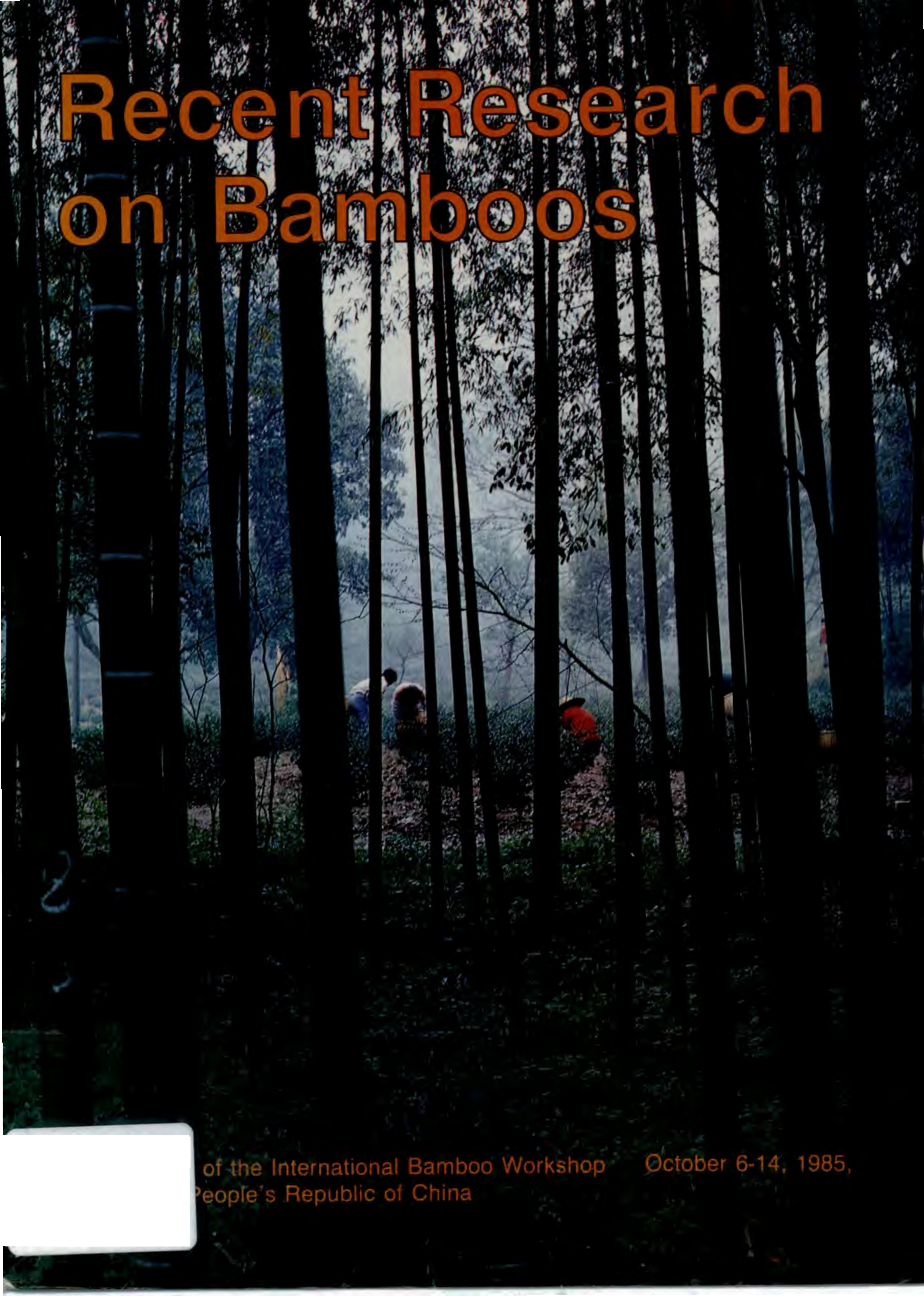
Recent Research on Bamboos



of the International Bamboo Workshop October 6-14, 1985,
eople's Republic of China

ISBN 9971-84-732-9

中国林业科学研究院

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Proceedings of the International Bamboo Workshop
October 6-14, 1985
Hangzhou, People's Republic of China

Organised jointly by:
Ministry of Forestry, People's Republic of China
International Development Research Centre, Canada
International Union of Forestry Research Organisations

Editors:

A.N. Rao, G. Dhanarajan, C.B. Sastry

Proceedings published jointly by:
The Chinese Academy of Forestry, People's Republic of China
International Development Research Centre, Canada

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Economics for Bamboo Forestry Research: Some Suggested Approaches

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Abstract

Bamboo is a commodity of historic economic value in Asia, Within the context of a steadily declining total natural forest stock in Asia, bamboo is becoming an increasingly scarce resource. Public and private *initiatives to reverse this trend, should consider bamboo cultivation as a viable alternative benejitting people* both *in* public *(social) and private (market) lands. Bamboo research and subsequent , development programmes should include economic analysis as an integral component for developing appropriate technology and in investing* resources for *employing that technology. Specific techniques of economic analysis; i.e. benefit-cost analysis, marginal analysis, budgetting* and *market research; are suggested vis-a-vis specific bamboo research and development objectives. Foresters are encouraged to involve experienced micro-economists in their research and/or undertake specialized* short-term relevant micro-economics *training.*

Introduction

From the information provided at the 1980 Workshop on 'Bamboo Research in Asia' (Lessard and Chouinard, 1980), and in other publications (Austin *et al.,* 1983); it is obvious that in Asia, bamboo is ecologically, socially and commercially an important plant. From, this same literature, plus the results of recent research as presented in this workshop; it is equally obvious that there exists a potential to significantly increase the production of bamboo .and improve its productivity in present and alternative uses, In other words, bamboo has 'value'. It is seen as a relatively scarce resource (due to low productivity of natural stands) with many uses in manufacturing, as a food and in making paper. Its collection and/or cultivation, processing and consumption involve people from different socio-economic groups in society. With new technology in such areas as – controlled flowering, seed technology, tissue culture, insect control, preservation, etc; it will be possible to increase extensive and intensive production and improve processing, employing many more physical and human resources of land, labour and capital.

By definition, economics is a study of the proper method of allocating scarce resources among competing uses (Ferguson, 1972). It attempts to answer the three basic questions of (Sammedson and Scott, 1968) 1. What to produce? – what mix of different outputs? 2. How to produce? – what techniques should be used to produce output? 3. For whom to produce. – who should receive the output produced? These are relevant questions with respect to scientific research and national development activities on bamboo to improve people's lives.

This paper is a limited attempt to provide a rationale for economic analysis of new technology for bamboo production and preservation. The arguments for conducting economic analysis, and the suggestions for using specific techniques, draws heavily from the work in Farming Systems Research (FSR) (Banta, 1982 Anon, 1984 Anon and Department of Agriculture Nepal, 1980), and Post-Harverst Research (PH) Austin, 1981; Edwardson and MacCormac, 1984) in Asia,

Bamboo as a Natural Forest Resource

Historically, in countries (or regions within a country) with a very low population density, the forest was considered a "common property natural resource". No single user had exclusive rights to the forest nor could he prevent others from sharing in its exploitation. As long as the annual 'cut' or harvest from the forest was less than or equal to the annual net natural growth of the 'stock' of the forest, people's needs were assured. There was no incentive to control or limit access to the forest. This situation no longer exists for Asia today. Since the end of World War ll, rapidly increasing population, with associated demands for fuel and farm land, and the fact that the developed country wood demand outpaces supply; has resulted in a significant decrease in land under forest in Asia. Between 1960-80, one-half of the increase in food supply in Southeast Asia came at the cost of extending crop areas in forests' (Barney, 1980).

The remaining forest areas are generally, in principle, subject to laws regulating their use. However, the effectiveness of these laws are limit&d due to needs of shifting cultivation, the needs for fuel which can be obtained without cash by rural (and urban) people, and the ability of special interests to disregard the laws without penalty. What this means is that traditional 'natural' forest stands cannot maintain or increase supplies of wood. While information on individual species is often difficult to obtain, it is reasonable to assume that the forest stock of bamboo and the total annual net growth has and will continue to decrease significantly under present conditions in Asia. Increasing forest (including bamboo) output over time by extending the area under cutting is no longer a long-term option. The raw material for an expanding wood products (including bamboo) demand will be found by intensifying production (Scott, 1982), (perhaps with the exception of Indonesia).

The Potential for Economic Intensive Bamboo Cultivation

Scott (1982) and Sedjo (1982) discuss the potential for intensive forest production in Asia. While they focus mainly on monocyclic and polycyclic timber (plantation) systems, several relevant points are made which are important regarding the economic feasibility of bamboo cultivation. Both polycyclic and monocyclic systems produce significantly higher mean annual increments (MAI) than natural forests, The extra costs of physical and management inputs should be offset from direct increased production, and there are other indirect national benefits in increased employment for production and wood processing. Bamboo has a rapid natural early growth which can be increased with application of fertilizers, Traditional techniques and 'industrial infrastructure' for processing bamboo exists, therefore expanding production should be quickly followed by an expanding processing sector, provided a market exists for the extra production.

The shorter the forest species rotation cycle, the less time this 'capital' (growing stock) has to be held before disposal. Related to this is that the longer the rotation cycle, the longer input costs are compounded and the longer future benefits must be discounted back to the present. Bamboo's very short rotational cycle makes it very attractive in terms of cash flow vis-a-vis other hardwoods and softwoods. This makes it attractive for those with little capital. The comparative net benefit over time would of course depend on factors such as the relative magnitude of costs and expected future prices of the species.

Monocyclic plantation systems require large areas and present evidence suggests that relative to polycyclic systems; they present a greater environmental threat due to a lack of flora-fauna mix and by sudden extensive destabilization of water flows by the disturbance of moisture absorbing watersheds. Bamboo seems well suited to poiycyclic harvesting, can be grown on steep hillsides and along banks of rivers, its interlocking root system and leaf deposit inhibit soil erosion (Austin, 1983). In Asia, countries have. little high quality arable land left for expanding crop area. Efficiency in the use of water and maintaining soil quality in even marginal agricultural areas, have both direct and indirect benefits to food producers and consumers.

Related to some of the above arguments is the issue (mentioned earlier) of the competitiveness of forestry versus agriculture. As Asian countries move closer to the 'cleared-forest' society, the success of forestry will depend upon its relative (to farming and urbanization) costs and benefits. Bamboo, either as a plantation or integrated into a farming system as a crop has potential, for many of the reasons stated earlier. However, it is important to note that in such a situation, the decision to maintain a forest crop (as bamboo) becomes highly decentralized. Region or site specific factors of environment, market demands, relative resource costs and product prices, etc will be the key determinants. A second characteristic is that the decisions become more micro-economic rather than socio-political (unless the government is willing to incur costs in the form of subsidies or transfer payments for a perceived social benefit). This means that local communities or associations and individual farm households will also decide if bamboo should be cultivated. This also means bamboo must be economic (per unit land area) not just compared to other tree species but compared to agricultural crops too. Or at least, it must complement crop production without reducing farm household income. It would appear that bamboo does have significant potential for economic intensive culture. Scientific research to produce the necessary technology must be accompanied by economic analysis to evaluate the ability of that technology to achieve private and social development goals.

Suggested Economic Analysis Approaches

This section is not a detailed "how to" manual for conducting economic analysis for specific bamboo forestry problems. That would require a lengthy presentation complete with detailed examples and take several days to present. Instead, some specific economic analysis approaches are listed followed by specific bamboo forestry research and/or development objectives, to which the economic approaches could be applied. It is understood that bamboo research and/or development projects can have more than one objective. How this is handled usually depends on the specific situation, Usually, secondary objectives. are expressed as constraints for selecting techniques to achieve the main objective (Gregersen and Contreras, 1979) (i.e. increasing bamboo output for paper making is the main objective but environmental objectives help determine harvesting techniques). It is up to researchers to be aware of the social and private decision makers' objectives and the relative weighting they give to those objectives, in the design and evaluation of new bamboo production and processing technology.

Benefit-Cost Analysis

Economic (Social): This form of economic analysis has been widely used in the natural resources to help assess the economic efficiency, from society's point of view, of new technology. It attempts to identify and quantify costs and benefits to society (not just individuals) by utilizing resources over a specified time period. It is not dependent only on known market prices for inputs and outputs but estimates values for such things as increased or decreased soil erosion, reduced unemployment, improved foreign exchange earnings, and other public "bads and goods". In the case of bamboo, this type of analysis can, for example, be used where the objective of research is to – develop and implement techniques for environmental soil and water conservation, soil improvement, shelterbelts, and increase the area under forest. The costs and benefits of those objectives are not only shared or consumed by specific individuals but by 'society' or groups within society. This analysis calculates the "net benefit" or "return" to society employing alternative bamboo techniques.

Financial (Private): This form of analysis calculates the costs and benefits to identified individuals and organizations using market prices only. The same methodology of discounted (over time) cash flow is used as in Economic Benefit-Cost Analysis, however the focus is on calculating the net benefit and return to the actual equity capital invested in the new technology. In the case of bamboo, this type of analysis can, for example, be used where the objective of research is to – maximize economic'output per unit time for a variety of market uses, i.e. paper-making, furniture, food; minimize costs of production and processing for a given quantity of bamboo cultivated or processed; and to develop economical techniques for improved quality of bamboo and bamboo products.

In both forms of Benefit-Cost Analysis, there are three main criteria by which a single or set of techniques can be assessed and compared. These are: (i) Benefit-Cost ratio: This is simply the total of the present worth of expected benefits divided by the total of the present worth of expected costs. Only technologies with a ratio of greater than 1 are economically efficient in terms of resource use. (ii) Net Present ***Worth*** (sometimes referred to as net present value): This is the difference between the present worth of the expected benefits less the present worth of the expected costs. All technologies which result in a positive net present worth are economically efficient in terms of resource use. (iii) Internal Rate of Return: This is defined as the average earning power of the value of resources used from the application of the technology. Only technologies that give a rate of return higher than the existing market interest rate are resource efficient.

The formal mathematical statements of these criteria are given below (Gittinger, 1976) :

$$\text{Benefit-cost ratio} = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+i)^t}}$$

$$\text{Net present worth} = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t}$$

Internal rate of return is that discount rate i such that

$$\sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t} = 0$$

where,

Bt = benefits in each year.

ct = costs in each year.

t = 1, 2 ,........ n.

n = number of years.

i = interest (discount) rate.

It should be noted that in comparing alternative (bamboo) technologies if due to resource constraints, only one of the alternatives can be employed, a comparison of the net present worths of the alternatives is the appropriate selection criteria.

The Single Variable Input-Output Production Relatioship .

Consider a product Y (bamboo, in kg), whose yield depends only on one input X (fertilizer, in kg) assuming all other inputs are used at a constant level. Where a unit of fertilizer is added, total output increases by some amount. Extra output resulting from 1 kg increase in fertilizer is called the marginal product of fertilizer (MPx). When multiplied by the price per kilogram of bamboo, we obtain a monetary measure called the marginal value product (MVPx) . The MVP represents the value of extra bamboo resulting from the application of an additional kilogram of fertilizer. On the cost side, the addition of a kilogram of fertilizer increases costs by a certain amount. This is called the marginal factor cost (MFC). It is equal to the price of the fertilizer, since increasing the use of fertilizer by one unit increases cost by an amount equal to the price of the fertilizer. Hence, using the rule stated above, the use of fertilizer should be increased as long as its MVP is greater than its MFC. To identify the optimum level of fertilizer, that is, the level where profits are maximized, we need to observe how production responds to fertilizer application. Assume that the output-input relationships are as shown in columns 1 and 2 in Table 1.

These show that when fertilizer (x) is increased, bamboo yield (Y) generally increases. At Iow fertilizer levels, the increase in yield from each 10 kg of fertilizer used is large. However, the yield increases from each unit of input (10 kg fertilizer) become smaller at successively higher levels of the input. In other words, extra yield (marginal product) tends to decrease at successively higher fertilizer levels if all other inputs are held constant. This observation is usually referred to as the law of diminishing marginal returns and applies to all input-output situations. In Table 1, percentage of yield increase begins to decrease when more than 30 kg of fertilizer is applied. This reflects the law of diminishing returns. Total yield begins to decrease when more than 100 kg of fertilizer is applied, but this decrease in total yield is not a necessary condition of the law of diminishing returns.

Column 3 of Table 1 shows the marginal product as fertilizer is increased in 10 kg units.

Table 1. Illustration of a simple input-output relationship.

Fertilizer (kg)	Yield (kg)	Marginal Product (kg)	Value of extra output (M)' .	cost of extra input (M)
0	2000	–	–	
10	2100	100	110.00	40
20	2300	200	220.00	40
30	2600	300	330.00	40
40	2800	200	220.00	40
50	2900	100	110.00	40
60	2950	.50	55.00	40
70	2980	30	33.00	40
80	3000	20	22.00	40
90	3010	10	11.00	40
100	3010	0	0	40
110	3000	-1	-11.00	40

• ' M is used as monetary unit.

At fertilizer levels above 30 kg, yield increases but marginal product decreases. We say diminishing returns has set in at 30 kg fertilizer. Assuming bamboo price is 1.1O/kg, column 4 shows the value of extra output, or the marginal value product (MVP), which is obtained by multiplying MP by the unit price of bamboo. MVP equals the additional value of output resulting from each 10-kg increase in fertilizer. Column 5 shows the cost of extra input or the marginal factor cost (MFC), which equals the increased cost of each additional IO-kg bag of fertilizer. If fertilizer price is 4/kg, a 10-kg increase in fertilizer will raise cost by 40. Therefore, marginal factor cost equals 40 because we are dealing with 10-kg bags of fertilizer,

Using this information, we can determine the quantity of fertilizer that will maximize profits by following the rule that additional fertilizer should be applied as long as extra return (MVP) is greater than extra cost (MFC). It is sufficient to compare columns 4 and 5. We can see it pays to increase fertilizer use up to 60 kg because value of additional output (MVP) is greater than additional fertilizer cost at levels lower than 60 kg.

Does it pay to increase the fertilizer level up to 70 kg? The larger value of the bamboo obtained from using more fertilizer is 33. Additional cost is 40. The farmer would be losing 7. Clearly, this will mean a reduction in net profit. Hence, he should stop at 60 kg where profit maximization occurs. To confirm that profit is maximized at 60 kg of fertilizer, compute total profit at each fertilizer level. This is illustrated in Table 2.

Columns 1 and 2 are the same figures as in Table 1. Column 3 is obtained by multiplying yield by the bamboo price (1.10/kg). Column 4 is obtained by multiplying the amount of fertilizer applied by its price per kg (4/kg). Column 5 shows net return, which equals value of production less total cost.

Note that profit increases as fertilizer is increased from 0 to 60 kg. Maximum profit is obtained at 60 kg fertilizer. Beyond 60 kg, net return decreases. Note also that maximum yield (at 90-100 kg fertilizer) does not mean maximum profit.

Although this illustration is simple, it provides a guideline for determining maximum profit level of input use. We compare the marginal value product with the marginal factor cost. This analysis shows information on marginal productivity of an input can be expressed in monetary terms and compared with the input price. When $MVPx>Px$, less input is being used than would maximize profits. When $MVPx<Px$, too much input x is being used. Because the law of diminishing returns generally holds for all input-output relations, the profit maximimizing level of any input will be less than the yield maximizing level. Note that yield was highest at 90 kg fertilizer but profits were highest at 60 kg fertilizer.

Table 2. Illustration of how to compute total profits.

Fertilizer (kg) 1	Bamboo (kg) 2	Total Value of production[a] 3	Total Cost of fertilizer[b] 4	Net returns[c] 5
0	2000	2200	0	2200
	2100	2310	40	2270
[illegible]	2300	2530	80	2450
30	2600	2860	120	2740
40	2800	3080	160	2920
50	2900	3190	200	2990
60	2950	3245	240	3005
70	2980	3278	280	2998
80	3000	3300	320	2980
90	3010	3311	360	2951
100	3010	3311	400	2911
110	3000	3300	440	2860

[a]Column 2 x 1.10. [b]Column 1 x 4. [c]Column 3 less 4

Budgets

Budgets are one of the simplest yet most widely used techniques in economic analyses. Budgets are used: i) to compare economic profitability of · different technologies; ii) to indicate whether a proposed change (i.e. new technology) will be profitable under a given set of circumstances; and iii) to explore conditions under which certain technologies become profitable or unprofitable.

Enterprise budgets, partial budgets, and parametric budgets are the three common types.

(i) Enterprise budgets: The process of producing a particular commodity is called enterprise. Small farms in tropical Asia usually are multi-enterprise farms — they produce more than one commodity possibly including bamboo. Enterprise budgets enable us to evaluate costs and returns of production processes. Comparing relative profitability of new technology with existing technology helps to show how the enterprise can be more profitable. The new technology may change existing technology to show a better way to grow bamboo or to compare possible new cropping patterns including bamboo.

A budget is a formalized way to compare production process benefits and costs. If benefits exceed costs, profit was earned. If benefits are fess than costs, a loss was incurred. The difference between gross returns and variable costs is called the gross margin (also referred to as returns above variable costs). Gross margin measures the contribution of an activity to profitability. Input quantities and values used in production process (costs) and output quantities and values (benefits) are the basic data required for budgets.

(ii) Partial budgets: Partial budgets are used to evaluate the effects of a proposed enterprise change. A partial budget is useful only when the change is relatively small. A partial budget highlights variations in costs and returns caused by proposed changes in the enterprise. Only items affected by the change are included in the budget. Levels and costs of all unchanged inputs are not included. When constructing a partial budget identify: costs that will increase or decrease, and returns that will increase or decrease.

Table 3 shows a basic partial budget. The left side shows negative effects of a proposed change — added costs and reduced returns of changing from an old to a new technology. On the right side are the positive effects — added returns and reduced costs. If positive effects exceed negative effects, proposed practice is more profitable than the existing production practice.

(iii) *Parametric budgets:* For any new technology, estimates of inputs and outputs are approximate, and prices are subject to change. Therefore, it is useful to explore how sensitive benefits are to changes in assumed levels of inputs, outputs, and prices. We often want to learn what yields and/or prices are necessary to make a technical change profit-

Table 3. Partial budget to estimate change in annual net cash income resulting from some change in resource use.

a. Added costs	c. Added returns M
b. Reduced returns	d. Reduced costs M-
Subtotal A:M	Subtotal B:M
	Estimated change (B-A)M

able. Parametric budgets, also called sensitivity analyses, answer these questions. The simplest situation to consider is the change in profit if one parameter is varied. Gross margin is then calculated as:

$$GM = (PXY) - VC$$

where

GM = total gross margin
Y = bamboo yield (the factor to be varied)
P = the price of bamboo, and
VC = total variable cost.

Gross margin can now be calculated for any yield within the range that yields are expected to vary. Table 4 presents gross margin for a range of yields between zero and 4,000 kg/ha. The data are also plotted in Figure 1. The figure shows that a yield of less than 1,198 kg is a loss for the enterprise. This yield is usually called break-even yield, calculated by solving for Y when (PY) - VC = 0. It is where the producer just recovers variable costs.

Market Research

Market research is an important type of economic research with respect to the development and recommendation of new technologies for growing and/or processing bamboo. For a,government or private institution (or private individual) to invest in new bamboo technology, it is essential to have data on input markets (resources used in bamboo production or processing) and output markets. The main marketing aspects to be considered in a market study are (Ranaweera, 1984): (i) input supplies, (ii) expected output increases, (iii) market potential (demand), (iv) capacity of the marketing system to handle increased output, and (v) anticipated government interventions.

Table 4. Effect of changes in yield on gross margin . .

Yield (kg/ha)	Gross margin (kg/ ha)
0	-1258
1000	208
2000	842
3000	1892
4000	2492

'GM = (Y x 1.05) - 1258.

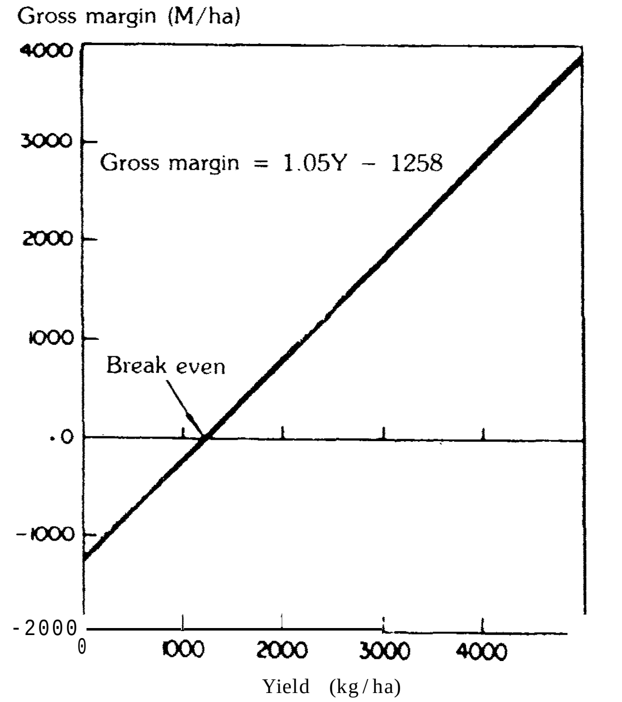

Fig. 1. Effects of changes in yield levels in gross margin.

Conclusions

This paper has had two objectives. First, define a role for economic analysis as part of a total research effort to develop new technologies for bamboo cultivation and utilization, and second, suggest specific economic analysis procedures that could be used. The material presented for the second objective is very superficial, in that the reader is strongly recommended to consult the references cited for developing even a basic understanding of the related economic concepts and techniques. It is also recommended that agricultural or resource economists with experience in micro-economic analysis be encouraged to undertake this research. Much of this analysis could be done by foresters if they have received appropriate training (a minimum of 6-8 weeks) from economists. The decisions to include an economist and/or train foresters in basic micro-economics for this research should depend on: (i) how 'basic' or 'applied' the bamboo research is, (ii) the existing availability of interested and/or experienced economists, and (iii) the research and training resources available.

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