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CHOOSING THE DISCOUNT RATE FOR ANALYSING AGROFORESTRY SYSTEMS/TECHNOLOGIES FROM A PRIVATE ECONOMIC VIEWPOINT

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ABSTRACT

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In this paper it is argued that the discount rate selected for the analysis of agroforestry systems needs careful consideration, especially when dealing with subsistence-oriented farmers. Adopting the borrowing or savings rate, or investment rate, common in most analyses from the private economic viewpoint, will not do since there are reasons to believe that in many cases the consumption rate of interest will, in fact, be lower. Furthermore, it is argued that farmers who are relatively well fed but face sustainability problems on their farms will have a lower discount rate than farmers who are less well fed but expect an upward trend in their production with their present activities. Applying the same discount rate for all farmers should therefore be avoided if there are clear indications that there are differences in relative wealth and future prospects.

INTRODUCTION

Agroforestry systems/technologies are long-term in nature because of the tree component present in each system. To compare future net benefits with present-day net benefits, analysts usually assign a lower weight to such future values. This procedure of revaluing future costs and benefits is normally referred to as *discounting*, while the rate at which future costs and benefits are revalued is referred to as the *discount rate*.

By comparing the discounted net present values of different systems, the analyst is able to forecast the likelihood of proposed systems being adopted. Since the selected discount rate obviously influences the outcome of this process, it seems appropriate to determine which rate is appropriate for a given situation. Particular attention is paid in this paper to the selection of discount rates under small farmers' conditions where most products are grown for home consumption. Attention is also paid to the fact that within a project area different discount rates may have to be used for the analysis of the same technology, depending on the recipient group of farmers.

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THREE POSSIBLE RATES

In most analyses, conducted from a private economic point of view, which is usually referred to as a financial analysis, analysts assume that additional inputs required to bring about a change in the farming system can be financed with commercial credit. Such an assumption greatly facilitates the determination of the minimum acceptable rate at which future costs and benefits can be discounted since it only requires the analyst to determine the rate at which farmers can borrow money. A simple method of determining such a rate is described in Perrin et al. (1976).

However, in many small farm situations, the farmer will not wish to, or be able to, borrow funds, but will either have to use his own equity capital or forego a proportion of present production so as to be able to reap benefits later.

Gittinger (1982) suggests, that whenever equity capital is used, the analyst should determine the rate of return a farmer normally expects from equity capital. Such a rate may, for example, be obtained by determining the return on some existing long-term farm enterprises such as livestock, orchards or timber trees, as well as by determining what interests accrue on savings.

However, on most small farms, little equity capital is used. Many crop activities are annual and attract mainly operational inputs such as family labour. For such activities, it is therefore difficult to determine a realistic return to the equity capital. Still, for small farmers, sacrificing part of their present annual production will often be the only way to improve or ensure future production. (This paper ignores improvements made by working harder, also called *sweat equity*.)

To find a rate for this form of capital, the analyst should first try to determine whether the production foregone would have been used for future productive or present consumptive purposes. If the purpose, by means of selling, was future production, to be used for investment or savings, the discount rate may again be derived from the normally expected returns on equity capital. If, on the other hand, the production foregone was, in fact, meant for present consumptive purposes either directly or indirectly, the question really is: at what rate is a farmer prepared to surrender part of his present consumption so he or she can have it at some future date? Such a rate is called the *consumption rate* of interest.

While the borrowing rate, as a minimum rate, and the rate on equity capital may be good indicators for analysing agroforestry systems in a commercial or semi-commercial farming system, the consumption rate of interest will be more appropriate for the analysis on subsistence-oriented farms. For the sake of simplicity, other factors influencing farmers' time preference rate are ignored here but will be discussed later.

While the first two rates are frequently discussed in textbooks dealing with economic analysis, the consumption rate of interest is not. Although agroforestry is certainly not the exclusive domain of subsistence farmers, many systems are appropriate for subsistence farmers because of their low

cash input nature. The application and determination of the consumption rate of interest will, therefore, be elaborated upon in the following paragraphs.

CONSUMPTION RATE OF INTEREST FOR SOCIETY AS A WHOLE

In a developing world with many economic activities taking place, future production is expected to increase, resulting in a higher per capita consumption. It is further argued that the higher the per capita consumption level, the lower the satisfaction obtained from an additional unit of consumption (Hufschmidt et al., 1983). Therefore, since the future consumption level is assumed to be higher than the present one, the value (utility) attached to a unit increase in consumption now is higher than the value attached to the same increase in the future.

The value attached to annual costs and benefits is commonly referred to as the *discount factor.* The lower the discount factor, the lower the present value of future costs and benefits. The annual discount factor, at a given discount rate, declines over time. A visual representation of this theory is given in Fig. 1.

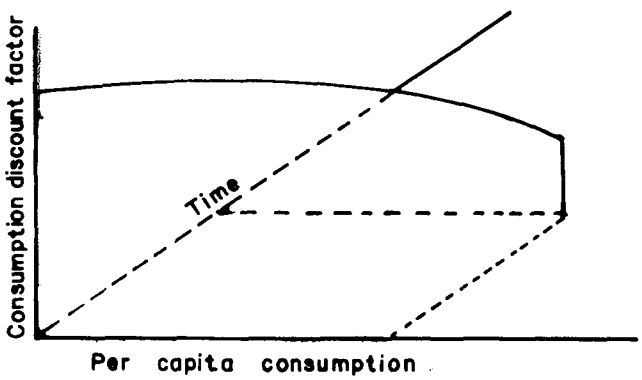

Fig. 1. Consumption discount factor over time, at a positive discount rate.

Although it is possible to give a good theoretical explanation for the consumption rate of interest, most authors (Little and Mirless, 1974; F.A.O., 1979) admit that, in practice, a rate is difficult to determine, not least because the parameters required are morally determined and therefore subject to contention. Most project analysts therefore ask the government to determine the rate for them, or simply take the rate on savings and investments by society as a whole. Alternatively the analyst computes the break-even discount rate which equals the internal rate of return and leaves it to others to decide whether or not the actual rate is higher or lower.

CONSUMPTION RATE OF INTEREST OF AGROFORESTRY PROJECT FARMERS

The consumption rate of interest is a composite rate made up of the rates of all individuals who make up a society. Let us therefore examine whether or not such a composite rate is appropriate for farmers who are considering the introduction of an agroforestry system/technology and whether or not this rate can be approximately equal to the rate on savings and on investments by society as a whole.

While it may be difficult to generalise, there is a particular feature about agroforestry systems/technologies which sets them apart from many other interventions, namely that they often aim at improving presently unsustainable systems. I hasten to add that there are, of course, plenty of agroforestry systems introduced or practiced on farms which do not have sustainability problems. However, let us look at those farms where sustainability is a problem. Is the assumption made about a perceived increase in per capita consumption in the future a realistic one? Unless technologies already exist which tackle the sustainability problems, the answer may be no, because production from such farms is expected to decline over time. It may be no, because the farmer expects income from non-farm activities to increase over time. It may be no also because, although the scientists may see a gloomy picture, the farmer is unaware of the bleak future and acts as if everything will be fine.

Although per capita consumption has improved for many members of the rural population over the past decades, this has definitely not been the case for everyone and it is even more doubtful whether it will continue to increase in the future in view of the sustainability problems mentioned above. There is, therefore, an argument for not discounting future costs and benefits for those farmers for whom no increase in per capita consumption is expected in the foreseeable future because of sustainability problems. In fact, even a *negative discount rate* may be considered. This reasoning, it must be pointed out, is based solely on the consumption rate of interest, ignoring for a moment time preferences associated with risk and uncertainty. Such a lower or negative rate would render longterm production systems relatively more attractive to such farmers than they presently are, when the average investment or savings discount rate is applied.

THE RISK DISCOUNT RATE OF FARMERS.

Perrin et al. (1976) rightly point out a factor which will affect the farmers' valuation of future benefits of a new system, i.e. risk and/or uncertainty. Roumassat (1981) defines uncertainty as a state of mind in which the individual perceives alternative outcomes to a particular action. However, he or she cannot assign a probability to a reduction in future net benefits. Risk, on the other hand, has to do with the degree of uncertainty in a given situation. In this case a probability can be given to a reduction of future net benefits. Risk and uncertainty about the outcome of an activity will both, in fact, lower the value of the benefits. If a farmer is absolutely sure about the out-

come he will, for example, assign a value of 100 to the benefits. However, if he is less certain about the outcome, he assigns a value less than 100. The higher the risks and uncertainties the lower the value attached.

Uncertainty about the outcome of an activity will, in general, lead to a lower valuation of benefits than risk because the outcome is more unknown. Also, farmers who are better off, and have a relatively high level of per capita consumption, are inclined to accept risk and uncertainty more easily than farmers who have a low per capita consumption level. Therefore, the same amount of risk will lead to a lower valuation of benefits by the less well off farmers than by the better off farmers.

Furthermore, it is generally accepted that the degree of uncertainty increases in time, especially when future prices are uncertain. It therefore follows that valuation of future benefits will be lower than present day benefits. The relationship between the level of the risk/uncertainty discount factor over time and the level of consumption is shown in Fig. 2. The risk/uncertainty discount factor is the multiplication factor at which net benefits are multiplied; it varies between 0 and 1. The higher the risk/uncertainty rate, the lower the discount factor.

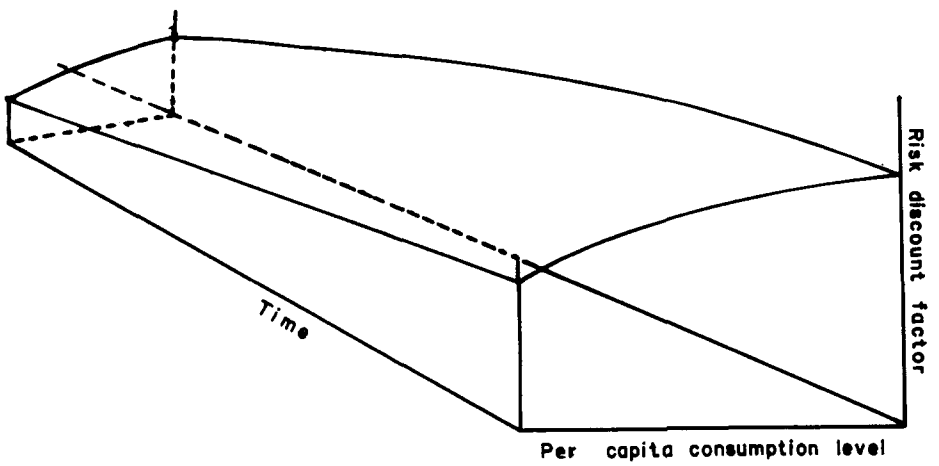

Fig. 2. Risk discount factor over time and in relation to per capita consumption, at a positive discount rate.

THE PERSONAL DISCOUNT RATE FOR DIFFERENT CATEGORIES OF FARMERS

If the risk discount rate is added to the consumption discount rate of the farmers*, the level of the resulting *personal discount rate* will depend on whether the farmer's production and income is expected to go upwards or

*Some authors argue against adding risk/uncertainty to the discount rate; they prefer to lower the actual benefits (Harou, 1983a). Whether or not the discount rate or the actual cost benefit flow is used to incorporate risk/uncertainty in the analysis, seems of little relevance to this discussion since both methods lead to the same grouping of farmers.

downwards and whether the farmer is able to feed the family adequately or not. Taking only the extreme values for each variable to classify farmers, the following combinations are possible:

Group 1. Poorly fed farmers, downward trend in production and income: these farmers will have a high-risk discount rate, while their consumption rate will be low.

Group 2. Poorly fed farmers, upward trend in production and income: these farmers have a high risk and high consumption discount rate.

Group 3. Well fed farmers, downward trend in production and income: these farmers will have a low risk and a low consumption discount rate.

Group 4. Well fed farmers, upward trend in production and income: these farmers will have a low risk discount rate and a high consumption discount rate.

Farmers who fall in Group 3 will therefore have the lowest personal rate, while farmers in Group 2 will have the highest rate. For these two extreme groups of farmers, it is worthwhile to examine whether or not their returns on equity capital and savings are different from those obtained, on average, by others. If these are different, the analyst is justified in assuming a lower personal discount rate than the average savings and investment for Group 3 farmers and a higher one for Group 2 farmers.

While farmers in Group 3 seem to be easily inclined to adopt a new agroforestry system/technology, Group 2 farmers are not. However, as mentioned earlier, uncertainty leads to a lower valuation of benefits than risk. Therefore by changing uncertainty to risk, the risk discount rate can be lowered. Several authors (Arnold, 1982; Harou, 1983b) claim that agroforestry systems are less risky, being less subject to variation in physical quantities, than annual cropping systems. It is, therefore, quite possible for farmers in Group 2 to lower their personal discount rate after they have observed the actual system and/or have been exposed to convincing information, whether true or false, on the system.

DISCOUNT RATE WHEN DIFFERENT SOURCES OF CAPITAL ARE BEING USED

Finally, what discount rate should apply if part of the capital required has to be borrowed, part has to be financed by equity capital and part has to be obtained by re-allocating the farmer's labour resources.

A weighted discount rate is suggested by Gittinger (1982), i.e. (borrowed capital × borrowing rate ÷ total capital) + (equity capital × return needed to attract equity capital ÷ total equity) + (value consumption foregone × personal rate of discount ÷ total capital). If the rate at which equity capital can be attracted is assumed to be similar to the personal rate of discount there is no need to differentiate between equity capital and consumption foregone.

Another possible solution is to determine the net benefits of a new tech-

nology after financing, thus eliminating the need to include the borrowed capital component in the determination of the weighted discount factor.

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REFERENCES

Arnold, J.E.M., 1982. Economic constraints and incentives in agroforestry. In: Proceedings of U.N.U. workshop on agroforestry, Freiburg, West Germany (not yet published).

F.A.O., 1979. Economic Analysis of Forestry Projects. F.A.O., Rome, Forestry Paper No. 17, 193 pp.

Gittinger, J.P., 1982. Economic Analysis of Agricultural Projects. The Johns Hopkins University Press, Baltimore, MD, 505 pp.

Harou, P.A., 1983a. Quantification of the Uncertainty and Risk of Forestry Projects. Yale School of Forestry and Environmental Studies Economic Growth Center, Yale University (unpublished), 12 pp.

Harou, P.A., 1983b. Economic principles to appraise agroforestry projects. Int. J. Agric. Admin., 12: 127—139.

Hufschmidt, M.M., Jones, D.E., Meister, A.D., Bower, B.T. and Dixon, J.A., 1983. Environment, Natural Systems and Development. An Economic Valuation Guide. Johns Hopkins University Press, Baltimore, MD, 338 pp.

Little, I.M.D. and Mirless, J.A., 1974. Project Appraisal and Planning for Developing Countries. Basic Books, Inc., Publishers, New York, NY, 388 pp.

Perrin, R.K., Winkelman, D.L., Moscardi, E.R. and Anderson, J.R., 1976. From agronomic data to farmer recommendations: an economic training manual. Centro Internacional de Majoramiento de Maiz y Trigo, Mexico City, 49 pp.

Roumassat, J.A., 1981. Introduction and state of the art. In: J.A. Roumassat, J.M. Boussard and I. Singh (Editors), Risk, Uncertainty and Agricultural Development.