columns 2, 3 and 4.

The example in Table 3 is based on the following estimates for the eight critical factors.

- Annual research costs - $300,000
- Duration of research - six years
- Probability of research success - 50 percent
- Costs of adoption - $8 per hectare
- Benefits of adoption - $24 per hectare
- Adoption period - twelve years to ceiling
- Ceiling on adoption - 50 percent of existing area, and
- Life of the innovation - thirteen years after release.

Such estimates must be made for all research projects which are to be quantitatively compared.

Step 3. In column 1, indicate the life of the project in years, extending the table from the start of the research project in question until the last year of the anticipated life of the resulting innovation. In the example, this time period extends through year 20:

Table 3. Rate of return analysis for a hybrid maize selection program (costs and benefits in $'000).

(1) Year	(2) Hectares adopting	(3A+3B) Research and adoption costs (2)x$8 adjusted for probability of success	(4) Benefits (2)x$24 adjusted for probability of success	(5) Net benefits (4)-(3)	(6) Discount factors for 10% (from Appendix)	(7) Disc. costs at 10% (3)x(6)	(8) Disc. benefits at 10% (4)x(6)	(9) Disc. net benefits at 10% (5)x(6) or (8)-(7)	(10) Discount factors for 20% (from Appendix)	(11) Disc. net benefits at 20% (5)x(10)	(12) Discount factors for 18% (from Appendix)	(13) Disc. net benefits at 18% (5)x(12)
1	0	300	0	-300	.909	273	0	-273	.833	-250	.847	-254
2	0	300	0	-300	.826	248	0	-248	.694	-208	.718	-215
3	0	300	0	-300	.751	225	0	-225	.579	-174	.609	-183
4	0	300	0	-300	.683	205	0	-205	.482	-145	.516	-155
5	0	300	0	-300	.621	186	0	-186	.402	-121	.437	-131
6	0	300	0	-300	.564	169	0	-169	.335	-100	.370	-111
7	0	0	0	0	.513	0	0	0	.279	0	.314	0
8	2,500	10	30	20	.467	5	14	9	.233	5	.266	5
9	7,500	30	90	60	.424	13	38	25	.194	12	.225	13
10	20,000	80	240	160	.386	31	93	62	.162	26	.191	31
11	45,000	180	540	360	.350	63	189	126	.135	49	.162	58
12	80,000	320	960	640	.319	102	306	204	.112	72	.137	88
13	125,000	500	1,500	1,000	.290	145	435	290	.093	93	.116	116
14	170,000	680	2,040	1,360	.263	179	537	358	.078	106	.099	135
15	205,000	820	2,460	1,640	.239	196	588	392	.065	107	.084	138
16	230,000	920	2,760	1,840	.218	200	602	402	.054	99	.071	131
17	242,500	970	2,910	1,940	.198	192	576	384	.045	87	.060	116
18	247,500	990	2,970	1,980	.180	178	534	356	.038	75	.051	101
19	250,000	1,000	3,000	2,000	.164	164	492	328	.031	62	.043	86
20	250,000	1,000	3,000	2,000	.149	149	447	298	.026	52	.037	74
Totals:		9,300	22,500	13,200		2,923	4,851	1,928		- 153		43

Notes:

1. NPV at a 10% discount rate (column 9 total) = + $1,928;
   NPV at 20% discount rate (column 11 total) = - $153;
   NPV at 18% discount rate (column 13 total)= + $43.

2. B/C ratio at a 10% discount rate = $\frac{\$4,851}{\$2,923} = 1.66$

3. Determination of IRR:
   IRR = Lowest discount rate + (Difference between discount rates x (NPV at lowest discount rate/Absolute difference between NPVs at lowest and highest rates))
   First iteration: IRR = 10% + (20-10)% x 1928/(1928-(-153)) = 10%+ 10%x1928/2081 = 19.26%.
   Second iteration: IRR = 18% + (20-18)% x 43/(43-(-153)) = 18%+ 2%x43/196 = 18.44%.
   A third iteration, if desired for additional precision, would use 18 and 19%, and would lead to an IRR of 18.41%.
   Further iterations would tend towards a final IRR of 18.36%; a computer program could arrive at this final result without showing intermediate steps.

Duration of research (years 1-6)	- 6 years
Seed multiplication (year 7)	-1 year
Adoption period (years 8-19)	-12 years
Life of innovation after reaching adoption ceiling (year 20)	-1 year
Total	20 years

In reality, of course, the life of an innovation is likely to end less abruptly than suggested in this simplified example.

Step 4. In column 2, write down the cumulative number of hectares (or trees or animals) to which the innovation is expected to spread in each year. In the example, adoption is assumed to follow a sigmoid or S-shaped curve, which is a common patern of adoption. In year eight, the innovation is assumed to reach 1 percent of the estimated ceiling (2,500 out of 250,000 hectares). In year eighteen, it has reached 99 percent (247,500 hectares). Between these two percentage points, the number of adopting hectares was determined with the aid of what is known as probability paper, as shown in Figure 2. Years are on the horizontal axis and percentages on the vertical. The 1 percent and 99 percent adoption points are connected by a straight line, and annual percentage values are read on the vertical axis. These percentages are then converted to hectares through their multiplication by the adoption ceiling. For example, in Figure 2, the drawn line representing the adoption curve intersects the line representing year fifteen at the 82 percent adoption level. The adoption ceiling of 250,000 is then multiplied by this 82 percent to get 205,000 hectares adopting by year fifteen.

Step 5. In Table 3, columns 3A and 3B are combined into one column. In column 3A, give the yearly costs of the research project. In this example, the cost is constant at $300,000 per year for years one through six.

Step 6. In column 3B, give the anticipated costs of adoption per hectare (or per tree or per animal) of the new technology. These are the costs of adopting and using the new technology minus the costs which are, or would have been, associated with continued use of the old technology. These cost figures must be adjusted for the probability of research success. In the example given in Table 3, the figures for years eight through twenty indicate the adoption costs of the new technology ($8/hectare) times the number of hectares, times the probability of research success (0.5). This is because the research is expected to produce adoptable results in only 50 percent of the cases, so that on average only half of the projected adoption costs can be anticipated. In the example of Table 3, the total cost of adoption consists of the costs of growing the new variety (fertilizer, labor and other inputs, as well as the cost of improvements in closely related agricultural services), minus the costs of growing the old variety (or another commodity produced previously on the same land). There are cases where this cost is negative, i.e. where the new technology leads to cost savings.

Step 7. Compute gross benefits of adoption in the same way as costs of adoption. In the example, this means

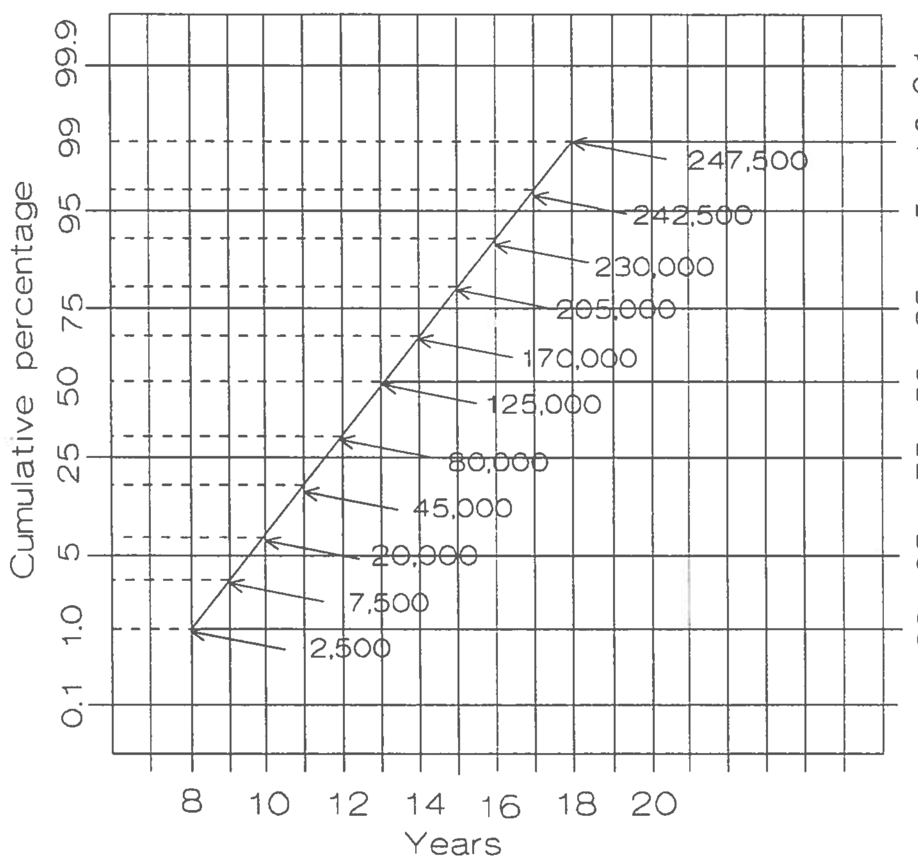

Figure 2. Probability paper plot of adoption.

multiplying the cumulative number of hectares over which the innovation is expected to have spread by each year (column 2), by the $24 gross which the new variety is expected to earn per hectare over and above the old variety (or the other commodity grown previously on the same land). The result is then multiplied by the probability of research success; in this case 0.5. The additional $24 consists of an assumed yield increase of 200 kilograms per hectare, above what might have been expected to take place in the absence of the innovation, times a farm-gate price in constant dollars of $120 per metric tonne (0.200 x $120 = $24). Note that these are additional returns, i.e. over and above those obtained with the old variety, and not total returns. Note also that if there is any reason to suppose that (in the absence of a new variety) the return on the old variety would have increased over time through the application of more fertilizer or some other input, this anticipated added gain must be deducted from the expected increased income from the new variety (and, similarly, the added input cost for the old variety deducted from the costs of adopting the new variety in calculating the data for column 3). Lastly, note that there are cases where the gross benefit is zero: this happens for example when the desired technology has no effect other than cost reduction.

Step 8. In column 5, compute the net benefits by subtracting the costs of adoption of the new technology (column 3) from the benefits of adoption (column 4).

Step 9. From the table given in the Annex 2, record in column 6 discount factors for the chosen discount rate. In this example, a discount rate of 10 percent is used. This represents the interest that will accrue to alternative investments in the economy at large. The national economic planners will be able to supply the appropriate discount rate. A good indicator is the interest on government bonds.

Step 10. In column 7, discount the costs at the chosen percentage (here 10 percent) so as to render them in present-value terms. This is done by multiplying the costs (column 3) by the discount factors (column 6) and summing the results. This column total is needed to calculate the B/C ratio.

Step 11. In column 8, discount the benefits in the same way as was done for costs in column 7: the benefits (column 4) are multiplied by the discount factors (column 6), and the results are summed at the foot of the column. This total is also used in the computation of the B/C ratio.

Step 12. Calculate the benefit/cost ratio by dividing the discounted total benefits in column 8 by the discounted total costs in column 7. In this example: $ 4,851,000 / $ 2,923,000 = 1.66.

Step 13. The internal rate of return (IRR) requires further calculations. In column 9, calculate discounted net benefits. This is done by multiplying columns 5 and 6, or by subtracting column 7 from column 8 which gives the same result. The sum given at the foot of the column represents the net present value (NPV) of the research project at a discount rate of 10 percent. The large positive value in the example indicates that the internal rate of return of this research is substantially greater than 10 %. (If the sum was 0, the IRR of the investment in the project would be exactly 10 percent.)

Step 14. In column 10, give the discount factors for a (higher) discount rate which will result in a negative NPV. In the example, 20 percent was chosen.

Step 15. In column 11, compute the net benefits of the research project at the higher discount rate, by multiplying column 5 by column 10. Verify that the total NPV at the foot of this column is negative. If it is positive, repeat steps 13 and 14 at a somewhat higher discount rate until a negative total is obtained.

Step 16. Produce a first estimate of the internal rate of return. This is done by applying the following formula:

$$\text{IRR} = L + \left[(H - L) \times \frac{\text{NPV at L}}{\text{absolute difference of NPV's at L and H))}} \right]$$

in which

L = lower discount rate

H = higher discount rate

In the example of Table 6, the formula yields:

$$\text{IRR} = 10\% + \left[(20\% - 10\%) \times \frac{1928}{2081} \right]$$

where absolute difference between NPVs is:

2081 = 1928 - (-153).

IRR = 19.26%

Step 17. If either of the NPVs is a large positive (column 9) or negative number (as might have been the case in column 11), repeat the process using one or two other discount rates. In the example, this is done in columns 12 and 13 for a discount rate of 18 percent, with a resulting NPV of 43, instead of 1928 at 10 percent. The more accurate IRR estimate is now:

$$\text{IRR} = 18\% + \left[(20\% - 18\%) \times \frac{43}{(43+153)} \right]$$

IRR = 18.44%

A third iteration, if desired for greater precision (which may be spurious given the uncertainties surrounding the estimates of the eight critical factors), would use 18 and 19 percent, and would lead to an IRR of 18.41% in the example. Further iterations would tend towards a final IRR of 18.36%.

A computer program exists which can arrive at this final result in a few seconds.

Stage 2. Ranking research projects

The foregoing steps have provided three indicators of the research project's benefit to society: net present value (NPV), internal rate of return (IRR), and benefit/cost ratio (B/C ratio).

The NPV shows the project's net gain in absolute present values. It is used here only as an input to determine the IRR. It cannot normally be used for ranking research projects, because projects with a large budget will tend to have a larger NPV than those with a small budget, whereas it is the return on each dollar which really counts. However, in a case of mutual exclusivity (by no means impossible in agricultural research given the scarcity of certain types of specialists), the NPV should be used to compare projects.

The B/C ratio shows the relationship between the present value of costs, both on the research station and the farm, and that of the accruing benefits. But in order to determine the discount rate at which the B/C ratio is calculated, the analyst (or the national planning board) must first hazard a guess at what the opportunity cost of capital is, both within the research budget itself and to the farmers who adopt research results. These discount rates may be thought to differ between the research budget and the credit market faced by farmers. For example, the former may be higher than the latter. If this happens, the B/C ratio may be determined by dividing the gross on-farm benefits of adoption, discounted at the lower rate, by the research costs discounted at the higher rate plus the on-farm costs of adoption discounted at the lower rate. This would give results different from those provided by the method previously described. Priority rankings may differ in consequence. However, the degree of uncertainty in guesstimating these two discount rates will normally be such that it is both safer and easier to use a common opportunity cost of capital (discount rate) which corresponds to, say, the going rate of return on government bonds.

Use of the B/C ratio can cause problems. First, the magnitude of the B/C ratio is influenced by the determination of costs and benefits. If certain costs are deducted from the gross benefits before calculating the ratio, this obviously affects the B/C ratio, and perhaps the rank order of projects. To consistently avoid this difficulty is not as simple as it may seem. Second, when gross benefits of adoption of a new technology are zero (as may happen when the new technology acts through cost reduction), the B/C ratio is zero. Such a value would mean, erroneously, that all research aimed at such technologies would be considered undesirable. Conversely, if discounted costs would happen to be close to zero, the B/C ratio would approach infinity even if the benefits are relatively small. A third difficulty is that one must have a fairly precise idea of the opportunity cost of capital. Finally, the B/C ratio cannot be calculated for a project of which the separate cost and benefit streams are unknown. To systematically avoid all these difficulties is not always easy.

The IRR has the virtue of not requiring guesstimates of the opportunity cost of capital. It simply represents the rate of discount at which the net present value of the costs of the research project, together with all the discounted costs and benefits of adoption of the research results, would be zero. It purports to show what the rate of return on capital invested by government and farmer will be. Ranking in accordance with IRRs thus tacitly assumes that this is indeed what it does. But opinions are still divided on the issue. However, the IRR is now the most commonly used measure to assess the relative economic attractiveness of different projects.

The matter of choice between discount rates and between indicators is not without consequence. The use of different discount rates to estimate B/C ratios will give a different priority ranking, notably when projects differ in their patterns of costs and benefits over time (as they often do). The IRR is likely to give yet another ranking.

In what follows, B/C ratios are used to illustrate the procedure for ranking projects and allocating budgets.

Step 1. Construct a table similar to Table 4. Column 1 lists the proposed research projects.

Table 4. Rank order of research projects on different themes according to their B/C ratios.

(1) Proposed research projects*	(2) B/C ratios	(3) Rank order of B/C ratios	(4) Undiscounted annual research cost (in $,000)
Soil acidity	2.00	1	300
Maize hybrid selection (from Table 6)	1.66	2	300
Cassava pests	1.50	3	100
Coffee quality	1.25	4	200
Sorghum diseases	1.00	5	60
Annual budget limit			1,000**
Dairy husbandry	0.90	6	100
Mechanization	0.85	7	500

* Hypothetical projects, except for maize hybrid selection based on table 6.

** At this point the budget is exhausted; research projects with a lower ranking (i.e. Dairy Husbandry and Mechanization) will not be carried out.

Step 2. In column 2, show the B/C ratio for each research project at the estimated opportunity cost of capital, which is 10 percent in the example.

Step 3. In column 3, rank the research projects in accordance with the size of their B/C ratios. The larger the B/C ratio, the more important it is to support the corresponding research with adequate funding. This is what is meant by priority. But, of course, some higher-priority projects may cost less than do some lower-ranked projects.

Step 4. In column 4, and in any additional columns for succeeding years, record the undiscounted research cost of each research project for each year of the budgetary period. The objective is to allocate the research budget to those projects which will together constitute a program yielding the highest NPV on this budget. Sum the undiscounted annual research costs one at a time from the top, which means starting with the research project which obtained the highest ranking on the basis of its B/C ratio. When the sum nears the total amount of funds available, research projects of lower priority are dropped.

In the example given in Table 4 for a one-year budget of $1,000,000, notice that the soil acidity project (expressed in terms of its effects upon commodities) has the highest B/C ratio (2.00) at a discount rate of 10 percent. This program is expensive, taking 30 percent of the total research budget. Maize hybrid selection is an equally costly program with an annual cost of $300,000, but its B/C ratio is lower at 1.66. Only the first five programs listed in the table can be selected because together they exhaust the research budget. Dairy husbandry, with a relatively low annual research cost, joins the mechanization project, which is relatively expensive, in being excluded. The practical difficulty always is that the marginal program for inclusion in the budget, in this case sorghum disease resistance research, is unlikely in practice to cost exactly the amount which is required to completely exhaust the research budget of $1,000,000. It may be more, or it may be less. In the example, there is $40,000 to spare, which is not enough for the next-ranked project, dairy husbandry. But in this case, the NPV of the research budget as a whole may well be greater if the lower-ranked dairy husbandry project, at $100,000 a year, is substituted for the higher-ranked farming systems research project costing only $60,000 a year but which would leave $40,000 a year to be allocated on an ad hoc basis.

It will generally be preferable to consider budgets in rolling three to five year terms, rather than annually. In this event, Table 4 will be expanded with additional columns beyond column 4 to cover each of the years in question. This will identify an insufficiency or excess of funds in particular years, given the priority ranking which has been determined. Priorities must then be adjusted at the margin, and reserves built up where possible, so as to optimize the situation.

5. The Relationship Between Checklists, Scoring Models and Benefit/Cost Analysis

Thorough benefit/cost analysis can be relatively expensive in terms of skills and time required to carry it out. For this reason, priority-setting methods such as scoring and the use of checklists may be preferred, despite their risk of greater subjectivity and the problems associated with assessing the relative weights of the different critical factors. But this latter difficulty will be reduced if a way can be found of using the results of past benefit/cost analyses to improve these other methods.

Sensitivity tests have been carried out on a variety of past research projects, and the results of these tests used to provide the weights given in the scoring matrix shown in Table 2. This is because such weights really are meant to be measures of the relative sensitivity of a research project's outcome (read: NPV) to changes or errors in ex ante assumptions regarding the value of different critical factors.

Sensitivity is defined here as the ratio between the percentage change in a project's net present value (NPV) and the percentage change in the value of a given critical factor from which that change in NPV results. For example, if a change of 10 percent in anticipated gross benefits accruing from a certain research project is calculated to result in a 23 percent increase in the project's NPV, then the sensitivity of that factor (in that part of the range of possible changes) is said to be 23/10 = 2.3.

The results of the sensitivity tests conducted on the benefit/cost analyses of a sample of agricultural research projects are summarized in Table 5. In the same table, the average sensitivities are converted into weights (points out of 100), and it is these weights which have been used for the column headings in Table 2. These weights show that, on average in this sample, benefits of adoption were the most sensitive item, whereas the cost and the duration of the research, as well as the adoption period (i.e. the time it takes to approach the adoption ceiling), are the least sensitive.

If this kind of analysis is done on a sufficient scale, it should be possible to obtain a more accurate impression of what a scoring model's column weights should be, so that one might use the scoring method with growing predictive accuracy.

The same ex-post benefit/cost analyses could also be used to show how particular lines of research should be scored under each criterion. For example, if new maize varieties resulting from selection have proved in the past, or in a similar situation elsewhere, to be adopted reasonably rapidly by farmers, planners can accord future research of this kind a high to medium score under this criterion.

Such systematic feeding of benefit/cost analysis results through to checklists and scoring models could have a salutary effect on the judgments which these simpler techniques involve.

Table 5. Average sensitivity of the net present value (NPV) of a sample of agricultural research projects to + or - changes of different magnitude in the values of the eight critical factors.

Critical factors	Average sensitivity* of NPV to + or - changes in critical factor mean. Range			Mean	Adjusted mean**
1. Benefits of adoption	2.58	-	3.97	3.11	32.3
2. Duration of research	0.49	-	1.13	0.78	8.1
3. Life of the innovation	0.82	-	1.34	1.08	11.2
4. Adoption period	0.12	-	0.68	0.34	3.5
5. Ceiling on adoption	1.02	-	1.19***	1.12	11.6
6. Costs of adoption	1.48	-	2.81	1.99	20.6
7. Probability of research success	1.02	-	0.68***	1.12	11.6
8. Annual research costs	0.02	-	0.19	0.11	1.1
					100.0

* Sensitivity is defined as the percentage change in NPV divided by the percentage change in the critical factor from which this change in NPV results.

** Adjusted so that the total of all eight factors is 100.0

*** These values are the same because probability of research success is expressed by multiplying the anticipated streams of costs and benefits of adoption by this probability. This has the same effect as multiplying the adoption ceiling by this probability.

6. Conclusions

In this manual five methods of priority setting have been discussed. Priorities are set at different levels. Depending on the level at which decisions are taken, certain methods are more useful than others.

The first two methods introduced, congruence and DRC ratios, are used only at the strategic level, and deal only with priorities among commodities or groups of commodities. With congruence, fund allocations follow directly from each commodity's contribution to the agricultural gross domestic product (AGDP) plus, perhaps, net imports for those commodities which might be produced competitively at home. With this method, priorities are synonymous with fund allocation decisions.

DRC ratios show the degree to which a country currently is, or can become, competitive in the production of a particular commodity. Priorities follow the ranking of the commodities in descending DRC order. Funds are not necessarily allocated proportionally to the magnitudes of the DRCs and some mechanism is still required to translate priorities into resource allocations, down the rank order of DRC values, until the research budget is exhausted.

The remaining three methods, checklists, scoring models, and benefit/cost analysis, can be used for priority setting at both the strategic and project level. At the strategic level, checklist and scoring models deal with broad categories of research, such as that on a commodity as a whole. In this event, the weights and scores, or their qualitative equivalents in a checklist, can only be based on a more or less intuitive aggregation of the expected costs and returns on the individual research projects of which the overall research program would be composed.

Application of checklists, scoring models, and benefit/cost analysis to project level priority setting is best based on assessments of eight critical factors, which in turn subsume a larger number of sub-factors or considerations. These eight factors bear upon the three methods in a logically related manner. For all three methods, assessments with respect to these factors emerge with increasing clarity as one proceeds down the decision-making hierarchy, from the strategic level to that of individual research projects.

At the research project level, it appears that benefit/cost analysis is the most illuminating technique--if it can be implemented. Even in attempting to carry out benefit/cost analysis, the process of thinking in benefit/cost terms can illuminate mental aggregations for checklists, and scoring weights may be empiricaly derived for the eight critical factors.

The methods presented in this paper are not meant as a substitute for wisdom and do not eliminate the need for good judgement. They can account for only part of the factors that go into a decision. They are intended to inform the planner: to improve the way he thinks about the decisions he must make, with or without adequate empirical support. They give the planner systematic procedures for exercising judgement.

In assessing the utility of these various techniques in different situations, the following should be kept in mind:

- Quantitative techniques are only as good as the quality of information fed into them. Statistically supported projections into the future usually will not be available and such projections will have to be based upon plausible hypotheses. When these hypotheses are very speculative, as they may be with respect to the outcome of some types of long-term research on environmental factors for example, quantitative methods become less convincing.

- The application of formal techniques requires different kinds and amounts of expertise and resources, especially managers' time; they themselves are subject to benefit/cost considerations.

- The method chosen should be one which contributes to the creation of a consensus between politicians, planners, and scientists.

- An iterative exchange of information should ensue between strategic and project level priority setting. Any initial allocation to an entire program made at the strategic level should be modified in the light of the anticipated returns to its different constituent research projects at the research institute or station level.

- Priority-setting exercises are more worthwhile for periodic zero-base budgeting than for budgeting at the margin. Zero-base budgeting means "looking afresh" at the entire program and the corresponding budget allocations. Existing projects and associated budgets should be justified anew and their continuation, amendment or cessation recommended, along with proposals for new lines of research.

The problem of ease of application with respect to all of the quantitative methods outlined in this manual stands out. The stark question remains as to what degree of accuracy should be conceded in practice in order to facilitate implementation. In reality, the ideal ranking will never be reached. But if researchers and decision-makers begin to think along benefit/cost lines, even in the application of checklists and scoring models, they will get closer to the optimum than they otherwise would.

Finally, it should be noted that exactly the ***same methods*** may be used for ***evaluating the impact*** which a research project has actually had when the research in question has run its course from the experiment station through widespread on-farm adoption. These ex post results can then be compared with what might reasonably have been expected to happen. This will provide insights which will, in the long run, be embodied in the application of the priority-setting techniques advocated here.

Annex 1: Illustrations of Strategic Level Priority Setting

While this manual primarily focuses on priority setting at the research project level, research planners even within research institutes often need to start the priority-setting process with general allocation decisions among commodities or groups of commodities. In recognition of this, this annex briefly illustrates relatively simple applications of the congruence and DRC ratio methods, both of which focus at the strategic, or commodity, level.

Application of the Congruence Method

Step 1. Construct a table similar to Table 6. In the first column list all commodities that contribute to the country's agricultural gross domestic product (AGDP) in order of the magnitude of their contribution to AGDP (plus net imports for those commodities which might be produced competitively at home).

Step 2. In column 2, write down the actual contribution to AGDP (plus net imports) of each commodity in monetary units. Total this column, which represents the AGDP.

Step 3. In column 3, the monetary contribution of each commodity to AGDP (plus net imports) in column 2 is expressed in percentage terms, the total of column 2 being 100%.

Step 4. Calculate the total current year's budgets for commodity research, including estimated personnel charges, commodity by commodity. List these in column 4.

Step 5. Express the amounts of column 4 as percentages of their total, and list these in column 5. A comparison between the percentages in column 3 and those in column 5 shows how far existing allocations, expressed in money terms, depart from the dictates of the congruence method.

Step 6. In column 6 (next year's research fund allocations based on congruence), compute the research expenditures on each commodity as they must be under the congruence rule. Do this by multiplying the AGDP (plus

Table 6. Priority setting by congruence.

(1) Commodities	(2) Contribution to AGDP ($'000,000)	(3) % Contribution to AGDP (%)	(4) Current year's research budget for commodities ($'000,000)	(5) Current year' research budget for commodities (%)	(6) Next year's research fund allocations based on congruence ($'000,000)	(7) Next year's rank order
1. Rice	1,144	30	14.0	40	12.6	1
2. Coffee	954	25	3.5	10	10.5	2
3. Maize	763	20	10.5	30	8.4	3
4. Timber	572	15	0	0	6.3	4
5. Dairy	381	10	7.0	20	4.2	5
Totals	3,814	100%	35.0	100	42.0*	

* Total next year's research budget =	$50,000,000
Allocations for non-commodity research and general services =	$8,000,000
Total budget available for commodity research =	$42,000,000

net imports) of column 3 by the total of next year's expected budget for commodity research (including estimated personnel charges).

Step 7. In column 7, rank the budget allocations of column 6.

Table 6 provides an example of a completed congruence exercise, for a hypothetical country that has only five commodities.

Taking maize as an example: its contribution to AGDP (plus net imports if these are relevant) is 763,000,000 dollars, out of a total AGDP of 3,814,000,000 dollars (column 2). This equals 20 percent of the AGDP plus net imports (column 3). But the current allocation of research resources to maize is 10,500,000 dollars out of a current commodity research total of 35,000,000 dollars (column 4). This represents a 30 percent budgetary allocation (column 5), against a 20 percent contribution of maize to AGDP (column 3). The discrepancy needs to be justified.

When the congruence method is used to allocate a future research budget of 42,000,000 dollars, the amount devoted to maize will be only 8,400,000 dollars (column 6).

It will be clear from the foregoing that the use of the congruence method can only be a preliminary in the priority-setting process. It will serve at the strategic level for a provisional, rough allocation of resources.

Application of the DRC Ratio Method

Step 1. Construct a table similar to Table 7. In column 1, list the commodities to be ranked. Across the top of the table, include four additional column heads: current DRC ratio, current rank order, post-research-and-adoption DRC ratio, and post-research rank order.

Step 2. For each of the commodities listed, obtain from the national planning authorities, the World Bank or other organizations, a current DRC ratio, and enter these data in column 2. To the extent that these figures do not exist, compute them, using the formula given in the text.

The manner in which the necessary data should be assembled is set out in Table 8.

It is recommended that the planner adjust the figures used in the computation to reflect the opportunity cost of labor (the so-called efficiency wage) and free market exchange rates.

For example, using the figures for maize production in Table 8, the current unadjusted DRC ratio would be:

$$\frac{\$100}{\$150 - \$20} = 0.77$$

To adjust this ratio for the efficiency wage, the figure in parentheses in the top line of column 2 in Table 8 must be used. This figure represents the opportunity cost of labor in alternative employment (ignoring any wage changes which the research itself might produce), at two-thirds the wage which is actually paid per worker. In this event, the DRC ratio will be:

$$\frac{\$80}{\$150 - \$20} = 0.62$$

If on the other hand we assume that if is local currency which is overvalued, so that, in this example, foreign exchange is actually worth twice the official rate, we must adjust for the "free market" exchange rate. Then the cost of imported inputs, as well as of competing foreign maize, doubles as shown in brackets in Table 3 for the total of column 3 and in the bottom right hand corner. The DRC ratio (with no opportunity cost adjustment for labor) now becomes:

$$\frac{\$100}{\$300 - \$40} = 0.38$$

If both the efficiency wage and the free market exchange rate (efficiency rate) are used, the DRC ratio will be:

$$\frac{\$80}{\$300 - \$40} = 0.31$$

This is the most appropriate ratio to use.

Step 3. Returning to Table 7, rank in column 3 the commodity research programs on the basis of the current DRC ratios given in column 2. Although post-research-and-adoption DRC ratios are preferable (see Step 4), existing, pre-research DRC ratios can be used as a guide as to where to build on existing success in a research program. Where the DRC ratio is high, research would have to be particularly promising for it to be worth undertaking.

Step 4. If one seeks the more informative solution which anticipated post-research-and-adoption DRC ratios can provide, one does not stop at step 3 but estimates these future DRC ratios, and then completes column 4. It must be recognized that these future DRC ratios can be difficult to estimate.

For each of the commodities listed, compute a post-research-and-adoption DRC ratio.

$$\text{Post research and adoption DRC ratio} = \frac{A'}{B' - C'}$$

Where:

A' = Estimated domestic resource cost per unit of the commodity produced locally after research and adoption of the resulting new technology.

B' = Anticipated future import costs (c.i.f.) of a unit of the commodity of equivalent quality produced abroad.

C' = Estimated future costs of imported inputs to produce a unit domestically.

Table 7. Example of priority setting using DRC ratios.

(1) Commodities	(2) Current DRC ratio	(3) Current rank order	(4) Post-research-and-adoption DRC ratio	(5) Post-research rank order
1. Maize	0.31	1	0.25	1
2. Coffee	0.40	2	0.35	2
3. Rice	1.30	4	0.90	3
4. Timber	1.10	3	0.95	4
5. Dairy	1.50	5	1.00	5

Table 8. Current domestic resource costs of producing a tonne of hybrid maize. In local currency units (LC). LC efficiency prices are given in parentheses.*

(1) Cost item	(2) Domestic cost elements for domestic production	(3) Foreign cost elements for domestic production	(4) Total costs of domestic production
Labor	(40) 60	0	60
Fertilizer	2	4	6
Other materials	1	2	3
Energy for irrigation	4	4	8
Maintenance	2	2	4
Administration	3	0	3
Interest	6	6	12
Amortization	2	2	4
Annualized value of the land	20	0	20
Total	(80) 100	(40) 20	(120) 120
Foreign equivalent (c.i.f. port of entry or f.o.b. port of export in a competing country)			(300) 150

* Current DRC ratio using financial prices equals 100/(120-20) = 1.00 in this example; but using opportunity costs (efficiency prices) it equals 80/(300-40)=0.31.

After computation these ratios are entered in column 4 of Table 7. As in the case of current DRC ratios, this computation should reflect efficiency wages and free market exchange rates. For example, the planner may feel that the domestic cost of maize production after research and adoption will fall from 100 dollars to 85 dollars. In that case, and adjusting for efficiency wages and free market exchange rates as in the example above, the post-research-and-adoption DRC ratio would be:

$$\frac{\$65}{\$300 - \$40} = 0.25.$$

<u>Step 5.</u> Rank in column 5 the commodity research programs based on the post-research-and-adoption DRC ratios.

The use of current and post-research DRC ratios in combination involves some subjectivity. For example, a high current DRC ratio indicates that no comparative advantage now exists for producing the commodity in question domestically, and that research will be unwarranted. However, if the post-research-and-adoption DRC ratio is expected to fall below 1, then funding research on this commodity may be beneficial, even if the current DRC ratio is above 1.

The lower the DRC ratio, the higher the priority of the research which brings this about.

Annex 2: Present value of a currency unit receivable or payable at the end of each year.

Year	Annual Discount Rate														
	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%
1	0.990	0.980	0.971	0.962	0.952	0.943	0.935	0.926	0.917	0.909	0.901	0.893	0.885	0.877	0.870
2	0.980	0.961	0.943	0.925	0.907	0.890	0.873	0.857	0.842	0.826	0.812	0.797	0.783	0.769	0.756
3	0.971	0.942	0.915	0.889	0.864	0.840	0.816	0.794	0.772	0.751	0.731	0.712	0.693	0.675	0.658
4	0.961	0.924	0.888	0.855	0.823	0.792	0.763	0.735	0.708	0.683	0.659	0.636	0.613	0.592	0.572
5	0.951	0.906	0.863	0.822	0.784	0.747	0.713	0.681	0.650	0.621	0.593	0.567	0.543	0.519	0.497
6	0.942	0.888	0.837	0.790	0.746	0.705	0.666	0.630	0.596	0.564	0.535	0.507	0.480	0.456	0.432
7	0.933	0.871	0.813	0.760	0.711	0.665	0.623	0.583	0.547	0.513	0.482	0.452	0.425	0.400	0.376
8	0.923	0.853	0.789	0.731	0.677	0.627	0.582	0.540	0.502	0.467	0.434	0.404	0.376	0.351	0.327
9	0.914	0.837	0.766	0.703	0.645	0.592	0.544	0.500	0.460	0.424	0.391	0.361	0.333	0.308	0.284
10	0.905	0.820	0.744	0.676	0.614	0.558	0.508	0.463	0.422	0.386	0.352	0.322	0.295	0.270	0.247
11	0.896	0.804	0.722	0.650	0.585	0.527	0.475	0.429	0.388	0.350	0.317	0.287	0.261	0.237	0.215
12	0.887	0.788	0.701	0.625	0.557	0.497	0.444	0.397	0.356	0.319	0.286	0.257	0.231	0.208	0.187
13	0.879	0.773	0.681	0.601	0.530	0.469	0.415	0.368	0.326	0.290	0.258	0.229	0.204	0.182	0.163
14	0.870	0.758	0.661	0.577	0.505	0.442	0.388	0.340	0.299	0.263	0.232	0.205	0.181	0.161	0.141
15	0.861	0.743	0.642	0.555	0.481	0.417	0.362	0.315	0.275	0.239	0.209	0.183	0.160	0.140	0.123
16	0.853	0.728	0.623	0.534	0.458	0.394	0.339	0.292	0.252	0.218	0.188	0.163	0.141	0.123	0.107
17	0.844	0.714	0.605	0.513	0.436	0.371	0.317	0.270	0.231	0.198	0.170	0.146	0.125	0.108	0.093
18	0.836	0.700	0.587	0.494	0.416	0.350	0.296	0.250	0.212	0.180	0.153	0.130	0.111	0.095	0.081
19	0.828	0.686	0.570	0.475	0.396	0.331	0.277	0.232	0.194	0.164	0.138	0.116	0.098	0.083	0.070
20	0.820	0.673	0.554	0.456	0.377	0.312	0.258	0.215	0.178	0.149	0.124	0.104	0.087	0.073	0.061
21	0.811	0.660	0.538	0.439	0.359	0.294	0.242	0.199	0.164	0.135	0.112	0.093	0.077	0.064	0.053
22	0.803	0.647	0.522	0.422	0.342	0.278	0.226	0.184	0.150	0.123	0.101	0.083	0.068	0.056	0.046
23	0.795	0.634	0.507	0.406	0.326	0.262	0.211	0.170	0.138	0.112	0.091	0.074	0.060	0.049	0.040
24	0.788	0.622	0.492	0.390	0.310	0.247	0.197	0.158	0.126	0.102	0.082	0.066	0.053	0.043	0.035
25	0.780	0.610	0.478	0.375	0.295	0.233	0.184	0.146	0.116	0.092	0.074	0.059	0.047	0.038	0.030
30	0.742	0.552	0.412	0.308	0.231	0.174	0.131	0.099	0.075	0.057	0.044	0.033	0.026	0.020	0.015
35	0.706	0.500	0.355	0.253	0.181	0.130	0.094	0.068	0.049	0.036	0.026	0.019	0.014	0.010	0.008
40	0.672	0.453	0.307	0.208	0.142	0.097	0.067	0.046	0.032	0.022	0.015	0.011	0.008	0.005	0.004

Annex 2 (cont): Present value of a currency unit receivable or payable at the end of each year.

Annual Discount Rate

Year	16%	17%	18%	19%	20%	21%	22%	23%	24%	25%	26%	27%	28%	29%	30%
1	0.862	0.855	0.847	0.840	0.833	0.826	0.820	0.813	0.806	0.800	0.794	0.787	0.781	0.775	0.769
2	0.743	0.731	0.718	0.706	0.694	0.683	0.672	0.661	0.650	0.640	0.630	0.620	0.610	0.601	0.592
3	0.641	0.624	0.609	0.593	0.579	0.564	0.551	0.537	0.524	0.512	0.500	0.488	0.477	0.466	0.455
4	0.552	0.534	0.516	0.499	0.482	0.467	0.451	0.437	0.423	0.410	0.397	0.384	0.373	0.361	0.350
5	0.476	0.456	0.437	0.419	0.402	0.386	0.370	0.355	0.341	0.328	0.315	0.303	0.291	0.280	0.269
6	0.410	0.390	0.370	0.352	0.335	0.319	0.303	0.289	0.275	0.262	0.250	0.238	0.227	0.217	0.207
7	0.354	0.333	0.314	0.296	0.279	0.263	0.249	0.235	0.222	0.210	0.198	0.188	0.178	0.168	0.159
8	0.305	0.285	0.266	0.249	0.233	0.218	0.204	0.191	0.179	0.168	0.157	0.148	0.139	0.130	0.123
9	0.263	0.243	0.225	0.209	0.194	0.180	0.167	0.155	0.144	0.134	0.125	0.116	0.108	0.101	0.094
10	0.227	0.208	0.191	0.176	0.162	0.149	0.137	0.126	0.116	0.107	0.099	0.092	0.085	0.078	0.073
11	0.195	0.178	0.162	0.148	0.135	0.123	0.112	0.103	0.094	0.086	0.079	0.072	0.066	0.061	0.056
12	0.168	0.152	0.137	0.124	0.112	0.102	0.092	0.083	0.076	0.069	0.062	0.057	0.052	0.047	0.043
13	0.145	0.130	0.116	0.104	0.093	0.084	0.075	0.068	0.061	0.055	0.050	0.045	0.040	0.037	0.033
14	0.125	0.111	0.099	0.088	0.078	0.069	0.062	0.055	0.049	0.044	0.039	0.035	0.032	0.028	0.025
15	0.108	0.095	0.084	0.074	0.065	0.057	0.051	0.045	0.040	0.035	0.031	0.028	0.025	0.022	0.020
16	0.093	0.081	0.071	0.062	0.054	0.047	0.042	0.036	0.032	0.028	0.025	0.022	0.019	0.017	0.015
17	0.080	0.069	0.060	0.052	0.045	0.039	0.034	0.030	0.026	0.023	0.020	0.017	0.015	0.013	0.012
18	0.069	0.059	0.051	0.044	0.038	0.032	0.028	0.024	0.021	0.018	0.016	0.014	0.012	0.010	0.009
19	0.060	0.051	0.043	0.037	0.031	0.027	0.023	0.020	0.017	0.014	0.012	0.011	0.009	0.008	0.007
20	0.051	0.043	0.037	0.031	0.026	0.022	0.019	0.016	0.014	0.012	0.010	0.008	0.007	0.006	0.005
21	0.044	0.037	0.031	0.026	0.022	0.018	0.015	0.013	0.011	0.009	0.008	0.007	0.006	0.005	0.004
22	0.038	0.032	0.026	0.022	0.018	0.015	0.013	0.011	0.009	0.007	0.006	0.005	0.004	0.004	0.003
23	0.033	0.027	0.022	0.018	0.015	0.012	0.010	0.009	0.007	0.006	0.005	0.004	0.003	0.003	0.002
24	0.028	0.023	0.019	0.015	0.013	0.010	0.008	0.007	0.006	0.005	0.004	0.003	0.003	0.002	0.002
25	0.024	0.020	0.016	0.013	0.010	0.009	0.007	0.006	0.005	0.004	0.003	0.003	0.002	0.002	0.001
30	0.012	0.009	0.007	0.005	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	-	-
35	0.006	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	-	-	-	-	-	-
40	0.003	0.002	0.001	0.001	0.001	-	-	-	-	-	-	-	-	-	-

Annex 2 (cont): Present value of a currency unit receivable or payable at the end of each year.

Year	Annual Discount Rate														
	31%	32%	33%	34%	35%	36%	37%	38%	39%	40%	41%	42%	43%	44%	45%
1	0.763	0.758	0.752	0.746	0.741	0.735	0.730	0.725	0.719	0.714	0.709	0.704	0.699	0.694	0.690
2	0.583	0.574	0.565	0.557	0.549	0.541	0.533	0.525	0.518	0.510	0.503	0.496	0.489	0.482	0.476
3	0.445	0.435	0.425	0.416	0.406	0.398	0.389	0.381	0.372	0.364	0.357	0.349	0.342	0.335	0.328
4	0.340	0.329	0.320	0.310	0.301	0.292	0.284	0.276	0.268	0.260	0.253	0.246	0.239	0.233	0.226
5	0.259	0.250	0.240	0.231	0.223	0.215	0.207	0.200	0.193	0.186	0.179	0.173	0.167	0.162	0.156
6	0.198	0.189	0.181	0.173	0.165	0.158	0.151	0.145	0.139	0.133	0.127	0.122	0.117	0.112	0.108
7	0.151	0.143	0.136	0.129	0.122	0.116	0.110	0.105	0.100	0.095	0.090	0.086	0.082	0.078	0.074
8	0.115	0.108	0.102	0.096	0.091	0.085	0.081	0.076	0.072	0.068	0.064	0.060	0.057	0.054	0.051
9	0.088	0.082	0.077	0.072	0.067	0.063	0.059	0.055	0.052	0.048	0.045	0.043	0.040	0.038	0.035
10	0.067	0.062	0.058	0.054	0.050	0.046	0.043	0.040	0.037	0.035	0.032	0.030	0.028	0.026	0.024
11	0.051	0.047	0.043	0.040	0.037	0.034	0.031	0.029	0.027	0.025	0.023	0.021	0.020	0.018	0.017
12	0.039	0.036	0.033	0.030	0.027	0.025	0.023	0.021	0.019	0.018	0.016	0.015	0.014	0.013	0.012
13	0.030	0.027	0.025	0.022	0.020	0.018	0.017	0.015	0.014	0.013	0.011	0.010	0.010	0.009	0.008
14	0.023	0.021	0.018	0.017	0.015	0.014	0.012	0.011	0.010	0.009	0.008	0.007	0.007	0.006	0.006
15	0.017	0.016	0.014	0.012	0.011	0.010	0.009	0.008	0.007	0.006	0.006	0.005	0.005	0.004	0.004
16	0.013	0.012	0.010	0.009	0.008	0.007	0.006	0.006	0.005	0.005	0.004	0.004	0.003	0.003	0.003
17	0.010	0.009	0.008	0.007	0.006	0.005	0.005	0.004	0.004	0.003	0.003	0.003	0.002	0.002	0.002
18	0.008	0.007	0.006	0.005	0.005	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.001	0.001
19	0.006	0.005	0.004	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001
20	0.005	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001
21	0.003	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	-	-
22	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	-	-	-	-
23	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	-	-	-	-	-	-
24	0.002	0.001	0.001	0.001	0.001	0.001	0.001	-	-	-	-	-	-	-	-
25	0.001	0.001	0.001	0.001	0.001	-	-	-	-	-	-	-	-	-	-
26	0.001	0.001	0.001	-	-	-	-	-	-	-	-	-	-	-	-
27	0.001	0.001	-	-	-	-	-	-	-	-	-	-	-	-	-
28	0.001	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Annex 2 (cont): Present value of a currency unit receivable or payable at the end of each year.

Annual Discount Rate

Year	46%	47%	48%	49%	50%	51%	52%	53%	54%	55%	56%	57%	58%	59%	60%
1	0.685	0.680	0.676	0.671	0.667	0.662	0.658	0.654	0.649	0.645	0.641	0.637	0.633	0.629	0.625
2	0.469	0.463	0.457	0.450	0.444	0.439	0.433	0.427	0.422	0.416	0.411	0.406	0.401	0.396	0.391
3	0.321	0.315	0.308	0.302	0.296	0.290	0.285	0.279	0.274	0.269	0.263	0.258	0.254	0.249	0.244
4	0.220	0.214	0.208	0.203	0.198	0.192	0.187	0.182	0.178	0.173	0.169	0.165	0.160	0.156	0.153
5	0.151	0.146	0.141	0.136	0.132	0.127	0.123	0.119	0.115	0.112	0.108	0.105	0.102	0.098	0.095
6	0.103	0.099	0.095	0.091	0.088	0.084	0.081	0.078	0.075	0.072	0.069	0.067	0.064	0.062	0.060
7	0.071	0.067	0.064	0.061	0.059	0.056	0.053	0.051	0.049	0.047	0.044	0.043	0.041	0.039	0.037
8	0.048	0.046	0.043	0.041	0.039	0.037	0.035	0.033	0.032	0.030	0.029	0.027	0.026	0.024	0.023
9	0.033	0.031	0.029	0.028	0.026	0.025	0.023	0.022	0.021	0.019	0.018	0.017	0.016	0.015	0.015
10	0.023	0.021	0.020	0.019	0.017	0.016	0.015	0.014	0.013	0.012	0.012	0.011	0.010	0.010	0.009
11	0.016	0.014	0.013	0.012	0.012	0.011	0.010	0.009	0.009	0.008	0.008	0.007	0.007	0.006	0.006
12	0.011	0.010	0.009	0.008	0.008	0.007	0.007	0.006	0.006	0.005	0.005	0.004	0.004	0.004	0.004
13	0.007	0.007	0.006	0.006	0.005	0.005	0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.002	0.002
14	0.005	0.005	0.004	0.004	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.001
15	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001
16	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
17	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	-	-	-	-
18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	-	-	-	-	-	-	-	-
19	0.001	0.001	0.001	0.001	-	-	-	-	-	-	-	-	-	-	-
20	0.001	-	-	-	-	-	-	-	-	-	-	-	-	-	-