Technical / Economic Analysis of Bamboo Fiber in Pulp and Paper Manufacture

Part I. Economics of growing bamboo in a plantation for biomass production

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Study in Two Parts

- **Part 1**
  - ***Economics of Growing Bamboo in a plantation***
- **Part 2**
  - ***Economics of Using Bamboo in an Uncoated Freesheet Mill***

Growing Bamboo

1. **Must know how a specific bamboo species grows in a specific geography, to predict delivered cost:**
   - ***Growth Rate, Harvesting and Chipping costs establish the cost at the plantation***
   - ***Delivery cost will depend of the distance from the plantation from the customer mill***

2. **Price - based on value to the customer – should be greater than $70 per BDT**

3. **At reasonable land prices and bamboo growth rates, an investor can earn >8% Internal Rate of Return**

Economic Model of Growing Bamboo in a Plantation

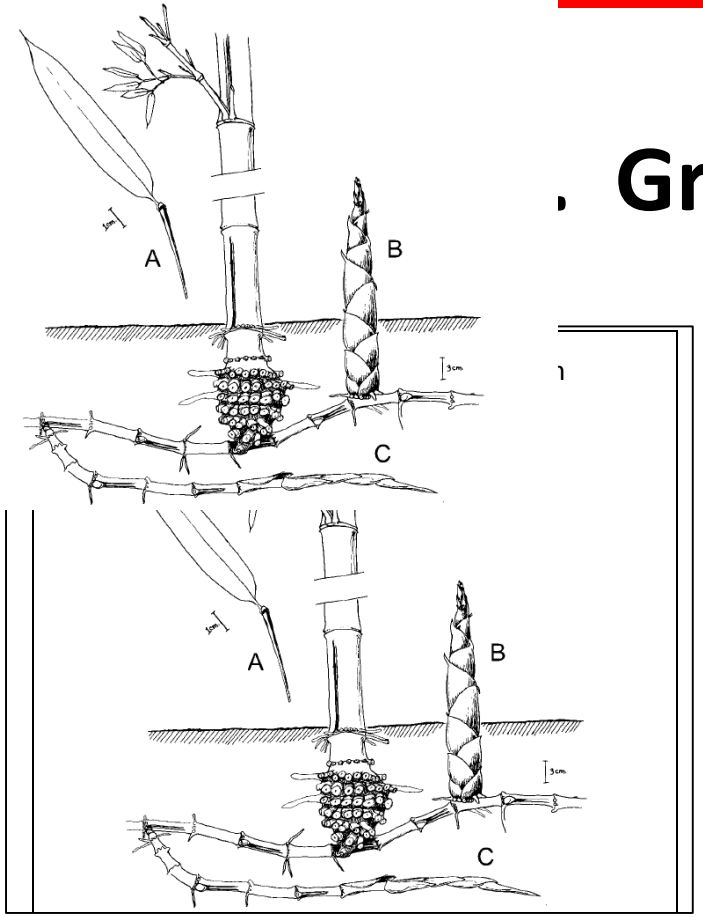
- **Three input parameters matter**
  1. ***Delivered Price of Bamboo chips to a pulp mill ($ per BDT)***
  2. ***Bamboo Growth Rate (BDT per Acre per Year)***
  3. ***Cost of Land (Own or Rent, $ per Acre)***

- **The expected return to the plantation owner will determine the range of the input parameters that can meet the financial expectations:**
  - ***8% Internal Rate of Return (Own)***
  - ***$150 per Acre EBIT (Rent)***

- **Plantation financial model were prepared to determine if reasonable input assumptions result in acceptable financial returns**

Outline

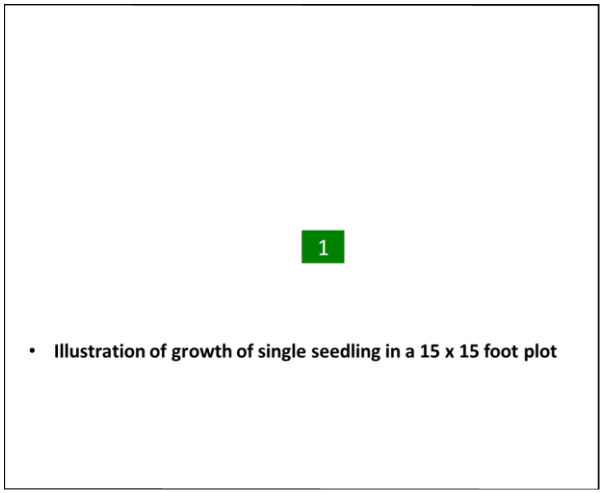
1. Growing Bamboo
2. Worldwide Bamboo fiber utilization
3. Plantation Model
4. Results
5. Conclusions

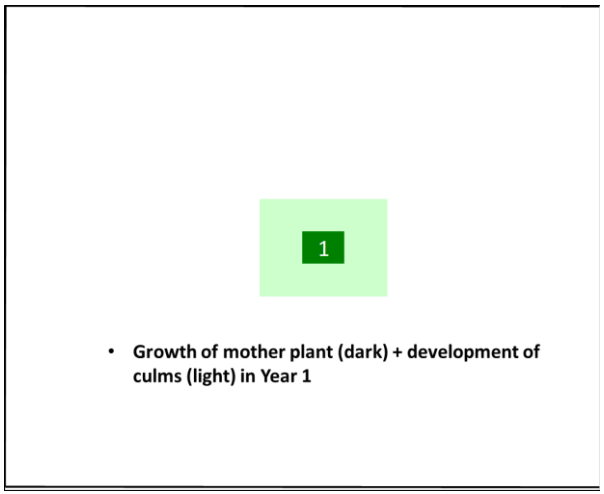


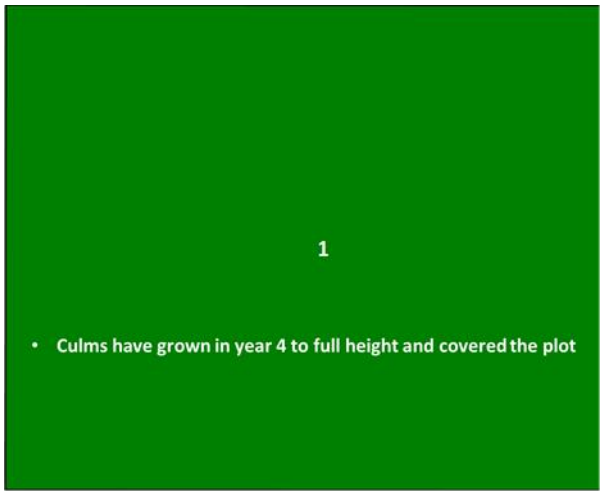
Growing Bamboo

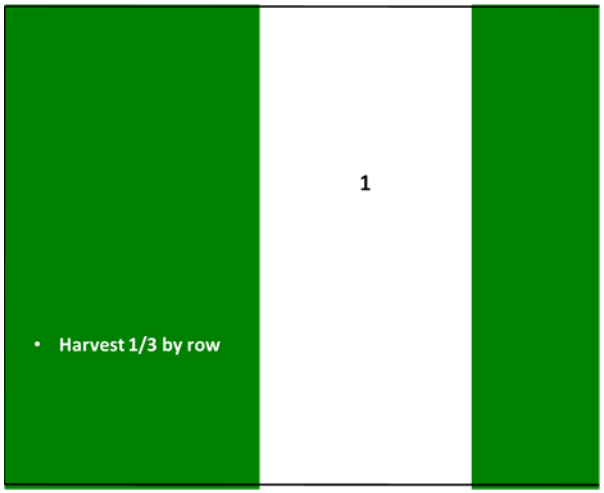
- Above ground growth in form of a culm, below ground growth of 10-20 feet from seedling in the form of rhizomes
- A bamboo seedling will grow to full 40-60 foot culm height in a single year
- Will also produce 10-20 shoots in a year, which can grow the next year to become new culms
- Typically plant ~200 seedlings per acre, at 15 foot spacing in all directions
- If left unmanaged, the old growth will crowd out the new growth and overall yield per acre will be sub-optimal and will make harvesting inefficient
- Flowering is not predictable but generally not an issue for 100 years

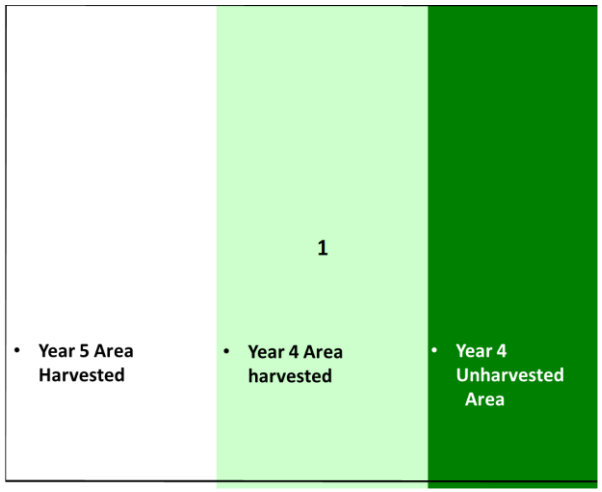
Bamboo Growth / Harvest

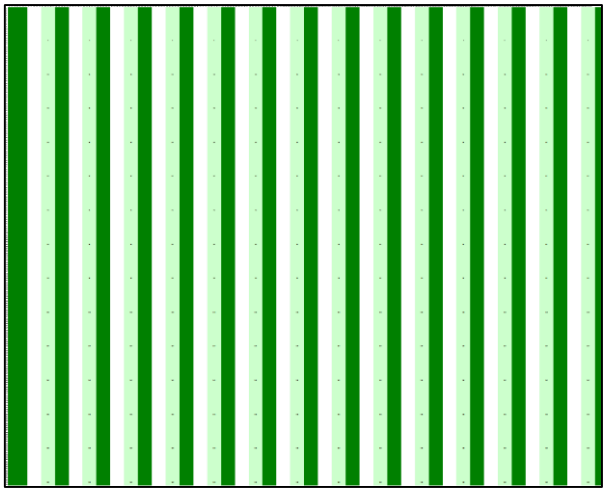






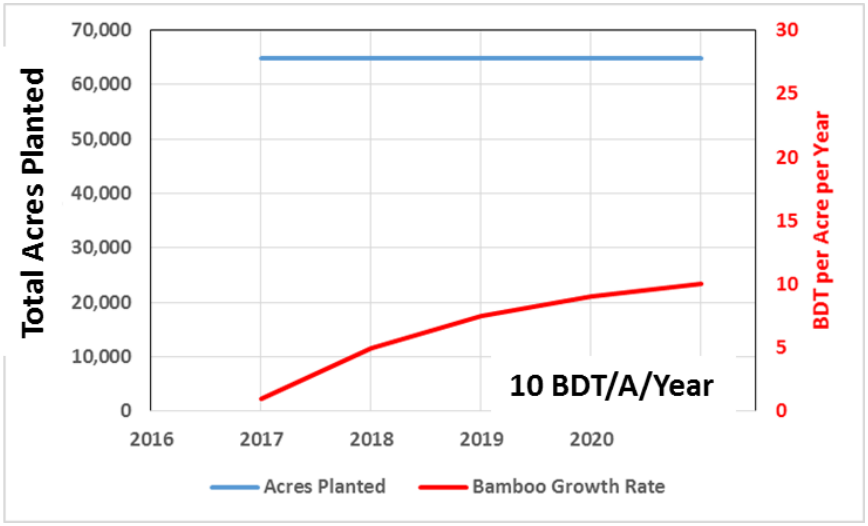


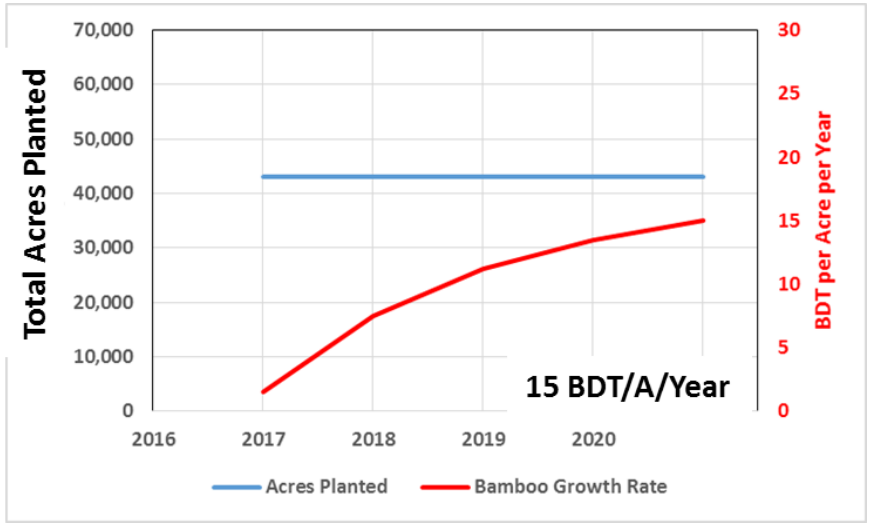


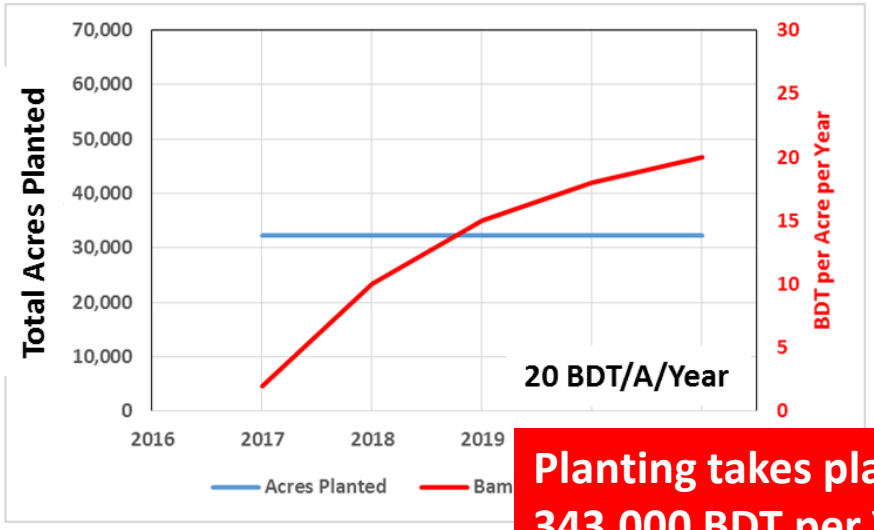


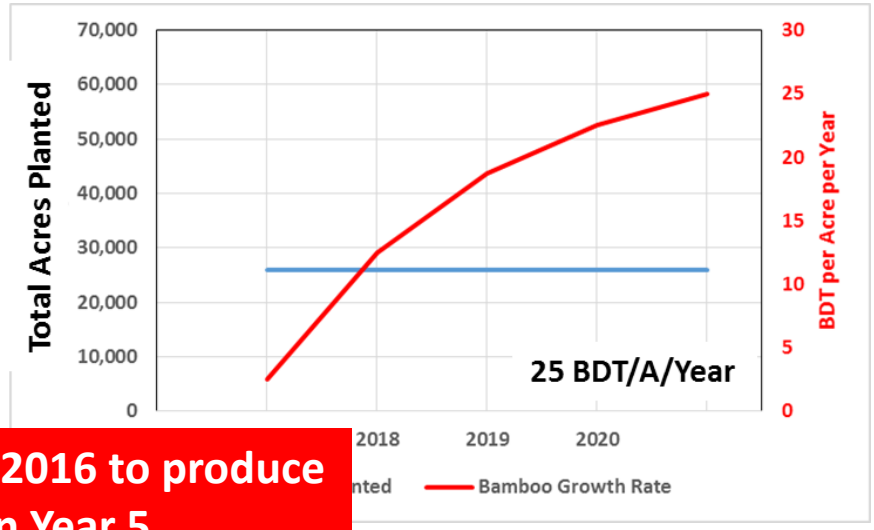
Growth Rates vary widely by soil and climate

Growth Rate determines production and land area





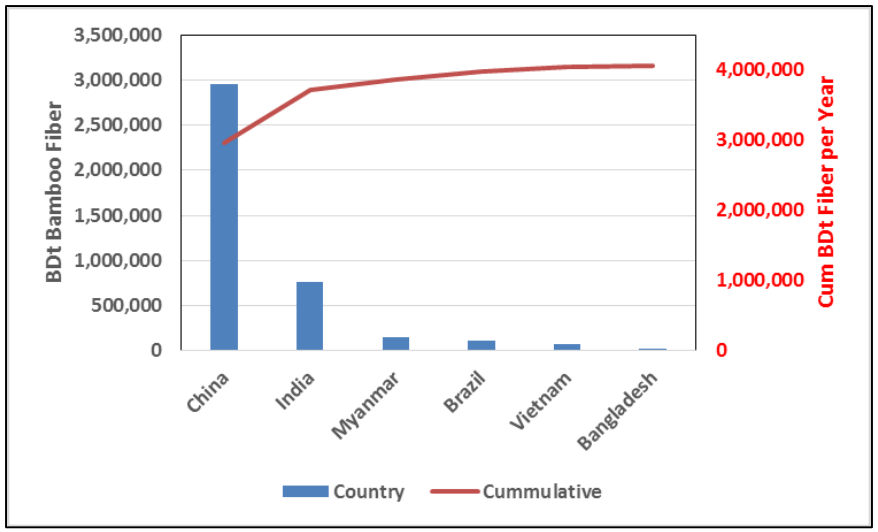




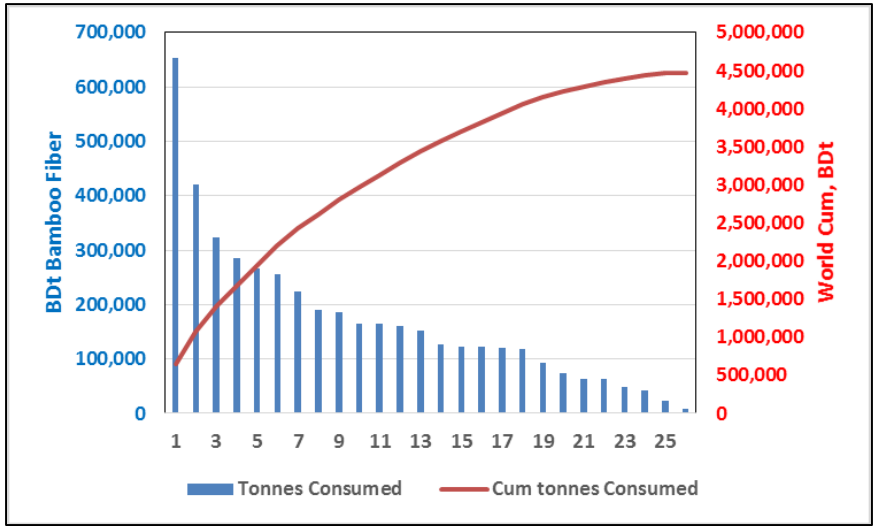
Planting takes place in 2016 to produce 343,000 BDT per Year in Year 5

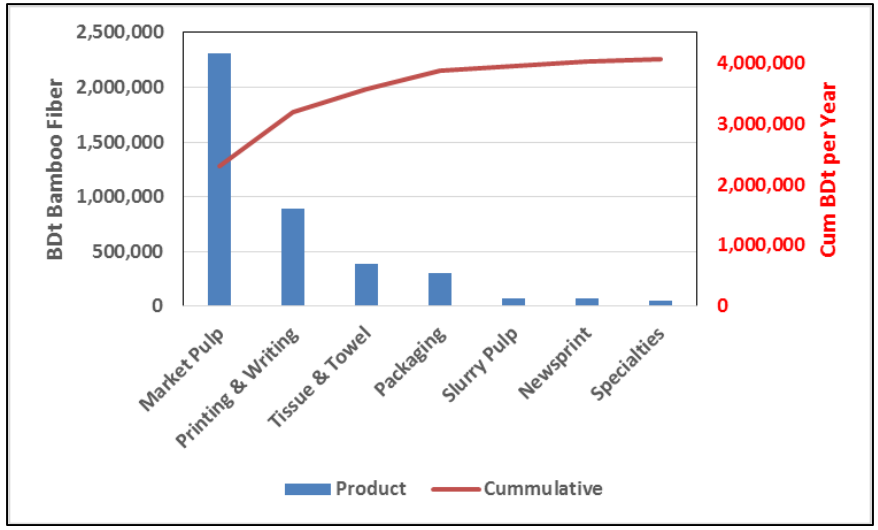
Source: FisherSolve

2. Worldwide Bamboo Utilization



- ~ 4 Million Metric Tonnes (t) consumed Worldwide
- 90% in China and India
- Largest consumer is the Chinese Taisheng – Chishui City market pulp mill
- ~ 1 Million t consumed in P&W papers





3. Plantation Model Preparation

- **Revenue**
  - ***Chips for pulp mill consumption***
- **Input costs**
  - ***Land (rent or buy)***
  - ***Seedlings (tissue culture seedlings)***
  - ***Land (composite North Carolina / South Carolina costs)***
  - ***Chemicals (fertilizer, herbicide, pesticide)***
  - ***Labor (planting, harvesting, maintenance)***
  - ***Rentals (tilling, planting, harvesting and chipping equipment)***
  - ***Freight (delivery to a pulp mill)***
- **Key Input Assumptions**
  - ***Land Cost ($800 - $1,200 per Acre)***
  - ***Land Rental ($50 - $150 per Acre per Year)***
  - ***Growth Rate (10 – 25 BDT per Acre per Year***
  - ***Seedling Cost ($1.00 per Seedling***
  - ***Many other assumptions of minor impact***

Critical Input Assumptions

Land Calculations	
Mass of bamboo pulp chips needed at 100% capacity	343,000
Maximum Growth Rate, BDT/A/Y	25
Acres needed for Growth	43,326
% Buffer	20%
Total Acres Purchased	54,158
Distance between furrows, feet	15
Distance between Plants, feet	15
Total Seedlings Planted per Acre	194

EXAMPLE

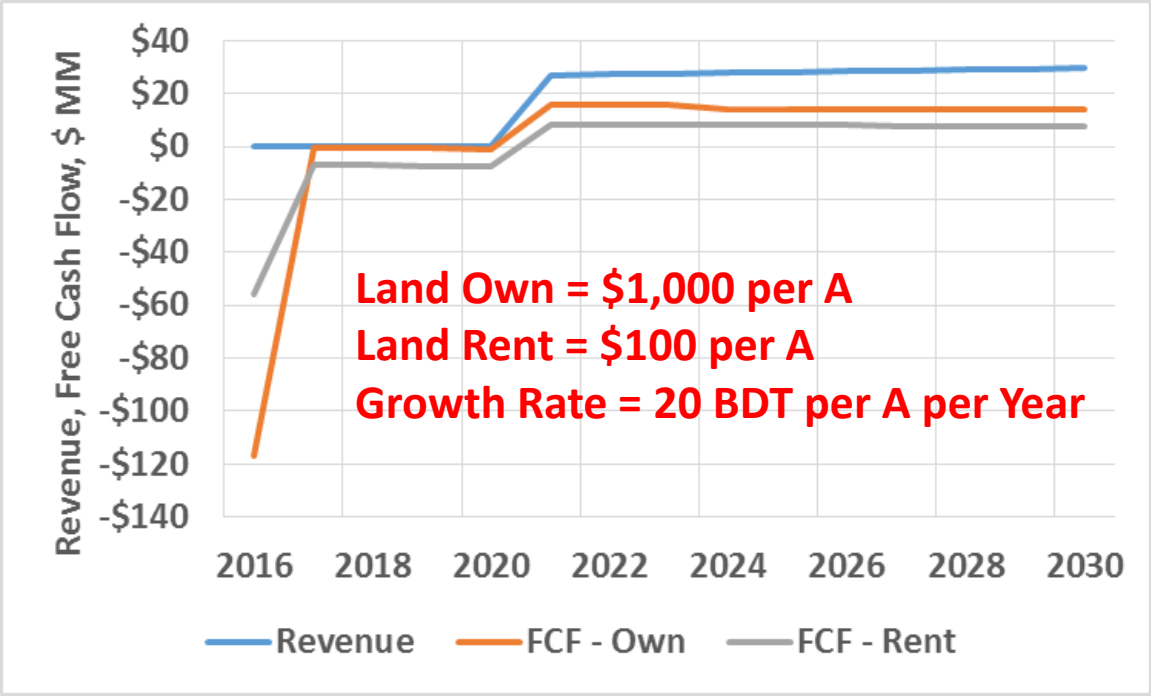
- Demand set by pulp mill customer base
- Modeled to produce maximum output in Year 5
- Growth Rate varied (10-15-20-25 BDT per A per Y)
- 20% of land set aside as buffer and/or future expansion
- Desired seedling spacing sets the Planting density
- Planting density sets the seedlings purchased (10% mortality)

Growth Rate Ramp Up

Growth Calculations			
Years to Achieve Maximum Growth	4	Years	
1	10%	2.0	BDT Growth per Acre
2	50%	10.0	BDT Growth per Acre
3	75%	15.0	BDT Growth per Acre
4	90%	18.0	BDT Growth per Acre
5	100%	20.0	BDT Growth per Acre
6	100%	20.0	BDT Growth per Acre
7	100%	20.0	BDT Growth per Acre
8	100%	20.0	BDT Growth per Acre
9	100%	20.0	BDT Growth per Acre
At the end of Year 9, each harvested area is plowed, refertilized and re-grown from the rhizomes of adjacent areas: 10% re-seeding	100%	20.0	BDT Growth per Acre

EXAMPLE

Example Financial Results

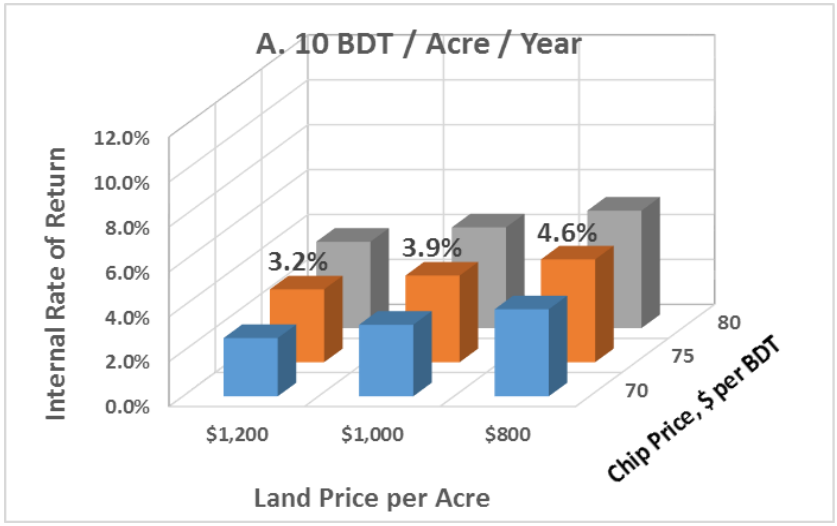


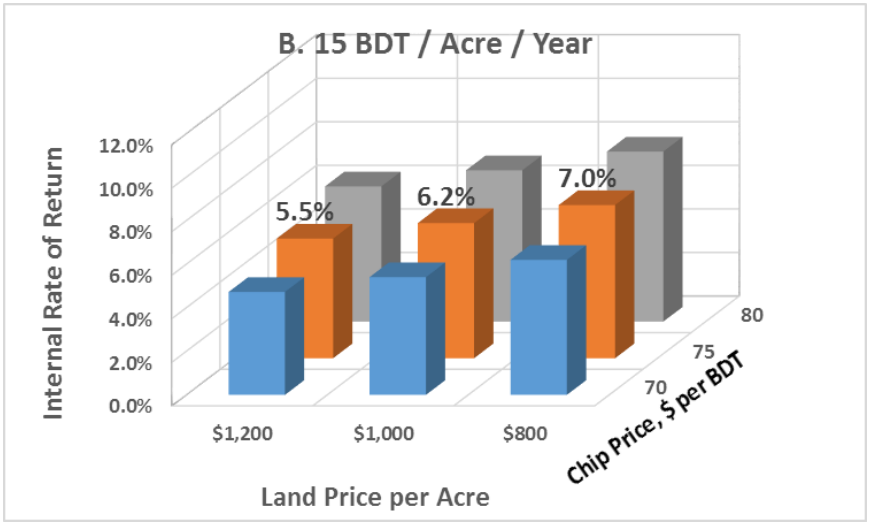
- "Own" Case experiences high negative cash flow in Year 0 due to Land Cost and Establishment Cost
- "Rent" Case has same Establishment Costs in Year 0, but continued rental cost in all future years

	Buy	Rent
Net Present Value, $ Millions	$12.1	-($20.6)
Internal Rate of Return, %	8.7	5.5
Year 10 EBITDA per Acre	$200	$116

4. Results

Land Purchase



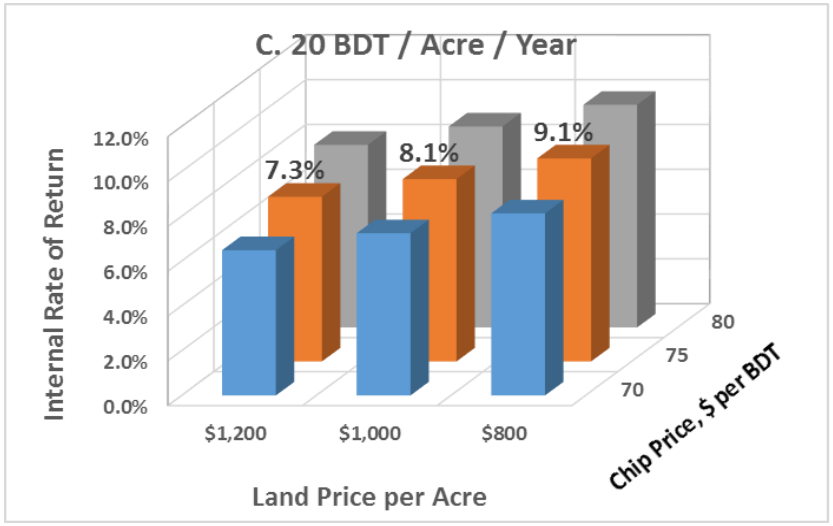


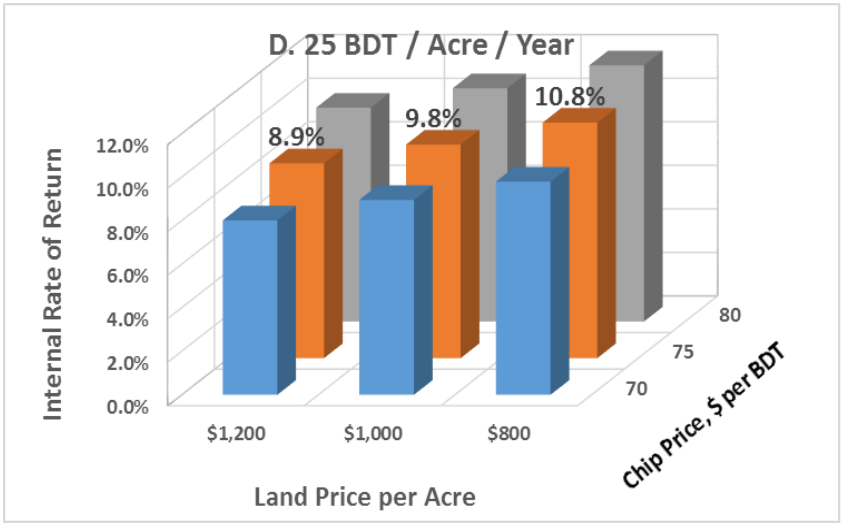
- **At 10 BDT per Acre per Year, no combination of Land Price and Chip Price will yield >8% IRR**

- **At 15 BDT per Acre per Year, no combination of Land Price and Chip Price will yield >8% IRR**

Results

Land Purchase

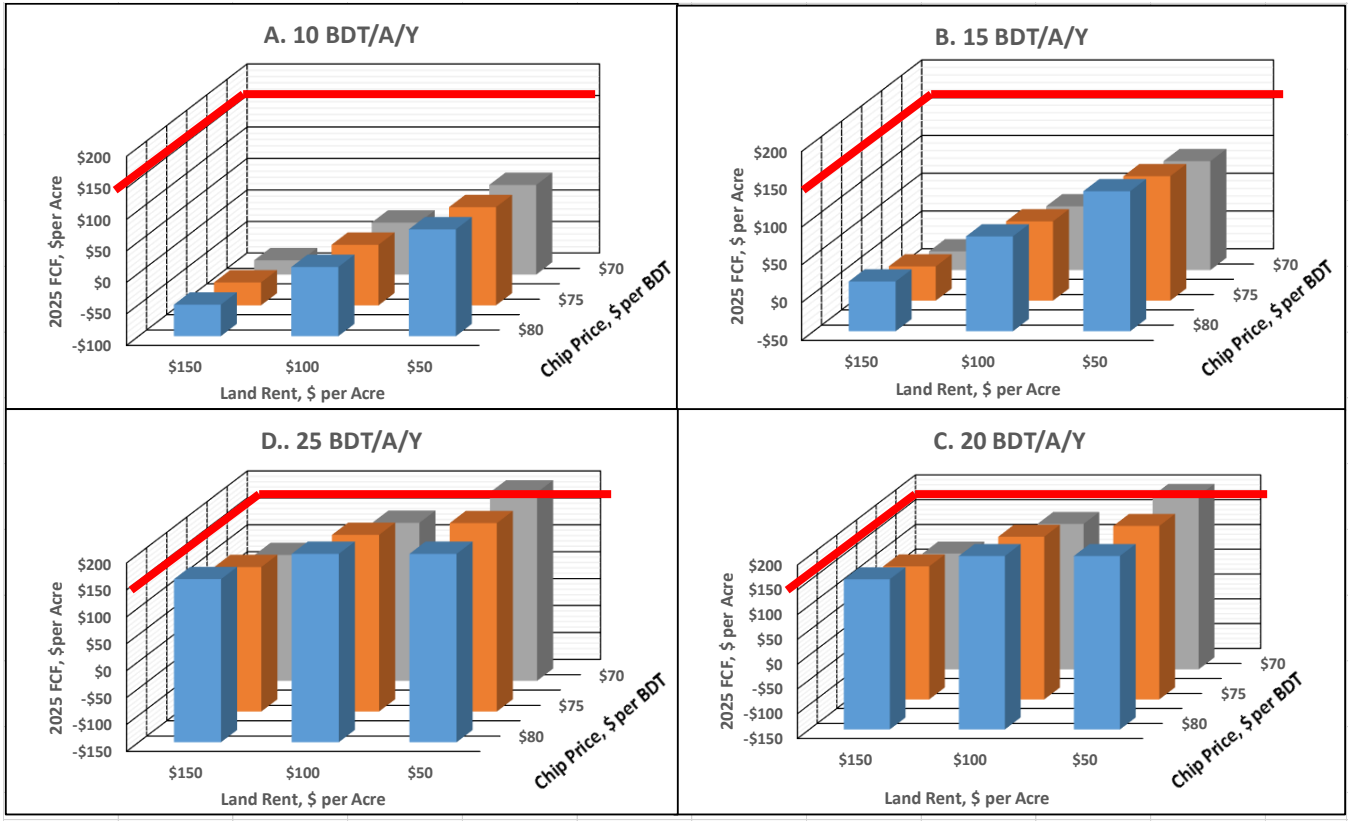




- **At 20 BDT per Acre per Year, Chip Price >$75 per BDT will yield >8% IRR**
- **At 25 BDT per Acre per Year, most combinations of Land Price and Chip Price will yield >8% IRR**

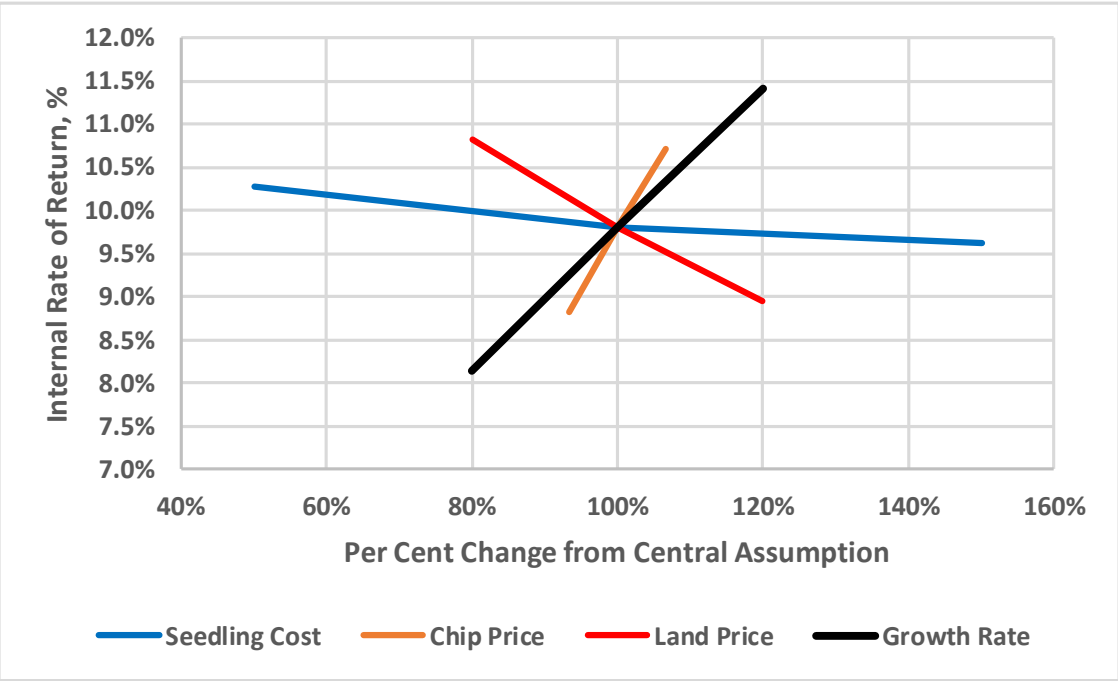
Results

Land Rent



- **Rental economics are expressed as 2025 (Year 9) Free Cash Flow per Acre to compare returns against alternative agricultural crops**
- **Typically, $150 per Acre is reasonable target for crops**
- **Only most optimistic conditions meet that target**

Sensitivity Analysis – Land Own



	Central Assumption
Growth Rate	25
Chip Price	$75.00
Land Price	$1,000
Seedling Cost	$1.00

- Chip Price most impactful assumption
- Land Price and Growth Rate are also high sensitivity
- Seedling cost relatively unimportant

Summary

1. **Bamboo chip price is the most important financial driver of success. At >$75 per BDT delivered price for bamboo chips to a kraft pulp mill, most scenarios yield attractive returns.**

2. **Growth rate greater than 20 BDT per Acre per year is necessary, even with chip prices >$70 per BDT, for satisfactory returns.**

3. **Growth rates are species – specific and geography – specific and must be determined in actual plantation field trial setting.**

4. **Land Purchase (within the purchase price range studied) is better than leasing, though the latter option may be an acceptable interim strategy to reduce risk of the targeted growth rates not being met.**

Perspective

1. **The study points to "What Must happen" for an investor to risk establishment of a bamboo plantation, without having the input data to establish "What Will happen".**

2. **Actual data with selected species planted for maximum mass growth rate (versus structural, ornamental or pole purposes) are not available and field trials are not available to completely inform the financial model developed.**

3. **Additional work is also needed to determine the value bamboo might provide, and will be reported on in Part II.**

4. **What we will see is the potential is enormous, but will remain as potential until an investment is made to determine reality**

Acknowledgement

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