INTERNATIONAL NETWORK FOR BAMBOO AND RATTAN
(INBAR)

TRANSFER OF TECHNOLOGY MODEL
(TOTEM)

MEDIUM AND LARGE SCALE BAMBOO PLANTATIONS

by

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TRANSFER OF TECHNOLOGY MODELS (TOTEMS)

Transfer of Technology Models (TOTEMs) are focussed educational tools providing relevant information and distance training on one specific area of bamboo/rattan management, processing or utilization. They are a means of technology transfer between similar regions throughout the world, with the emphasis on South-South transfer for livelihood development. They enable those involved in the management and use of bamboo and rattan resources to more efficiently and effectively develop and use skills relating to these resources.

TOTEMs are primarily intended as practical information resources and teaching aids for those at the local extension level in their communities, who can utilize them to assist local community development. Each TOTEM consists of a detailed written report of the technology, a PowerPoint presentation, a film, and, where relevant, a set of technical photographs. They also include information on target users, financial analyses of sample set-ups from the partner country preparing the report and information on where to source particular technologies (such as equipment). The TOTEM thus provides all the information required for establishing similar technologies within interested countries and regions.

- The **report** contains all the technical details of the particular processes involved, as well as other relevant information for establishing the technology such as costs of business establishment, running costs and cash flows.

- The **PowerPoint** presentation contains details of the relevant technologies and their applications, and is intended to provide an overview of the potential of the technology for development.

- The **film** provides a visual guide to the processes involved and helps to bring them alive in the minds of the learners.

The different parts of the TOTEM are targeted at slightly different audiences, via the local extension workers. The report and film are intended to be the main means of extension to the individuals and communities who will implement the technology and who will directly benefit from it. The PowerPoint presentation is primarily intended as a tool for the extension worker to sell the technology and its role in development to those who provide the infrastructural, policy and financial support for its implementation, such as government departments, donors and NGOs. There is considerable flexibility, however. Local extension workers will be able to incorporate the TOTEMs in their own work as they wish and adapt and develop the TOTEM to suit their particular requirements and conditions.

This TOTEM on m**edium and large scale bamboo plantations** has been produced by Xiao JiangHua and Yang XiaoSheng at the Research Institute of Tropical Forestry, Fuyang, China. The report part of this TOTEM describes the technology for producing and establishing medium or large scale bamboo plantations for rural development in regions where bamboo is available as a raw material. It is intended to be used in conjunction with the illustrative film included in this TOTEM package.

The first part of the report introduces the technology, discusses its history, its development attributes, its benefits and it's applicability. The second part of the report provides detailed information on establishing and running a medium or large-scale bamboo plantation. **Appendices I** and **II** provide financial analysis for establishing and running a medium or large scale bamboo plantation.

This TOTEM is one of the first to be produced by INBAR/ RISF and your feedback is most welcome - kindly contact INBAR or RISF with your comments or suggestions.

Note 1: This TOTEM has been edited at INBAR and differs slightly from the form in which it was received from the authors.

Note 2: All calculations are in Renminbi (RMB). At the time of writing RMB 8.25 = US$ 1.

PART ONE

INTRODUCTION

DEVELOPMENT ATTRIBUTES, TARGET GROUPS and BENEFITS of

MEDIUM and LARGE SCALE BAMBOO PLANTATIONS

1. Medium and Large Scale Bamboo Plantations

Medium and large-scale bamboo plantations are plantations too large for an individual family to manage on their own. They are thus about 1 hectare or larger and may be up to many square kilometres. They may be managed for culm production, shoot production or both. Most of the commercially productive bamboo plantations in the world are medium or large scale and they benefit from the economies of their size.

2. General development attributes and advantages

The main development attributes of the technology are as follows:

- Income generation for poor rural people
- Improves and broadens farmers plant cultivation skills base, making them more able to handle shocks and empowering them with new abilities
- Increasing the area of managed bamboo resources
- Brings degraded land back into productivity and reduces erosion
- Promotes the sustainable increased use of bamboo as a wood substitute

The main advantages of the technology are:

- It builds upon rural farmers own inherent plant-cultivation abilities and hence is easily adopted
- It is extremely environmentally friendly - organic inputs such as fertiliser are better for bamboo growth than inorganic ones.

3. Suitable agro-ecological regions

The medium or large-scale bamboo plantation may be established in any bamboo-growing region of the world. Additionally tropical, subtropical and temperate regions that presently do not have natural bamboos are also suitable. There are many species suitable for different climatic conditions and some are very frost-hardy. However bamboos are not suitable for very dry areas unless irrigation is provided. Consideration will need to be given to the market for the culms produced. Species with large culms often have a wide range of uses but those with small culms have limited uses. These small species are often the most resilient, as they grow at the fringes of the natural bamboo distribution areas. Thus one needs to define suitability as suitability for the particular species one wishes to grow.

The plantation of bamboo improves the physical and chemical composition of soil considerably, prevents soil erosion in river and sea banks and preserves water in soil by creating a natural water reservoir. Land productivity per unit area increases, reducing the pressure on land due to high population density. Bamboo also produces more oxygen in comparison with the same quantity of many other trees

4. Requirement for success

The essential requirements for a successful medium or large-scale bamboo plantation are:

- Interest of local communities to plant bamboo
- Land availability, ideally degraded land.
- Availability of raw materials - Propagules, fertilisers, tools.
- Finance for the purchase of seedlings, fertilisers, tools and equipment charges of skilled and semi-skilled labour at various stages.
- Well established financing mechanism
- Institutional support and infrastructure.
- Regular supply of labour
- Market for the bamboo culms produced by the plantation

Concluding remarks

The bamboo sector is not easily affected by climate and environment. Related activities are environmentally friendly and do not normally require a high level of mechanisation or financial input. A good plantation can be established with the help of local untrained manpower who can be taught the necessary skills. Due to the size of the plantation it may be established as part of a coordinated regional or local bamboo development venture including bamboo processing units that the plantation could supply. In this case it may be preferable to establish it with the assistance of NGOs or state agencies to ensure the proper infrastructural facilities and linkages are in place.

PART TWO

THE BAMBOO MEDIUM/LARGE SCALE BAMBOO PLANTATION

1. Introduction

The main activities involved in establishing a medium or large scale bamboo plantation are:

- Selection of suitable species,
- Land selection,
- Preparation of nursery and afforestation. This involves digging, clearing the ground, planting bamboo propagules, cutting bamboo culms and applying fertilisers,
- Techniques for raising seedlings and plantlets, weeding and tending.

2. Establishing a medium or large scale bamboo plantation

Selection of suitable species

There are many bamboo species and varieties and over 100 of them are commonly cultivated. Depending on the genetic characters, species vary in growth and development pattern and in their response to environmental conditions.

Dos and Don'ts

- Understand the basic biological characters of bamboo species before selecting.
- Understand the climatic features of the chosen planting site.

2.1 Nursery practice

2.1.1 Nursery site selection and preparation

Dos and Don'ts

- Select land preferably on the lee side of a sunny site with a gentle slope and good drainage and with abundant water resources for easy irrigation.
- The soil should be porous and fertile, sandy loam or loam with a pH neutral or slightly acidic.
- The groundwater lever should not be high and usually should be under 1m.
- The soil should be friable to increase the ability to preserve moisture, weeds should be cleared and soil pests and insects should be eliminated. Attention at this stage to the soil will go a long way in creating favourable conditions for growth of the bamboo.
- The preferred time for preparing the soil is before freezing in winter or after defrosting in spring.
- Plough the site thoroughly and deeply. The best time for ploughing is at the beginning of winter.

- Dig out roots and rocks, rake and level the soil well.
- After ploughing the seedbed and pace can be made. Add manure or plant ash as a basal fertilizer to improve seedling growth and root development.

2.1.2 Methods of raising seedlings and plantlets

There are two kinds of plant propagation: sexual and asexual propagation. As flowering is rare in bamboo species and produces very few matured seeds, plant propagation through seedling planting can only be used for a few bamboo species such as *Dendrocalamus strictus* which is regularly found in flower.

The common and practical method of raising new plantlets is asexual propagation. This involves taking offsets, culm (or branch) cuttings, stumps with rhizomes, and rhizomes only for direct afforestation or for plantlet propagation. Culm or branch cuttings are the most commonly used of all methods for sympodial bamboos. Some asexual methods of raising plantlets of sympodial bamboos are listed below:

a. Propagation by branch cuttings.

Raising plantlets by branch cutting is mostly suitable for relative large-sized species with dominant nodal branches, such as *Dendrocalamus* spp., *Neosinocalamus* spp. and *Bambusa* spp. Primary and secondary branches are used in most cases and around 90 percent of them will produce new stock.

b. Propagation by single-node culm cuttings.

Propagation of thin-walled bamboos by culm cuttings is usually less successful as it requires efficient handling that can often be tedious and hence it is difficult for large-scale production. However, it is suitable for thick-walled and large-sized species, such as *Dendrocalamus latiflorus* and *Dendrocalamopsis grandis*.

c. Propagation by two-node culm cuttings.

Plantlet survival rate with two-node cuttings is higher than with single-node cuttings but slightly lower than with whole culm cuttings.
Raising plantlets using single or two-noded cuttings may be unsuitable for the establishment of large scale plantations because of the tedious handling procedures involved.

d. Propagation by culms with rhizomes attached.

This method of propagation usually achieves good survival rate and has been the best approach of propagation for the following reasons:

Advantages:

- The holes made in the culm internodes enhance sprouting of nodal buds. Using the same method without holes most of the culm buds fail to develop.
- Water and nutrients absorbed by the rhizome can be transported through the linkages of each node to meet the nutritional requirements of the plantlet before rooting. This avoids failure due to the exhaustion of nutrients, as may be the case when propagating by culm cuttings.

e. Propagation by whole culm cuttings.

Method:

In comparison with the propagation using whole culms with rhizomes attached, the operation in this case is the same, except the parent culm is simply severed at ground level and does not have the rhizome attached.

Advantages:

Though it produces fewer plantlets compared to culm cuttings with rhizomes attached it is less expensive in terms of labour and costs. This method is more suitable for raising plantlets at a site near the stand from which the parent culm was collected. When long-distance transportation is essential, certain measures like watering and covering with thatch or plastic film should be taken to prevent the parent culm from drying out.

f. Tissue culture

This is the fastest and most economical way of raising plantlets for sympodial bamboo plantations on a large scale, if the species are suitable for tissue culture.

Conclusion: Ideally, propagation using branch and culm cuttings needs experienced and efficient operation and is suitable for thick-walled species, while the culm-burying method may be the suitable choice for propagating mid-sized species at a site which it is less developed in technical and economic aspects.

2.2 Nursery tending during vegetative propagation

The propagation with opened culm can be divided into 6 stages. These are

- planting of parent culm;
- growth of new roots on parent culm;
- growth of new culm;
- rooting;
- tillering;

2.2.1 Planting parent culms

The parent culm dries out easily after digging from the soil, so it should be kept in a shady, moist and cool location. Adequate shading and regular watering are essential when the parent culm is in storage, during transportation and after planting in the nursery, so as to improve recovery of its root system.

2.2.2 Rooting

The recovery of the parent culm's root system usually takes place 1-2 weeks after planting. Sufficient watering at the base of parent culm after planting will significantly improve its recovery and survival rates.

2.2.3 Shooting

Shoots younger than one month old do not have their own root system. It is important to prevent them from being damaged by drought and sunshine. This can be achieved by regular irrigation and keeping the original cover for lowering the ground temperature. Fertilization during this stage, at the base part of the parent culm, can improve the quantity and quality of shoots. Complete weeding should be done in time, but carefully avoiding any injury to the parent culm and the young shoots.

2.2.4 Rooting

Rooting takes place about 30 days after shooting when the new culm has completed is extension growth and has shed its sheaths and produced branches and leaves. The young plantlets without developed root systems may die easily from drought and exhaustion of nutrients in the parent culm. They develop root systems from late May to mid June. Weeding, soil loosening and fertilizing at this time will stimulate tillering.

2.2.5 Tillering

The plantlets that have already established their well-developed root system can produce 2 to 3 generations of new culms from July to November provided they have sufficient water and nutrients. The first generation of new culms appears from mid July to mid August, the second from early September to early October and the third from late October to late November.

Do and don’ts

- Large amounts of water and nutrients are consumed by the plantlets during this stage and one should ensure adequate supply of water and nutrients.
- Fertilizers must be applied at intervals of 2 to 3 weeks.
- Weeds should be removed in time to avoid them competing for water and nutrients.
- The rhizome should be earthed up to a depth of 5-6cm if it is exposed.
- Pest control may be needed, which is discussed later in the text.

2.2.6 Dormancy

The plantlets will be in a dormant condition from December to February and no measures are adopted during this stage.

2.3 Field -planting practices

2.3.1 Planting site

Plantations should be established at sites suitable for bamboo growth and survival. For example, sympodial species are susceptible to damage by cold weather conditions and such damage will occur on some species if the temperature falls below - 4.
Bamboo performs well in porous, deep and fertile soil with good drainage and relatively high moisture content. Sympodial bamboo species that have dense and concentrated root systems demand particularly high levels of soil moisture and nutrients. Therefore, plantations of these species are best established on sites such as valleys, mid and lower slopes, streams and areas along rivers, reservoirs or land around ponds and homes. Plantations established on dry and infertile soils will only produce small culms with limited economic profits.

2.3.2 Soil Preparation

If dense grasses and shrubs cover the afforestation site, burning will be necessary before soil preparation. There are three methods of soil preparation: Overall preparation, strip preparation and pit preparation.

2.3.3 Planting Season

There is a local saying that plant bamboos in Feb. but plant trees in March. This is because bamboo recovers from resting in winter earlier than trees do and the rise in temperature in February is favourable for the planting of bamboos.
Sympodial bamboos are usually planted from February to April and the survival of new plantlets will improve if they are planted after rains when the moisture content of the soil is fairly high.

2.3.4 Planting Density

The initial planting density depends upon site conditions and the size of the species involved. Generally, higher densities are suitable for the establishment of small-sized bamboos. Plantations established with low density will suffer from canopy exposure, low soil moisture and strong competition from weeds. This may result in poor productivity and necessitate a lot of labor during tending.

Overstocking at planting will also result in low productivity from smaller plants due to the intense competition among the plantlets for light, space, soil moisture and nutrients.

2.3.5 Transplanting

Plantlets propagated by seed or vegetative materials are ready for transplanting to the field at one year of age. Prior to field planting, the culms are cut back in the nursery to 2-3 basal nodes. The clumps are dug up and then divided into smaller clumps each containing 1 to 3 culms. After planting the root portion in thick mud or soil, they are ready for transporting and planting. Planting involves placing them upright in the planting hole, covering and firming the soil and finally earthing up the base part with loose soil to a depth of 3 to 4cm.

3. Running a medium or large scale bamboo plantation

3.1 Tending bamboo shoot stands

a. Inter-cropping

It has been proven that inter-cropping in newly established bamboo stands increases the productivity and economic returns from the land. Crops suitable for inter-cropping in bamboo stands depend on the various local needs and conditions. These crops could be beans, watermelon, maize, cassava and green manure crops. Crops that are heavy consumers of soil nutrients, such as buckwheat and sesame seed, are not recommended. Crops should be planted not too close to the bamboo plants to avoid disturbing their growth, with taller crops being about 1 meter away. Inter-cropping with sun loving crops will not be possible when the stand canopy is dense, about 1 to 2 years after planting.

b. Weeding and soil-loosening

Weeds should be controlled effectively to prevent them competing with bamboos for soil moisture and nutrients. Soil-loosening in bamboo plantations is important, as maintaining a good soil structure in the stand will be beneficial to the growth of shoots and root system, as well as water conservation. Soil loosening should be done from November to February once or twice per year.

c. Fertilizing and earthing-up.

Results of soil chemical analysis shows that bamboo plants consume 500-700g N, 100-150g P and 200-250g K from the soil, per 100 kg fresh shoots produced.
The chemical fertilizer available to bamboos quite soon after dressing, is usually applied during shooting stage. Alternatively, 37, 500 kg per hectare of organic fertilizers, such as barnyard manure or bean-cake and rape-cake, can be applied.

Application of fertilizers, by placing in drills, is best done in combination with soil loosening in the winter months. The edible part of newly germinated bamboo shoots underground are very tender and delicate, with light yellowish sheath, but they become tough with green sheaths after they emerge from the soil. This can be delayed by earthing

up the base of the clump at the beginning of shooting and thus increasing the size of the shoot. But in order to stimulate development of shoot buds, the soil cover should be removed to expose the bud to high temperature and light in March or early April.

d. Shoot harvesting

Sympodial bamboos produce shoots from May to October with peak production in July and August. Generally, the early shoots and most of those produced in the peak period are harvested, but those produced towards the end of shooting season are retained as mother culms. The operation of shoot harvesting varies with size of shoots for processing different products.

Dos and don'ts

- Edible shoot should be harvested before they become tough. Any delay will result in loss of quality and quantity.
- Shoots produced in August and September should be retained as mother culms in order to maintain a reasonable culm-density in the clump.
- Over-harvesting will result in a decline of both quality and quantity of shoots in future years and may even cause serious degeneration of the stand.
- Three or four fairly distributed shoots are normally retained to develop for each clump annually.
- In order to harvest high outputs, a reasonable age-structure and density of culms should be maintained.

e. Pest control

Insect pest problems are more significant on large-scale plantations.There are leaf-feeders, sap-feeders, borers and timber pests. Many approaches to pest insect control have been developed, based on the end uses of the culms in the stands, the stands involved, the insect pest species and the extent of infestation. The general principles of pest insect control in bamboo stands are:

(1) to consider silvicultural measures as the basis, which involve appropriate tending, felling or thinning and regenerating in bamboo stands,

(2) to aim for unfavorable environment conditions for the pests and insects and make plants more resistant to them,

(3) to choose correct measures in time to prevent the population of the pest reaching epidemic levels. The main approaches to pest insect control include silvicultural measures, biological control, and behavior control.

3.2 Tending bamboo timber stands

a. Inter-cropping

Inter-cropping is also an important procedure in tending bamboo timber stands and can be operated in the same way as for shoot-use stands.

b. Fertilizing

Balancing the nutritional supply by fertilization is one of the most important measures for ensuring high productivity of bamboo stands. The method of application is the same as that employed in shoot-use stands.

c. Shoot retaining

Retaining well-developed shoots is important in keeping the plantation at favourable culm densities and high productivity. Sympodial bamboos normally shoot from May to October. Shoots produced in the beginning and mid of the shooting season, which are strong and account for over 85% of the total in number, should be retained as much as possible to obtain quality plants. Shoots produced towards the end of the season are weaker and fewer in number and can mostly be harvested. Protective measures, if necessary, may be required to avoid damage by animals, pests and diseases.

d. Reasonable felling

Objectives:

Felling is done with the aims of
- harvesting bamboo timber,
- controlling pests and diseases,
- removing suppressed plants and
- maintaining good culm age-structure and density.

The time of felling significantly influences plant growth and timber quality. Suitable culm ages for felling vary with species.

<u>Dos and Don'ts</u>

- Felling should be done in late autumn and winter when the physiological processes in the plants are relative inactive
- Avoid felling during the shooting season, or it will cause the death of new shoots or less developed culm.

- Avoid felling during growing season. This will cause considerable loss of nutrients due to profuse exudation from the cut stumps, and the harvested timber is susceptible to infestation from fungi and boring insects.

e. Pest control

The conditions influencing pest and disease incidence in timber-use stands are similar to those in shoot use stands, and the control measures employed are also similar.

APPENDICES

Appendix I

LABOUR

Activities	Gender	Level of skill required
Planting, seedling, and most of the manual work of sympodial bamboo planting	Men and women	Normal
Cutting and transportation	Mainly by men	Strenuous work
Design of planting stands, selection of suitable species, management for high yield, supervising pest control operations	To be done by specialists (men or women)	

The table below is an example for a scale of 1,000 ha of sympodial bamboo plantation.

Table 2 The labor requirement of 1,000 ha of sympodial bamboo plantation

Total labor	Managerial labor	Skilled labor		Non-skilled labor		Other Labor	
		Male	Female	Male	Female	Farmer	Non-farmer
4,000	15	700	800	1,000	1,485	3,980	20

TOOLS AND MACHINERY AND INFRASTRUCTURE

The main tools are hoes and knives for collecting/harvesting culms and shoots, which can be purchased in the market or can be made easily by the units.
The cost of infrastructure are listed as follows (see table 3):

Table 3 Cost of infrastructure($\times 10^3$ RMB Yuan)

Buildings and roads	Equipment	Others
500	200	30

The total cost of infrastructure will be 530,000 RMB Yuan.

WORKING CAPITAL REQUIREMENT

The re-afforestation cycle for the majority of sympodial bamboo species is 15 years. The annual working capital requirements are shown in the following table (table 4).

Table 4 The working capital requirements ($\times 10^3$ RMB Yuan)

Years	Annual output		Fertilizer	Seedlings or plantlets	transport	land	Salary
	Shoots	Culms					
First			180	1,200	50	750	4,000
Second			180		50	750	1,950
Third			180		50	750	1,060
Forth	6,000	3,000	180		50	750	1,060
Fifth	6,600	3,400	180		50	750	1,060
Sixth	9,000	4,500	180		50	750	1,060
Seventh	9,000	4,500	180		50	750	1,060
Eighth	9,000	4,500	180		50	750	1,060
Ninth	9,000	4,500	180		50	750	1,060
Tenth	9,000	4,500	180		50	750	1,060
Eleventh	9,000	4,500	180		50	750	1,060
Twelfth	9,000	4,500	180		50	750	1,060
Thirteenth	9,000	4,500	180		50	750	1,060
Fourteenth	9,000	4,500	180		50	750	1,060
Fifteenth	9,000	4,500	180		50	750	1,060

Years	Management	Equipment maintenance	Others	total		
First	400	20	30	6,630		
Second	400	20	30	3,380		
Third	400	20	30	2,490		
Forth	400	20	30	2,490		
Fifth	400	20	30	2,490		
Sixth	400	20	30	2,490		
Seventh	400	20	30	2,490		
Eighth	400	20	30	2,490		
Ninth	400	20	30	2,490		
Tenth	400	20	30	2,490		
Eleventh	400	20	30	2,490		
Twelfth	400	20	30	2,490		
Thirteenth	400	20	30	2,490		
Fourteenth	400	20	30	2,490		
Fifteenth	400	20	30	2,490		

OUTPUT

Outputs are mainly bamboo shoots, bamboo culms and by-products including branches, leaves etc. The annual output value in a re-afforestation circle is listed as follows (see table 5).

Table 5 The annual total output values in a re-afforestation cycle ($\times 10^3$ RMB Yuan)

Year	Yuan
First	0
Second	0
Third	0
Fourth	9,000
Fifth	10,000
Sixth	13,500
Seventh	13,500
Eighth	13,500
Ninth	13,500
Tenth	13,500
Eleventh	13,500
Twelfth	13,500
Thirteenth	13,500
Fourteenth	13,500
Fifteenth	13,500
Total	1,54,000

The total output value during a cycle of the sympodial bamboo plantation is 154 million RMB Yuan.

CASH FLOW

The cash flow is mainly constituted of following table 6:
Table 6 Cash flow requirement and component ($\times 10^3$ RMB Yuan)

Bankroll for finished products	**For shoots and culms**	**6000**
	Outsourcing commodities	**700**
Balance of bankroll	**Advance payment**	**600**
	Accounts receivable	**6000**
Bankroll in currency	**Fund of disbursement**	**2000**
	Vault cash	**400**
	Deposit in bank	**3000**
Total		18, 700

The total cash flow will be 1,3300,000 RMB Yuan

Explanation of assumptions used in calculating financial aspects

Flow capital is calculated based on requirements of reserve, working capital, Bankroll for finished products, Balance of bankroll and Bankroll in currency.

Reserve is calculated based on following equation:

$$\text{reseve} = \frac{\text{annual quantity of raw materials} \times \text{price}}{360} \times \quad \text{days for reserve}$$

working capital is calculated based on following equation:

$$\text{working capital} = \text{daily working capital} \times \text{days for production circle} \times \text{cost coefficent}$$

Bankroll for finished products is calculated based on following equation:

Bankroll for finished products = quantity of products sold daily x unit cost x days

Calculating Balances of bankroll and bankroll in currency are similar with bankroll for finished products.

Cost of products = cost of raw materials + wages + management fee + selling fee + depreciation charge + other cost

Output value is calculated based on total selling income

Net present value is calculated based on following equation:

$$FNPV = \sum_{t=1}^{n} (CI - CO)_t \ (1 + i_c)^{-t}$$

FNPV: Net Present value
CI: Amount of cash influx
CO: Amount of cash outflow
$(CI – CO)_t$: Net cash value in t year
n: Evaluation period (years)
i_c: Fiducial rate of return (8%)
Benefit-Cost Ratio is calculated based on following equation:

$$\text{BCR: Benefit-cost ratio} = \frac{\text{average annual profit}}{\text{total cost}} \times 100\%$$

Breakeven Period is calculated based on following equation and data in following table:

$$\sum_{t=1}^{P'_t} (CI - CO)_t \ (1 + i_c)^{-t} = 0$$

P'_t: Breakeven period
CI: Amount of cash influx
CO: Amount of cash outflow
$(CI – CO)_t$: Net cash value in t year
i_c: Fiducial rate of return

Appendix II

FINANCIAL ATTRIBUTES

Based on the costs of production activities for bamboo plantation, as well as the outputs mentioned above, the Annual Net Present Value is listed as follows (see table 7), and Benefit-Cost Ratio, Breakeven Period will be 94.91% and 5. 5.26 years respectively (Calculation of net present value refers to Appendix 1). The Internal Rate of Return will clearly be very high.

Table 7 the Annual Net Present Value($\times 10^3$ RMB Yuan)

Years	Net cash value	Net present value	Accumulation of net present value
1	-7.360	-6.815	-6.815
2	-3.380	-2.898	-9.713
3	-2.490	-1.977	-11.689
4	6.510	4.785	-6.904
5	7.510	5.111	-1.793
6	11.010	6.938	5.145
7	11.010	6.424	11.569
8	11.010	5.948	17.518
9	11.010	5.508	23.025
10	11.010	5.100	28.125
11	11.010	4.722	32.847
12	11.010	4.372	37.219
13	11.010	4.048	41.268
14	11.010	3.748	45.016
15	11.010	3.471	48.487