**INTERNATIONAL NETWORK FOR BAMBOO AND RATTAN**
**(INBAR)**

TRANSFER OF TECHNOLOGY MODEL
(TOTEM)

# RATTAN POLE STEAM BENDING

Produced 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 r**attan pole steam bending** has been produced at the Forest Products Research and Development Institute (FPRDI), Laguna, Philippines. It may be used alone, or in conjunction with the TOTEM on the rattan oil curing, bleaching and preservation unit, which has been produced by the Forest Research Institute, Malaysia (FRIM) and the TOTEM on the rattan furniture manufacturing unit, which has been jointly produced by FPRDI and FRIM.

The report part of this TOTEM describes the technology for establishing a steam bending unit for rattan poles for rural development in regions where rattan 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 development attributes, benefits and applicability. The second part of the report provides detailed information on the technical aspects of steam bending rattan poles.

This TOTEM is one of the first to be produced by INBAR/ FPRDI and your feedback is most welcome - kindly contact INBAR or FPRDI 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 Philippine Pesos. At the time of writing P40 = USD $1

# STEAM BENDING RATTAN POLES AT-A-GLANCE

## Why steam bend rattan poles?

The production of bent components for rattan furniture and handicrafts is traditionally done by blowtorch. This process results in scorch or burn marks on the surface of the bent component and consequently reduces the quality and sale price of the products. The steam-bending technique eliminates such processing defects.

## How are poles steam-bent?

Rattan poles are first straightened using straightening jigs. After selection and grading they are then cut to length and steamed for up to 20 minutes, by which time they are very pliable. They are bent to shape in jigs where they are left for about 24 hours so the bend can set. They are removed, trimmed and can be used in furniture making.

## What is the role of a steam-bending unit in rural development?

A steam-bending unit is best established as a community venture supplying a range of small community-based processors and manufacturers. By providing employment opportunities the unit promotes individual and community development. Steam bending is an environmentally friendly means of bending poles, requiring only water and waste rattan to fuel the boiler.

## How do I establish a steam-bending unit?

A rattan pole steam-bending unit is relatively expensive to establish, but is also profitable. Initial capital investment of about USD$ 33, 000 is required, of which $ 9, 000 is for the cost of the steam bending equipment. A regular supply of good quality poles is also necessary, as is a secured, skilled workforce. As an intermediary processing stage in the manufacturing of end products, close linkages to the users of the bent poles will be vital to ensuring the unit is sustainable and profitable.

# PART ONE

# INTRODUCTION

## DEVELOPMENT ATTRIBUTES, TARGET GROUPS and BENEFITS of a

## RATTAN POLE STEAM BENDING UNIT

# 1. Introduction to steam bending

Rattan is one of the most important non-timber forest products (NTFP) in the Philippines. It is in great demand for furniture and handicrafts for local and overseas markets. The country's exports of rattan furniture alone averaged US$ 119 million per year from 1994-1998.

Rattan is a climbing palm with unique physical and mechanical properties. It is light and has good strength properties but the main attribute of the material that influences product designs and quality, whether in round pole or split form, is its flexibility. Round poles can be bent into various forms and shapes for the structural and decorative components of rattan furniture and handicrafts.

The bending of rattan poles into the desired shape is traditionally done with a blowtorch. This process produces scorch or burn marks on the surface of the bent items and this consequently degrades product quality and value. The most efficient bending method involves plasticizing the stocks for a suitable period in a steaming chamber prior to bending to the required shape with the aid of appropriate bending jigs. After this the bent pieces are dried to the required moisture content in restrained mode before product assembly. This is referred to as "steam bending".

The main equipment for steam-bending rattan poles that served as the model for this TOTEM was located inside the plant site at the Asia Rattan Manufacturing Company (ARMC), one of the four privately owned organizations that compose the AWECA group of companies based in Angeles City, Central Luzon. The ARMC and its sister companies have been the major beneficiaries of the technology transfer program of the FPRDI on rattan processing since 1987. ARMC cooperated in the documentation of the rattan pole steam-bending technology for this TOTEM.

# 2. General development attributes and advantages

The main development attributes of the technology are as follows:

- Provides employment to rural people
- Improves community welfare
- Empowers individuals through skills development

The main advantages of the technology are:

- Prevents surface damage to poles and maintains their quality
- Is far more productive than bending with a blowtorch
- Uses waste rattan to heat the water for the steam.

# 3. Target groups

The main target group are the people that will be employed in the unit. The unit requires mostly unskilled labour with a few technically trained personnel to maintain the steam bending equipment and the local rural people in the community in which the unit is established can provide the workforce. The unit can be established to secondary processing units, such as furniture making factories that can be established concurrently. If set up as a community cooperative the broader community will also benefit.

The nature of the work means that it is not so suitable for women. However women are involved in the quality control, sanding and other operations in the secondary processing units.

# 4. Scope for small enterprise development

The rattan pole steam-bending technology may be adopted by or transferred to any medium to large-scale rattan furniture and handicraft manufacturers in the urban or rural areas, particularly to those who are still using the traditional bending techniques or have limited knowledge of the technology. Most if not all the cottage or small-scale enterprises are employing the traditional rattan pole bending technique in their operation and there is considerable scope for the adoption of steam bending practices. The steam-bending unit can also be used/installed as a common service facility for groups of cottage or small-scale enterprises within a community.

# 5. Present limitations of the technology

The rattan pole steam-bending technology requires considerable capital for equipment and skilled labor. For this reason, presently the technology is only commonly used by the export oriented, medium to large-scale enterprises that mainly supply rattan furniture and handicrafts to the export market. However, as noted above, establishing the unit as a central facility for a number of small producers may be a feasible option.

# 6. Requirement for success

The essential requirements for a successful rattan pole steam-bending unit are:

- Adequate working capital
- Sustainable supply of good quality rattan poles
- Skilled operators
- Proper bending jigs to minimize undue breakage during the bending operation
- Proper linkages to the users of the bent components

# 7. Potential improvements and research needs

Considering the large investment required for installing steam-bending equipment, research should be done to develop less expensive equipment that is suitable for cottage and small-scale enterprises. The practicality of having common service steam-bending equipment for a group of cottage or small-scale rattan enterprises within a community also needs to be investigated.

# Concluding remarks

Rattan pole steam bending is an effective and efficient means of producing bent pole components for use in manufacturing furniture and other items. A steam-bending unit may be established as an integral part of a furniture-making unit or may be established separately. In the latter case proper linkages to the secondary processors who use the bent pieces will be necessary to ensure sustainability of the enterprise.

# PART TWO

# THE RATTAN POLE STEAM BENDING UNIT

# 1. Introduction

Rattan poles are steam-bent by the following basic steps

- Pole selection
- Pole straightening
- Cutting poles to length
- Pole steaming
- Pole bending in jigs
- Drying

# 2. Principles and processes of steam-bending

All rattan species are resilient to some extent when bent if the raw material is properly selected and processed. However, in designing rattan products with curved components it is important to consider at the outset the bend tolerance or smallest degree of curvature to which a certain species can be safely bent. This may be based on previous studies, experience, earlier designs or by trial bending. Forcing the rattan to bend beyond its tolerable radius of curvature results in a high percentage of raw material wastage or rejects during the bending process, due to failures or breakages.

Smaller diameter rattan poles are more pliable and have shorter bending radii than large diameter poles. In general, good quality and sufficiently softened rattan can be bent to a minimum radius of curvature 3 to 4 times the pole diameter.

The moisture content (MC) and quality of the raw materials are also important factors for successful bending operations. Rattan poles suitable for bending are usually dried to MC levels of around 18-20 percent. Wet or green poles are easier to plasticize and bend, but they need a longer setting period. On the other hand, very dry poles require longer period of steaming or heat treatment to become semi-plastic.

High-grade rattan poles are preferred for bending. High-grade poles are mature and free from fungal stains and pinholes caused by insect attack or drying defects such as surface checks and end-splits. Low-grade rattan poles are prone to premature fractures even with slight bending. Immature poles or the top portion of the cane are susceptible to bending compression failures and collapse during drying.

**The major steps involved in rattan pole steam bending are as follows:**

**Step 1.** Select appropriate materials to use.

Be sure to pick a suitable species and the right sizes of canes or poles. Ensure the canes are mature and free from fungal stains, pinholes and surface checks (damage). Dry the material to MC of 18 to 20 percent.

**Step 2.** Straighten the poles by the following procedure:

First, soften the poles by steaming (a blowtorch may be used but is less desirable). This is done to be sure that when the force applied to straighten the poles is released, the poles will not return to their original shape.

Next, straighten the poles manually if there is no straightening machine. Pass the softened pole through a straightening jig. The jig is a straight block of wood of the desired length and about 10.16 cm (4 in) wide and 10.16 cm (4 in) thick on which approximately equidistant square grooves are made. It rests on a stand for the convenience of the user. Each bent or crooked pole is passed through a groove with firm pressing and tugging motions against the sides to straighten the pole.

**Step 3.** Poles should be sorted by size if unscraped poles are required for the end product. If scraped poles are required, feed the poles into a sizing machine for scraping. To obtain uniform-diameter poles next smooth the surface by sanding with 80 followed by 120 then 160 grit abrasive paper.

It is best to have poles of uniform diameter and with smooth surface for bending. Uneven surfaces caused by nicks and nodal bumps or depressions induce buckling and compression or tension failure during bending.

**Step 4**. Cut the poles to the required lengths, allowing sufficient extra for trimming the bent component.

**Step 5.** Soften or plasticize the bending stocks by steaming to facilitate bending.

Steaming is done in an enclosed chamber with a temperature of $100^0$C under atmospheric pressure. The steaming period varies with the species, moisture content, diameter of the pole and degree of curvature required. A rough guide for determining the length of steaming time is:

**One-half to one minute steaming per millimeter of pole diameter gives satisfactory plasticization of stocks with 18-20% MC.**

The steaming chamber should be designed to ensure uniform heating throughout the whole cane piece - that is, throughout its length and from the outside to the core of the pole, without affecting the strength properties.

The poles may be steamed in bulk but avoid crowding so that the heat is evenly distributed.

**Step 6.** Remove the poles from the steaming chamber one at a time and immediately bend each one manually or by mechanical means.

Hand fashioning of bends is usually done with bending forms or jigs.

Bending jigs are made of wooden or metal blocks shaped to the desired form of bend. They are used to hold the bending stock and serve as guides for controlling the bending operation. The use of jigs ensures uniform curvature in the bends.

The procedure for bending with jigs is as follows:

First, lay and bolt the jig on the bending bench. Bolting allows the jig to be moved sideways or adjusted for other forms of bends without dismantling. This cannot be done if the jig is nailed to the bending bench.

Next, secure one end of the pole where bending will start and slowly force the pole against the jig to follow its contour.

Slightly overbend the pole to give allowance for spring back.

**Step 7**. Fix and set the bend.

Place restraining attachments on the ends to prevent springback by tying them together. This is called fixing the bend.

Allow the bend to cool and dry. This is the setting period.

The setting period of the bend depends upon the species, size or diameter of the pole, MC of the material, room temperature, and radius of curvature. The bend sets in about 24 hours under ordinary room conditions.

**Step 8.** Remove the restraining attachment and adjust the bend to the required or correct curvature following a set pattern. To facilitate adjustment, soften the pole by passing a blowtorch 3 to 4 times over the bent portion for about 25 to 30 seconds.

**Step 9.** Trim any excess from the ends of the bent piece.

The bent piece is now ready for product assembly.

# 3. Cost and Profitability Analysis

All calculations in the financial analysis are given in Philippine Pesos (P). Note that it is difficult to split the steam bending technology from the furniture manufacturing unit of which it was a part in the example used here, and some of the financial information provided reflects this. The exchange rate at the time of writing is P40 = US$1 and assumptions used in the financial analysis are shown in the **Appendix**.

## 3.1 Investment Cost

An initial investment of P1.2 million is required to start a rattan furniture making enterprise for a minimum production of 500 chairs per month, if a rattan steam conditioning facility is integrated in the processing system (Table 1). This amount includes a fixed investment of P372, 380.00 (Table 2) which covers the necessary tools and equipment and a steam conditioning facility valued at P325, 000.00. Working capital is estimated at P880, 000.00, which covers inventories for raw materials, labor costs, and accounts receivables covering a minimum number of days. The pre-operating cost is estimated at 10% of fixed investment or P37, 238.00. These include expenses for licenses, registration and other standard operating procedures, and other expenses for preparation of the business or enterprise.

Of the P1.2 million investment cost, it is assumed that 60% of the project cost is loaned and 40% is from the owners (or community organisations) equity.

Table 1. Projected Initial Investment

| Investment | Cost |
|---|---|
| Fixed Investment | |
| Equipment | 372,380.00 |
| Working Capital | 881,037.00 |
| Pre-operating Cost | 37,238.00 |
| Total Investment Cost | 1,290,655.00 |

## 3.2 Production Costs

Production cost per chair is estimated at P1,160.00. The product can be sold at P1,500.00 per chair. The price can reach P3,000.00 depending on the accessories and finishing materials used. Annual production cost is estimated at an average of P5.7 million (Table 3).

**Table 2. Fixed Investment Costs**

| Equipment | No. of Units | Source | Unit Cost | Total Cost |
|---|---|---|---|---|
| 1. Framing jigs | 4 | Fabricated | 1,000.00 | 4,000.00 |
| 2. Tacker | 1 | Purchased | 4,000.00 | 4,000.00 |
| 3. LPG tank with blow torch | 1 | Purchased | 7,000.00 | 7,000.00 |
| 4. Hammer | 4 | Purchased | 120.00 | 480.00 |
| 5. Table with metal | 4 | Purchased | 1,000.00 | 4,000.00 |
| 6. Metal scraper | 2 | Purchased | 25.00 | 1,000.00 |
| 7. Long nose pliers | 4 | Purchased | 100.00 | 400.00 |
| 8. Hacksaw | 2 | Purchased | 150.00 | 300.00 |
| 9. Electric drill | 2 | Purchased | 5,000.00 | 10,000.00 |
| 10. Air compressor with accessories | 1 | Purchased | 10,000.00 | 10,000.00 |
| 11. Blow torch | 4 | Purchased | 1,500.00 | 6,000.00 |
| 12. Knives | 4 | Purchased | 50.00 | 200.00 |
| 13. Steam conditioning facility | 1 | Fabricated | 325,000.00 | 325,000.00 |
| **Total fixed investment** | | | | **372,380.00** |

**Table 3. Annual Production Cost Estimate**

| **Year**<br>**Production capacity** | **1**<br>**100%** | **2**<br>**100%** | **3**<br>**100%** | **4-10**<br>**100%** |
|---|---|---|---|---|
| 1. Raw materials | 2,302,200 | 2,302,200 | 2,302,200 | 2,302,200 |
| 2. Factory supplies | 521,500 | 521,500 | 521,500 | 521,500 |
| 3. Maintenance cost | 3,250 | 3,250 | 3,250 | 3,250 |
| 4. Direct Labor | 2,712,500 | 2,712,500 | 2,712,500 | 2,712,500 |
| 5. Factory Overhead | | | | |
| 6. Administrative Exp. | 37,700 | 37,700 | 37,700 | 37,700 |
| 7. Financial cost | 156,942 | 104,628 | 52,314 | - |
| 8. Depreciation cost | 37,428 | 37,428 | 37,428 | 37,428 |
| 9. Selling expense | 110,000 | 110,000 | 110,000 | 110,000 |
| **Total Cost of Production** | 5,881,520 | 5,828,206 | 5,775,892 | 5,723,578 |

cost per piece: 1,160.00
selling price: 1,500.00

### 3.3 Profitability

Projected Income Statement (Table 4) and Cash Flow Statement (Table 5) were used in analyzing the profitability of rattan steam bending for furniture making. Sales revenue is estimated at P7.5 million per year. Average annual net profit after tax is estimated at P1.6 million or P133,000 per month.

Net Present Value (NPV) is positive with a value of P6,188,272 and Internal Rate of Return (IRR) of 270%. Return on investment is 4.95 and cash payback period is 0.7962. or 9 months.

Breakeven point sales volume (BEPSV) was computed at 220 chairs per month while break-even selling price was computed at P1,120.00

The assumptions used in the profitability analysis are presented in the **Appendix**.

**Table 4. Projected Income Statement**

| **Year**<br>**Production Capacity** | **1** | **2** | **3** | **4-10** |
|---|---|---|---|---|
| Sales Revenue<br>(1,000 @ 5000 chairs) | 7,500,000 | 7,500,000 | 7,500.000 | 7,500,000 |
| Less: Cost of Sales | | | | |
| Raw materials | 2,302,200 | 2,302,200 | 2,302,200 | 2,302,200 |
| Factory Supplies | 521,500 | 521,500 | 521,500 | 521,500 |
| Direct Labour | 2,712,500 | 2,712,500 | 2,712,500 | 2,712,500 |
| Factory Overhead | 37,700 | 37,700 | 37,700 | 37,700 |
| Maintenance Cost | 3,250 | 3,250 | 3,250 | 3,250 |
| Depreciation Cost | 37,248 | 37,248 | 37,248 | 37,248 |
| Gross Profit | 1,885,602 | 1,885,602 | 1,885,602 | 1,885,602 |
| Less: Operating Expenses | | | | |
| Adm. Expense | 156,000 | 156,000 | 156,000 | 156,000 |
| Selling Expense | 110,000 | 110,000 | 110,000 | 110,000 |
| Operating Profit | 1,619,602 | 1,619.602 | 1,619,602 | 1,619,602 |
| Less: Financial Cost | 156,942 | 104,628 | 52,314 | -00,000 |
| Net Profit Before Tax | 1,572,660 | 1,514,974 | 1,671,916 | 1,619,602 |

ROI = 4.95

**Table 5. Projected Cash Flow Statement**

| Year | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| **Production Program** | | **100%** | **100%** | **100%** | **100%** | **100%** |
| Cash Inflow | | 7,500,0000 | 7,500,000 | 7,500,000 | 7,500,000 | 7,500,000 |
| Sales Revenue | | 7,500,0000 | 7,500,000 | 7,500,000 | 7,500,000 | 7,500,000 |
| Cash Outflow | 409,618 | 6,607,615 | 5,831,206 | 5,778,892 | 5,726,578 | 5,726,578 |
| Fixed investment | 372,380 | | | | | |
| Pre-Operating Expense | 37,238 | | | | | |
| Working Capital | | 881,037 | | | | |
| Operating Cost | | 5,616,578 | 5,616,578 | 5,616,578 | 5,616,578 | 5,616,578 |
| Marketing cost | | 110,000 | 110,000 | 110,000 | 110,000 | 110,000 |
| Interest Expense | | 156,942 | 104,628 | 52,314 | | |
| Net Cash Flow | (409,618) | 892,385 | 1,668,794 | 1,721,108 | 1,773,422 | 1,773,422 |
| Net Present Value (NPV) | | 6,188,274 | | | | |
| Benefit Cost Ratio (BCR) | | 1.24 | | | | |
| Internal Rate of Return (IRR)) | | 270% | | | | |
| Return of Investment (ROI) | | 4.95 | | | | |

# 4. Implementation

## 4.1 Variability of raw materials

The commonly used rattan species for making bent furniture structural components are palasan (*Calamus merrillii*) and limuran or kalape (*C. ornatus var. philippinensis*). Canes of these species attain more than 5 cm in diameter. Depending on the size and grade the cost is about P40 per pole for lengths between 3.3-4 meters (10-12 ft).

There are other large-diameter rattan poles used to a limited extent derived from lesser known species including labsikan (*C. marginatus*), saba-ong (*C. grandifolius*), ulisi (*C. aidae*) and kumaboi (*C. discolor*). The last three species have relatively higher density and shorter internodes compared to the commercial or traditionally used species. These are also susceptible to surface checks. For these reasons, they are classified as difficult to bend and so the poles are cheaper.

## 4.2 Institutional support in the Philippines

Institutional support to backstop development of the unit is extremely important. It is useful to relate the experiences of the AWECA group of companies from Angeles city in the Philippines. They have good links with FPRDI and other support institutions through the Asian Rattan Manufacturing Company (ARMC). Since 1987, FPRDI has been providing technical assistance to the company on "call or official request" basis or through a memorandum of agreement (MOA) depending on the nature of assistance needed (i.e. in-plant training, equipment design and installation, consultancy or advisory services). These include technologies on rattan pole steam-bending, pole/wicker drying, bleaching and finishing. A wood-rattan waste-fired Fluidized-Bed Combustor as a source of heat for steaming and drying purposes was also installed in their plant with the assistance of FPRDI. In line with the FPRDI technology transfer program, the rattan steam-bending technique evolved in 1988 into the manufacture of steam-bent wood components for rattan furniture (seat frames, back legs, rockers, etc.)

## 4.3 Marketing system

The ARMC or AWECA as a whole is an export-oriented large-scale enterprise. As such, it has established marketing linkages and product outlets in US, Europe, Australia and other foreign markets. Aside from secondary sources of marketing information the company has regular staff tasked with marketing operations and monitoring changes in product designs and market trends, locally and internationally.

Product designs, type of finishes and packaging system are normally dictated by the buyers. However, the company continues to develop new designs of products for exhibit in local and foreign trade fairs in order to create new market outlets and diversify its product lines.

## 4.4. Environmental aspects

The company's operation is characterized by great concern for environmental protection and safety standards for its workers. Among actions and strategies being implemented in relation to environmental concerns are the following:

**Waste disposal.** All processing wastes (wood or rattan) are used as fuel in their steam-boilers and Fluidized-Bed Combustor.

**Smoking ban**. This policy is strictly enforced inside the plant to prevent fire accidents and safeguard the health of the workers.

**Environmental Clearance Certificate (ECC**). The company has an ECC issued by the Department of Environment and Natural Resources which certifies that their operation conforms to necessary environmental policies and standards.

**Tree and rattan plantation development.** To augment its raw material supply the company is currently managing 600 hectares of industrial tree plantation in the province of Tarlac, Central Luzon. Wildings of rattan are interspersed with the tree plantation for future use. Half of their 15-hectare Malino Plant Site is also planted with fast-growing hardwood species to ameliorate environmental condition and scenery around the area.

## 4.5. Policy aspects

In the Philippines, the technology of rattan plantation development has been recently commercialized. This has prompted the government to prepare policies and guidelines on rattan plantation establishment in different parts of the country. The commercial or massive development of plantation, together with the ban on the export of rattan poles from the country, is expected to broaden the resource base and enhance sustainable operation of the rattan industry.

Since the forest-based industry in the Philippines is allowed to export only finished products, the production and utilization policies may, to some extent, promote the intensified use of the rattan steam bending technology in the industry to strengthen its competitiveness in the global market.

## 4.6 Transferability of the technology

The technology involves the mass production of high quality rattan bentworks for furniture and handicrafts components to improve productivity and reduce unit cost of production. However, this requires skilled labour, adequate and sustainable raw materials and high investment costs. These features of the technology indicate its suitability mainly for the medium to large-scale rattan processors and product manufacturers. However, rattan pole steam-bending equipment can be used as a common service facility by a group of cottage or small-scale rattan furniture or handicraft manufacturers within a particular community to distribute the cost of the equipment and optimize its operation.

# APPENDIX

## Appendix. Assumptions used in the financial analysis

1. The product produced is a club chair.

2. Production is 500 pieces per month.

3. The level of production is small to medium scale

4. The average number of working days is 25 days per month with one shift operation only.

5. The average output per worker is 5 chairs per day.

6. The average time for conditioning poles is 20 minutes.

7. Water consumption using the steam bending method is 21 kg/hr at P180 per cu.m. Steam conditioning of the bent poles required for 500 club chairs takes 3 days. The total volume of water consumed for feed water is estimated at P90.72 per month.

8. Woodfuel consumption for steam conditioning is P820.00 per month.

9. Nineteen workers are required and are paid on a piecework basis. Around 3-8 workers are involved in the bending operation depending on the schedule of production; whilst the rest are employed in secondary processing operations such as drying of bentworks, adjustment of bends for final shape and other operations needed before or during product assembly.

10. Average selling price is P1,200 per chair. The chair can be sold at a higher price of P3,000.

11. Production is 10 months a year only due to holidays and lean months of production.

12. Depreciation is estimated for 10 years.

13. Maintenance cost is based on 10% of depreciation cost of the steaming facility.

14. Land and building are assumed to be leased or rented at P5,000 per month.