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Economic analysis of cultivation of bamboo (*Bambusa balcooa* Roxb. and *Dendrocalamus stocksii* Munro.) in Konkan belt of Maharashtra, India

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ABSTRACT : The past decade has seen an increasing impetus of growing bamboo in India. There has also been an increase in availability of micropropagated plantlets in substantial quantities. Both the reasons combined is making farmers explore bamboo cultivation as an alternative to traditional agriculture and horticulture crops. In this stusy, the economics associated with growing two bamboo species viz. *Bambusa balcooa* Roxb., a relatively new addition in the Konkan belt of Maharashtra and *Dendrocalamus stocksii* Munro., traditionally grown bamboo species in the region have been studied. The study projects that the potential of economic benefit from *D. stocksii* (₹ 2,28,473 or \$3,147 ha^{-1} $year^{-1}$) which is relatively greater than that of *B. balcooa* (₹ 1,99,715 or \$2,752 annually $ha^{-1}year^{-1}$) and could primarily be attributed to greater number of new culms that emerge annually in *D. stocksii* (16.5±0.81) as compared to *B. balcooa* (7.2±0.58) for medium density block plantations. The input cost for growing the two bamboo species also varies considerably and better B/C ratio (6.02 and 5.70) was observed in *D. stocksii* as compared to *B. balcooa* (4.00 and 3.93). The study indicates that although both species are beneficial to the farmers, higher culm emergence and better culm and clump characteristics makes *D. stocksii* a better option in financial returns. Better market opportunities in terms of utility and demand also favour this species in the Konkan belt of Maharashtra.

Keywords: *Dendrocalamus stocksii* Munro., *Bambusa balcooa* Roxb., Konkan, Economics, bamboo.

INTRODUCTION

Bamboo cultivation has gained impetus over the past decade in India with increased availability of micropropagated plantlets in substantial quantities. Due to its biological characteristic and growth habits, it is not only an ideal economic investment but also has enormous potential in carbon sequestration. In addition, there is also an enhanced global interest on bamboo species as an alternative horticulture/ plantation crop with multiple uses and benefits to mankind (Sastry, 2008). Globally, India has the second highest number of species (140 species) after China and within the country, the North-East states have more than seventy per cent of total species recorded in India (Nirala *et al*., 2015, Nathani 2008; Bashir, 2010).

More recently, the Indian Forest (Amendment) Act, 2017 introduced in December 2017 to declassify bamboo grown outside forest areas from its current definition of tree has provided additional encouragement. This turn of events along with its potential as an economically lucrative crop has enhanced the number of farmers who are opting bamboo cultivation as an alternative to traditional commercial horticulture crops like mango, banana, cashew etc. Cultivation is primarily practiced with encouragement and inputs from other successful farmers. While lucrative outputs from these plantations are undisputed, there is less consideration on matching species with site conditions. With this increasing trend, it was imperative to understand the economic benefit of growing bamboo from a farmer's

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perspective. Region-wise farmers have identified bamboo species that are grown based on the climatic conditions of the region. For instance, Handique *et al.*, (2010) in a study trying to understand the role of bamboo resources for the socio-economic development of Tribal people of Arunachal Pradesh, found that three species are cultivated and utilized maximum in the region viz. *B. tulda, B. pallida* and *D. hamiltonii.* In Konkan region, farmers grow their own bamboos which are extracted from their field for various purposes like building their traditional housing, fencing, and religious activities like 'Gudhipa-dava', wherein a bright coloured cloth is tied to the tip of *D. stocksii* (Subbanna *et al.*, 2016; Subbanna *et al.*, 2017). This in turn ensures less expenditure on buying products thereby indirectly contributing to their socio-economic status. However, many farmers are also moving towards bamboo cultivation from cash crop cultivation. . One such study Ly (2012), looks at farmers who have moved to bamboo cultivation from traditional annual crops in Vietnam. The study revealed that during the period of growth of bamboo which usually lasts for 3-4 years, there is a wait period for farmers. Even post completion of this maturity period, the return per area is lower when compared to traditional annual cash crops. But the study emphasized that the ecological benefits of growing bamboo as much higher.

Studies have also been conducted on the economic analysis of agricultural crops (Deosthali and Nikam, 2004; Purushothaman, 2005), which has been explored briefly in the paper. Mainly, we have examined the financial returns associated with growing two bamboo species viz. *Bambusa balcooa* Roxb., a relatively new addition in the Konkan belt of Maharashtra and *Dendrocalamus stocksii* Munro., a bamboo that has traditionally been grown in the Konkan region.

B. balcooa as a species is believed to have originated from the north-eastern part of India. Due to its intrinsic characteristic of being an extremely sturdy bamboo with multiple uses, cultivation has spread to other locations in India (Rao *et al*., 1998; Banik 2000). The species has more recently gained impetus as a high calorific value (19.6 MJ kg^{-1}), high fuel value index (2120) species with low ash content that is ideal for electricity generation through gasification (Ritesh and Chandrasekher 2014). In addition, one of the largest biotechnology companies dealing in bamboo in India viz. Growmore Biotech India Ltd., Hosur, has produced approximately 6 million plantlets of B. balcooa until 2016 through tissue culture. The annual sale which was approximately 0.2 million in 2007-08 has now escalated to almost 1.5 million is in 2016 which has also led to an increased spurt in commercial bamboo cultivation of this species in India (Dr. Barathi, perss comm.). The bamboo species is being grown in both barren land and land wherein predominantly agricultural crops like paddy were grown.

D. stocksii has traditionally been a part of the local ecosystem in the Konkan Belt of India. It is extensively used by the furniture industry of the region (NMBA 2005). The region boasts of few prominent furniture industries like Konkan Bamboo Corporation (KONBAC) (Viswanath *et al*., 2014). The species is thornless is nature with non-prominent nodes and having great culm variation across the Konkan Belt (Rane *et al.*, 2016; Rane *et al.,* 2015). Moreover, study on macronutritional composition of *D. stocksii* revealed that it was on par with the other three species viz. *Bambusa bambos, Dendrocalamus strictus* and *Dendrocalamus stocksii* (Chandramouli *et al.,* 2014) enhancing its prospects for cultivation for shoot production. Considering this widespread cultivation of the two species in India with specific reference to the Konkan belt led to a need for examining the financial returns from the two species which has been explored in the study.

MATERIALS AND METHODS

The above study was conducted using a semi-structured pretested questionnaire along with an informal interaction with farmers (Figure 1). Study villages selected along with the methodology adopted has been detailed below.

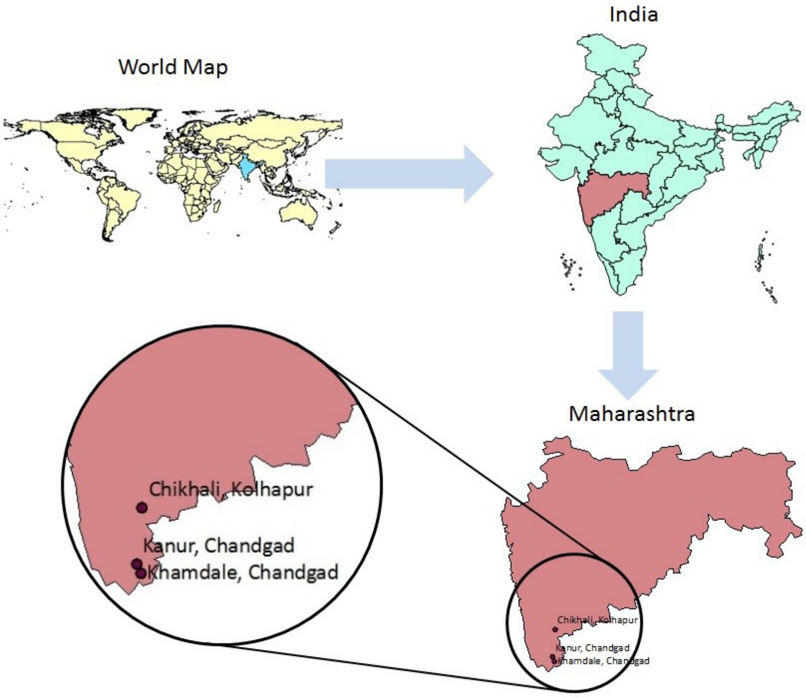

Figure 1: Study villages where empirical field work was conducted

Study Area and Survey Locations

For the study, villages were selected in the Western Ghats and surrounding regions of Maharashtra. Since our study involved specifically on economics of *B. balcooa* and these seedlings were primarily supplied by Growmore Biotech in the region, we relied on data from Growmore to decide on the study villages. A preliminary field visit was made to the study villages. This is when the prepared questionnaire was tested for its efficacy in conducting the empirical field survey. Another final field study was conducted in the three villages of interest. The final study area included three villages viz. Khamdale and Kanur in Chandgad taluk and Keneri in Kagal taluk of Kolhapur district in Maharashtra. It is in these regions that *B. balcooa* plantations were observed. Data on *D. stocksii* plantations were taken to have a comparative view of *B. balcooa* with some other bamboo species. The prime reasons for choosing *D. stocksii* was the abundance with which it has been grown in the past around the study region if not as a major crop then as a crop at the edges of farm land. The first two villages are part of the Western Ghats of India having 65 and 257 households respectively while the latter is in region abutting the Western Ghats of India with 1292 households (Census 2011). Census data on the three villages have been tabulated in Table 1.

Table 1: Village statistics of Study villages

Village Name	Taluk	District & State	Area (in ha)	No. of HH	No. of Persons
Kanur	Chandgad	Kolhapur, Maharashtra	797.62	257	1230
Khamdale	Chandgad		271	65	329
Chikhali	Kagal		486	1292	6301

Source: Census of India, 2011

Preparation of Questionnaire

A questionnaire based model was used to gather data and subsequently evaluate the economics of bamboo cultivation in the region. A draft questionnaire was prepared in the first stage to include questions pertaining to different inputs involved in the cultivation along with the outputs. The draft questionnaire was then tested at a preliminary field visit subsequent to which it was modified and a final questionnaire was drafted for field work. The questionnaire took a brief family background of the farmer, in terms of number of family members, qualification etc. It then went on to ask in greater depth on bamboo cultivation with respect to inputs at every stage of bamboo cultivation over a period of five years from before sowing to harvesting. Questions included cost of seedlings, transportation cost of seedlings purchased, labour and other costs involved in land preparation and planting, organic and inorganic fertilizers used, their quantity, frequency and price/unit, irrigation costs, if any, and other labour expenses like regular tending and harvesting. The questionnaire also took into account benefits accrued by farmers once harvesting begins, in terms of the quantity of harvest and benefits/unit sold. Table 2 gives demographic information like the average family size along with agricultural crops grown in the region other than bamboos.

Table 2: Characteristics of Households sampled

Characteristic	Kanur, Chandgad	Khamdale, Chandgad	Chikhali, Kagal
Average family size	4.02	4.74	3.87
Average Land under bamboo plantation	2.5	4.25	1.5
Bamboo species grown	*B. balcooa, D. stocksii, B. tulda*	*B. balcooa, D. stocksii, B. tulda, B. bambos, T. oliverii*	*B. balcooa, D. stocksii*
Agricultural crops being grown/grown in past	Paddy, wheat, Jowar	Paddy, finger millet, sugarcane	Paddy, wheat

Data Collection and Data Analysis

Empirical field work was done to collect data from the study locations. The collected data was then entered in excel sheets and analysed using standard formulae. A total of 31 surveys were conducted which was pretty much the farmers list we had growing bamboos in the region.

A financial and economic benefit-cost analysis of the traditional system was carried out using the data collected from the primary survey and secondary data collected from different sources. The net benefits accrued were assessed by conducting financial and economic analysis following standard methods (Purushothaman (2005); Friday *et al.*, 2000 and Nair, 1993). Questions in the primary survey were designed so as to identify and quantify benefits and costs related to growing *B. balcooa* and *D. stocksii.*

Benefit Cost ratio (B/C ratio)	$\frac{B}{C}\ \text{Ratio} = \frac{\text{Total Discounted Benefits}}{\text{Total Discounted costs}}$
Net Present Value (NPV)	$NPV = \frac{\sum(B_t - C_t)}{(1+r)^t}$
Internal Rate of Return (IRR)	$IRR = \sum_0^t \frac{B_t - C_t}{(1+r)^1} = 0$
Equivalent Annual Income (EAI)	$EAI = NPV\ \frac{R\,(1+r)^t}{(1+r)^t - 1}$

B_t is the benefits in year t; C_t the costs in year t; and r is the selected discount rate

Four case studies evolved of the surveys conducted during the study: (i) Six year old *B. balcooa* plantation with 1000 clumps ha^{-1}; (ii) Five year old *B. balcooa* plantation with 600 clumps ha^{-1}; (iii) Greater than twenty year old *D. stocksii* plantation with 500 clumps ha^{-1}; and (iv) Ten year old *D. stocksii* plantation with 600 clumps ha^{-1}.

Figure 2A: D. stocksii as a live hedge in Kanur village, Chandgad taluk, Kolhapur, Maharashtra;

Figure 2B: Two and a half year old *B. balcooa* plantation in Khamdale, Chandgad, Maharashtra

Figure 2C: Collage of on-field Interaction with farmers at the study villages

RESULTS AND DISCUSSION

Traditionally, bamboos have always been considered to be present naturally in forests, though fewer numbers are also maintained by farmers either in their farmlands along the border (Figure 2A) or in their homegardens. It is keeping this in view that bamboos usually come under two broad categories viz. cultivated or village bamboos and native or forest bamboos (McNeely, 1995). Recently, bamboos as a plantation crop are gaining increasing popularity as a combination of many reasons. From ease in availability of micropropagated plantlets to declassification of bamboos as a tree, all factors have been influential in enhancing bamboo cultivation in India. Economic benefit from bamboos is another incentive for farmers who are moving towards bamboo cultivation. In the study region of interest, we observed an indication that farmers prefer to grow bamboos especially *B.balcooa* (Figure 2B).

The study region selected is high rainfall humid region wherein traditional agricultural crops like *Oryza sativa* (paddy) and *Eleusine coracana* (finger millet) was grown extensively. Over the years few farmers have also started to grow sugarcane and cashew. In this study, we haven't shown a detailed economic analysis of the traditional crops since many research studies have already looked at the particular aspect. Table 3 depicts the input and output costs for one of the most popular traditional crops in the region paddy. Being high rainfall region, paddy along with a few other crops was one of the favourite crops grown. Results indicate a cost benefit ratio of 1.48 for paddy. Few farmers also ventured into growing cash crops like sugarcane and cashew, which they termed was a failure. Farmers ventured into growing bamboos as they felt it to be a good alternative to these other cash crops.

Table 3: Monetary input and output for *Oriza sativa* grown in one hectare of land in the study region

INPUTS	QUANTITY	COST PER UNIT (₹)	COST PER UNIT (₹)
Seeds	20 kgs	15	300
Organic fertilizer	10 tractor load	500	5000
Inorganic fertilizer	10 bags	500	5000
Labour before sowing	15 MD	250	3750
Labour for sowing	20 MD	250	5000
Weeding	20 MD	250	5000
Harvesting and post	25 MD	250	6250
Tractor	20 hours	600	12000
Transportation	2.5 hours	600	1500
			43800
OUPUT			
Yield	3.5 T	15000	52500
Fodder	5 tractor load	2500	12500
			65000
B/C Ratio			1.48

Table 4: Particulars, Unit and Quantity of different inputs in bamboo cultivation

SL. NO.	PARTICULARS	UNIT AND QUANTITY				UNIT COST (₹)
		B. balcooa		*D. stocksii*		
		A	B	C	D	
2	No. of clumps/ha	1000	600	600	500	
3	Survival/ha	900	540	510	425	
4	Casualty	10%	10%	15%	15%	
5	No. of seedlings	1000	600	600	500	25/seedling
6	Labour: Site preparation	36MD - 1st year				250/person/day
7	Labour: Alignment & staking	5MD - 1st year				250/person/day
8	Labour: Land Preparation	5MD - 1st year and 1MD - 2nd year				250/person/day
9	Addition of Farm Yard Manure	5kg/plant/year - 1st year and subsequently 3kg/plant/year				150/50kg bag
10	Addition of Urea	60g/plant - 1st year; 120g/plant - 2nd year; 180g/plant - 3rd year (spread over 6 doses)		100g/plant		270/50kg bag
11	Addition of DAP			Nil		900/50kg bag
12	Addition of Potash	45g/plant - 1st year; 90g/plant - 2nd year; 135g/plant - 3rd year (spread over 6 doses)		Nil		1125/50kg bag
13	Addition of Biofertilizer	10g/plant		Nil		120/g
14	Addition of Insecticide	As and when needed, approximately once in 2-3 years				Nominal at approx. ₹200/two years
15	Transportation and planting of seedlings	Nil				15/plant
16	Labour: Planting & replanting	11MD - 1st year; 2nd year 5MD and subsequently 2MD/year				250/day
17	Labour: Soil fertility management	15 MD in first and second year; 25MD in third year				250/day
18	Labour: Tending,marking cleaning & harvesting of culms	10MD in 2nd and 3rd year; 15MD from fourth year				250/day
19	Fencing	400m fence for first year and a 100m refencing for second year				5/rmt
20	Irrigation	20l/plant/day first four years		50l/clump/year first four years		
21	Watch and ward	Labour to live in house during the first four year				4500/month

Many studies in the past have explored the potential of bamboos as an agroforestry species as an economic and an ecological perspective. However, studies related to bamboos being grown as a plantation crops are minimal. Few studies like Rane *et al.* (2016) have estimated that a plantation managed for culm and shoot production of *D. stocksii* could potentially add a revenue of ₹ 450,000 or \$ 6705 $ha^{-1}year^{-1}$ from 5630 fully grown culms of harvestable size. The study also exhibited potential of ₹ 160,000 or \$ 2384 from fifth year onwards from 5630 juvenile shoots.

Economic analysis of two bamboo species grown as plantation crops in the region has been the focus of this study viz. the traditionally grown *D. stocksii* and a more recent addition of *B. balcooa*. The study primarily calculated the economic benefits accrued by farmers by conducting a structured questionnaire based survey and one on one informal interaction with farmers (Figure 2C). The study region had each of the species at different planting densities and hence for this analysis we have considered all the four scenarios (as mentioned in the materials and methods subsection) for conducting our analysis. This is also because different planting densities had different new culm emergence resulting in different results for economic analysis. Table 4 lists the different inputs, its quantity and its unit cost which formed the basis for calculating the flow of input costs. One can observe from the table that labour forms an important component at many different stages of growing bamboos from plantation to management and harvesting.

Tables 5 and 6 depict the detailed input and output cost involved in cultivation of the two bamboo species. As can be observed from Table 5, an additional cost of ₹ 54,000 was added during the first four years of bamboo cultivation for initial protection of plants. This forms the major input cost for the first four years in all four scenarios. Total input cost in maximum for the first year at ₹ 148,073, ₹ 121,478, ₹ 115,605 and ₹ 110,512 respectively for each case study. The flow of costs stabilizes from fifth year onwards to ₹34,038, ₹ 24,675, ₹ 17,325 and ₹ 15,750 respectively. fihure 3, figure 4, figure 5 and figure 6 shows yearly contribution of each input for both bamboo species at different planting densities. The next big contributor to the input cost is the cost of seedlings and labour involved at different stages of planting and harvesting. Labour not only constitutes land preparation and planting, it also involves the initial alignment and staking for placement of seedlings. In the latter years, as the clump grows, labour is also involved in management of clumps and regular harvest. A study conducted by Pande *et al.,*(2012) on economics if bamboo plantation in three major ravine system Mahi, Chambal and Yamuna concluded that the major expenditure in the first year can be attributed to site preparation and planting. For *B. balcooa*, because there is regular addition of fertilizers in the form of Urea and DAP, along with addition of potash and biofertilizer, these too play a significant contribution in the input costs. Most farmers with *D. stocksii* plantation did not specifically add DAP, potash or fertilizers though many did add Urea. This formed a major difference in the input costs of *D. stocksii* and *B. balcooa.* The percentage contribution of each input also stabilizes from the fifth year thereby resulting in lower and consistent input costs from thereon as can be observed in Figure 3E, Figure 4E, Figure 5E and Figure 6E.

Overall the percentage expenditure on different inputs remained more or less consistent irrespective of planting density and species. Sapling costs account to about 18 percent, 13 percent, 14 percent and 12 percent of total costs respectively for the four scenarios. Typically both bamboo species need farm yard manure addition in the initial years and there are also costs involved for transportation of bamboo seedlings to the farm land. Both these account to about 11 percent, 8 percent, 8 percent and 7 percent of total costs respectively for both the species in the first year of cultivation. An additional expenditure in case of *B. balcooa* is in the addition of fertilizers like Urea, DAP, potash and biofertilizer. This is marginal and accounts to approximately 6 percent and 5 percent of total costs for planting density of 1000 and 600 respectively with a large part being accounted by biofertilizers.

Table 5: Flow of costs from *B. balcooa* and *D. stocksii* plantation in one hectare at study locations in Kolhapur district, Maharashtra

Particulars	Cost per year (₹)																			
	First year				Second year				Third year				Fourth year				Fifth year onwards			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Bamboo Species	*B. balcooa*		*D. stocksii*		*B. balcooa*		*D. stocksii*		*B. balcooa*		*D. stocksii*		*B. balcooa*		*D. stocksii*		*B. balcooa*		*D. stocksii*	
No. of clumps/ha	1000	600	600	500	1000	600	600	500	1000	600	600	500	1000	600	600	500	1000	600	600	500
Survival/ha	900	540	510	425	900	540	510	425	900	540	510	425	900	540	510	425	900	540	510	425
Casualty	10%	10%	15%	15%	10%	10%	15%	15%	10%	10%	15%	15%	10%	10%	15%	15%	10%	10%	15%	15%
Cost of seedlings	25000	15000	15000	12500	2500	1500	2250	1500												
Labour: Site preparation	9000	9000	9000	9000																
Labour: Alignment & staking	1250	1250	1250	1250																
Labour: Land Preparation	1250	1250	1250	0	250	250	250	250												
Addition of Farm Yard Manure	15000	9000	9000	7500	9000	5400	5400	4500	9000	5400	5400	4500	9000	5400	5400	4500	9000	5400	5400	4500
Addition of Urea	330	198	600	500	660	396	600	500	990	594	600		990	594	600		990	594	600	
Addition of DAP	1080	648			2160	1296			3240	1944			3240	1944			3240	1944		
Addition of Potash	1012.5	607.5			2025	1215			3037.5	1822.5			3037.5	1822.5			3037.5	1822.5		
Addition of Biofertilizer	5400	3240			5400	3240			5400	3240			5400	3240			5400	3240		
Addition of Insecticide					250	200	200	200					250	200	200	200	250			
Transportation and planting of seedlings	15000	9000	9000	7500	900	900	900	900												
Labour: Planting & replanting	2750	2750	2750	2750	2750	2750	2750	2750	1250	1250	1250	1250	500	500	500	500	500	500	500	500
Labour: Soil fertility management	3750	3750	3750	3750	3750	3750	3750	3750	3750	6250	6250	6250	6250	6250	6250	6250	6250	6250	6250	6250
Labour: Tending,marking cleaning & harvesting of culms annually					2500	2500	2500	2500	2500	2500	2500	2500	2500	3750	3750	3750	3750	3750	3750	3750
Fencing	4000	4000	4000	4000	1000	1000	1000	1000												
Irrigation	2200	2000	500	2500	2200	2000	500	2500	2200	2000	500	2500	2200	2000	500	2500				
Watch and ward	54000	54000	54000	54000	54000	54000	54000	54000	54000	54000	54000	54000	54000	54000	54000	54000				
SUB TOTAL	141022	115693	110100	105250	88345	81147	74100	74350	85367	79000	70500	71000	87367	79700	71200	71700	32417	23500	16500	15000
CONTINGENCY 05 %	7051	5784	5505	5262	4417	4057	3705	3717	4268	3950	3525	3550	4368	3985	3560	3585	1620	1175	825	750
GRAND TOTAL	**148073**	**121478**	**115605**	**110512**	**92762**	**85204**	**77805**	**78067**	**89635**	**82950**	**74025**	**74550**	**91735**	**83685**	**74760**	**75285**	**34038**	**24675**	**17325**	**15750**

Table 6: Output costs from *B. balcooa* and *D. stocksii* plantation in one hectare at study locations in Kolhapur district, Maharashtra

Year	***B. balcooa* at planting density of 1000/ha**				***B. balcooa* at planting density of 600/ha**				***D. stocksii* at planting density of 600/ha**			***D. stocksii* at planting density of 500/ha**		
	Avg culms/ clump	Culms/Ha	Biomass productivity/culm (kg)	Income (₹)	Avg culms/ clump	Culms/Ha	Biomass productivity/culm (kg)	Income (₹)	Avg culms/ clump	Culms/ Ha	Income (₹)	Avg culms / clump	Culms/ Ha	Income (₹)
3	2	1800	3.8	49248	2	1080	3.8	29548	3	1530	76500	3	1275	63750
4	3	2700	5.2	101088	3	1620	5.2	60652	4	2040	102000	4	1700	85000
5	4.1	3690	6.7	178005	4	2160	6.7	104198	7.2	3672	183600	7.2	3060	153000
6	4.9	4410	7.3	231789	6	3240	7.62	177759	11.8	6018	300900	12.7	5397.5	269875
7	5.4	4860	10.8	377913	7.2	3888	11.1	310729	14.9	7599	379950	16.5	7012.5	350625
8	5.4	4860	10.8	377913	7.2	3888	11.1	310729	14.9	7599	379950	16.5	7012.5	350625
9	5.4	4860	10.8	377913	7.2	3888	11.1	310729	14.9	7599	379950	16.5	7012.5	350625
10& ABOVE	5.4	4860	10.8	377913	7.2	3888	11.1	310729	14.9	7599	379950	16.5	7012.5	350625

Expected price/Ton of dried biomass for *B. balcooa* = ₹ 7200; Expected price/culm for *D. stocksi*i = ₹50

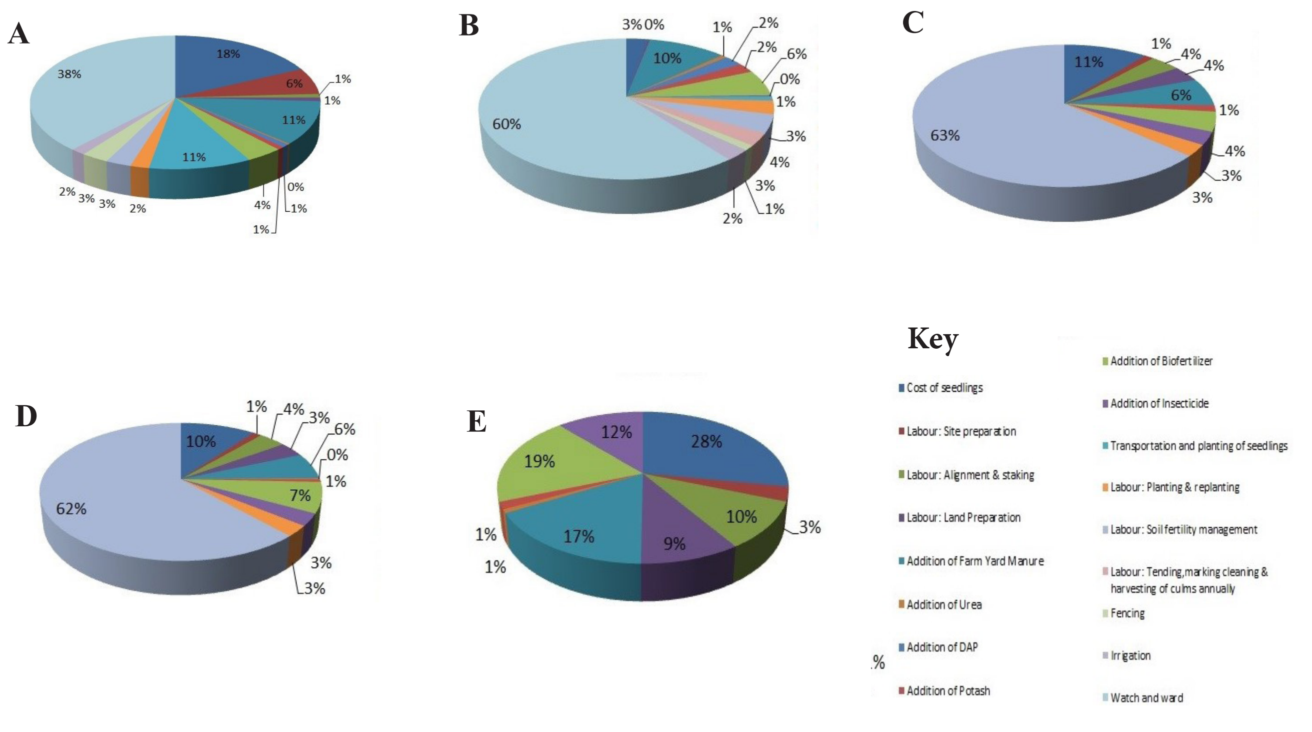

Figure 3: Percentage distribution of each input for *B. balcooa* at planting density of 1000/ha for **A**: Year 1; **B**: Year 2; **C**: Year 3; **D**: Year 4 and **E**: Year 5

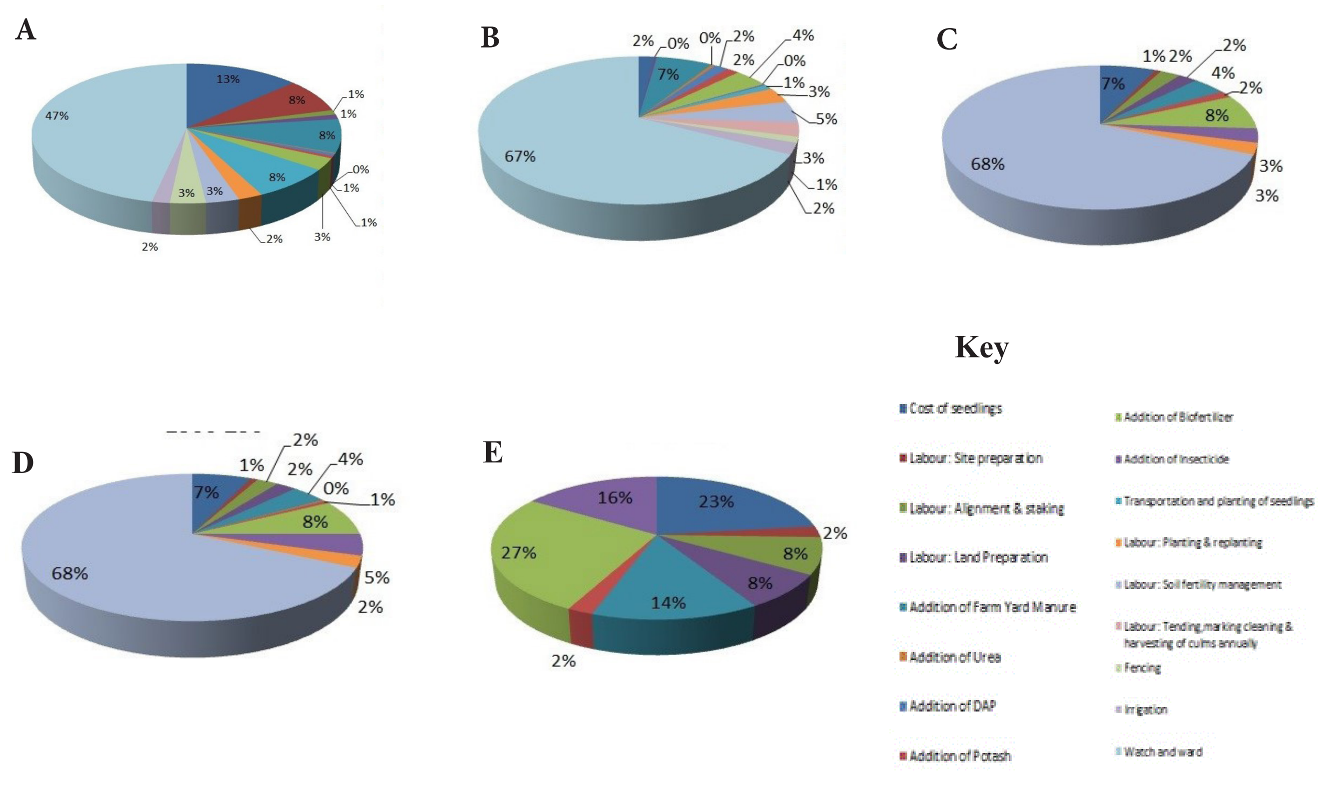

Figure 4: Percentage distribution of each input for B. balcooa at planting density of 600/ha for **A**: Year 1; **B**: Year 2; **C**: Year 3; **D**: Year 4 and **E**: Year 5

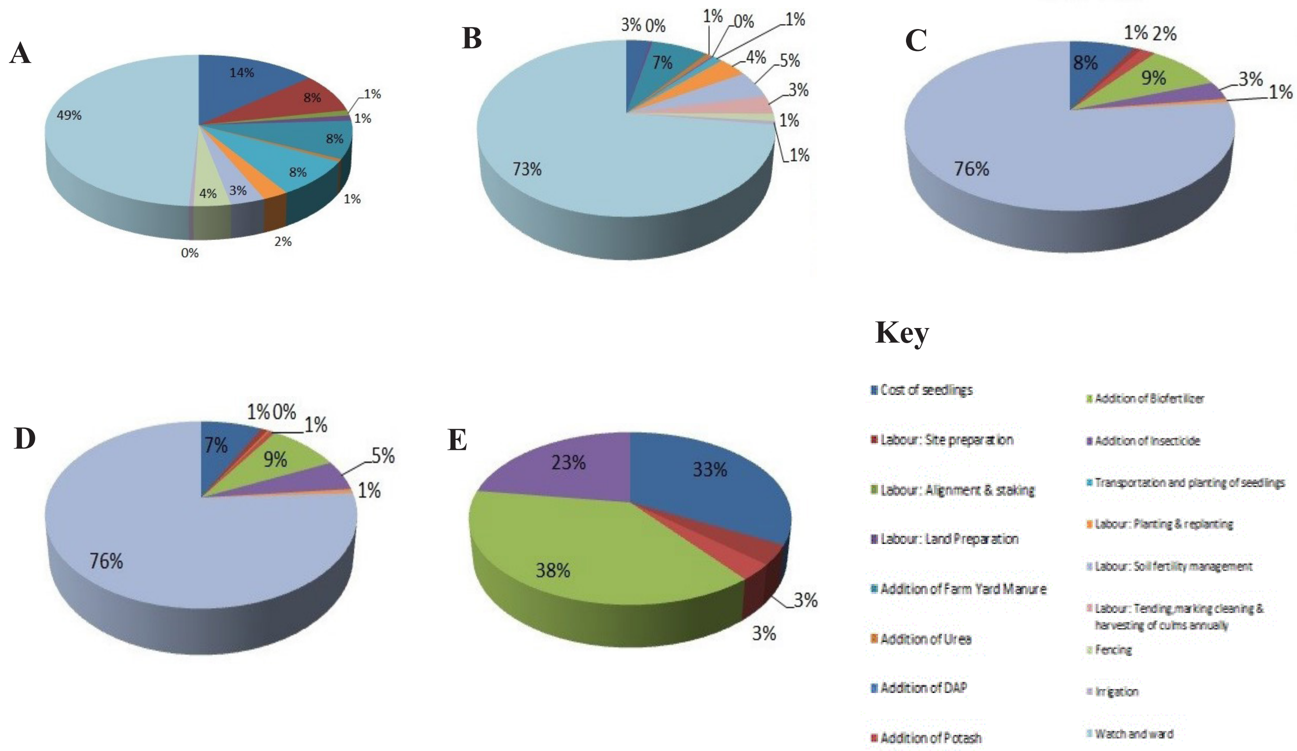

Figure 5: Percentage distribution of each input for *D. stocksii* at planting density of 600/ha for **A**: Year 1; **B**: Year 2; **C**: Year 3; **D**: Year 4 and **E**: Year 5

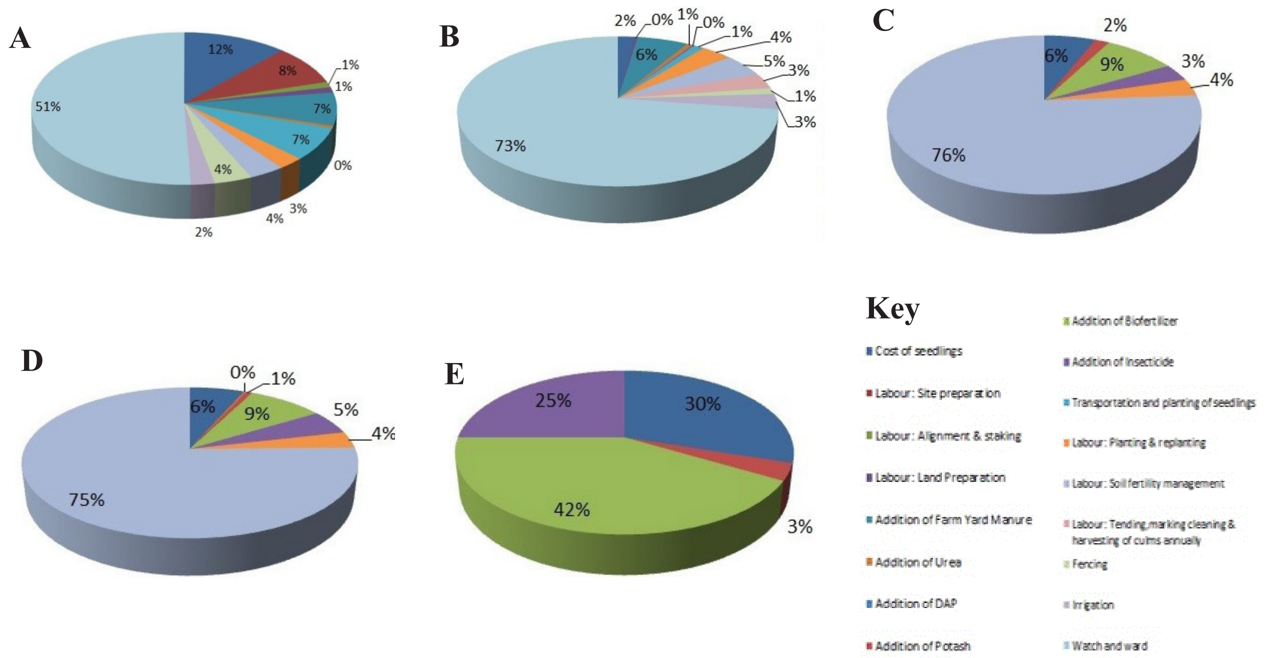

Figure 6: Percentage distribution of each input for *D. stocksii* at planting density of 500/ha for **A**: Year 1; **B**: Year 2; **C**: Year 3; **D**: Year 4 and **E**: Year 5

Table 6 depicts the income generated from plantations from the third year to the tenth year. In the surveyed results we observed most farmers utilized the bamboo culm. Tender shoots for consumption and other biomass products in the form of leaf litter were not being used extensively by the farmers. Leaf litter was primarily just left on the farmland to act as manure for the bamboo plants. The income has been calculated based on mean clump characteristics of block plantations in the study villages. The mode of calculation of income for the two species is different. This is because *D. stocksii* is sold on a per culm basis while *B. balcooa* is sold on weight basis. This has also been depicted in Table 6.

Table 7 depicts the Economic analysis of the two bamboo species. Three factors Benefit to Cost (B/C) ratio, Internal Rate of Return (IRR) and Net Present Value (NPV) has been calculated and tabulated of the two bamboo species based on empirical field work. B/C Ratio is an indicator used to assess the financial viability of land-use practices. Currently agriculture loan interest rates were from 9 to 10.5 percent we have hence considered 10% for our calculations of discounted benefits and costs. Results indicate the ratio is positive in all four scenarios at 4.00 and 3.93 for *B. balcooa* at planting density of 1000 and 600 and 6.02 and 5.70 for *D. stocksii* at planting density of 600 and 500. IRR determines the earning power of money invested in a particular venture. The values can be deemed high for both bamboo species. For *B. balcooa*, IRR was calculated at 33 percent and 31 percent for planting density 1000 and 600 respectively for a period of forty years. *D. stocksii* showed much greater IRR values at 41 percent and 38 percent for planting density 600 and 500 respectively. NPV is the sum of net discounted benefit at the selected discount rate of 10 percent. NPV was calculated at ₹ 19,53,021 ($26,909) and ₹ 15,53,599 ($21,405) for *B. balcooa* at planting density of 1000 and 600 respectively. NPV values were much greater for *D. stocksii* at ₹ 22,34,245 ($30,783) and ₹ 20,16,891 ($27,789) at planting densities of 600 and 500 respectively. An earlier study by Viswanath *et al*. (2016) estimated a B/C ration of 4.71 for *D. stocksii.* IRR was estimated at 28 percent in the study and NPV was calculated at 14,43,000. The calculations were done at 15 percent discount rate in the study however as mentioned we have calculated at 10 percent discount rate. This could be one of the probable reasons for the change in values.

Table 7: Economic Analysis of *B. balcooa* and *D. stocksii* in humid regions of Maharashtra for a forty year period considering 10% discounted rate.

Species	**Age**	**Planting density**	**Benefit to Cost Ratio**	**Net Present Value**	**Internal Rate of Return**	**Equated Annual Income**
	Years	**Ha^{-1}**	**B/C Ratio**	**NPV**	**IRR (%)**	**EAI**
Bambusa balcooa Roxb.	6	1000	4.00	₹ 19,53,021 $26,908.5	33%	₹ 1,99,715 $2,751.7
	5	600	3.93	₹ 15,53,599 $21,405.3	31%	₹ 1,58,870 $2,188.9
Dendrocalamus stocksii Munro.	10	600	6.02	₹ 22,34,245 $30,783.2	41%	₹ 2,28,473 $3,147.9
	20+	500	5.70	₹ 20,16,891 $27,788.5	38%	₹ 2,06,246 $2,841.6

$1 = ₹ 72.58 as on 19th September 2018

The economic analysis clearly indicates that both bamboo species have the potential to be lucrative to farmers, albeit *D. stocksii* is more lucrative than *B. balcooa*. Greater economic benefit from *D. stocksii* is primarily a result of greater culm emergence annually. The average annual new culm emergence in *D. stocksii* (16.5±0.81) was greater than in *B. balcooa* (7.2±0.58). Another factor contributing to *D. stocksii* being more lucrative is that the selling price for it is calculated on a per culm basis unlike *B. balcooa* which is calculated on weight basis. An increase in planting density of *B. balcooa* was more lucrative despite having lower culm emergence. However, the potential from *D. stocksii* plantations are still higher than *B. balcooa.*

CONCLUSIONS

The study evaluated the economic benefits accrued by farmers for two prominent bamboo species in the region i.e. *B. balcooa* and *D. stocksii*. Three economic factors, B/C ratio, IRR and NPV were calculated and tabulated in the study for the two bamboo species. B/C ration was calculated at 4.00 and 3.93 for *B. balcooa* at planting density of 1000 and 600 and 6.02 and 5.70 for *D. stocksii* at planting density of 600 and 500. Other economic parameter like IRR and NPV were also found to be economically beneficial in both species. The study indicates that overall both species i.e. *B. balcooa* and *D. stocksii* are beneficial to the farmers in the three study villages. *D. stocksii* has been an integral part of the farming lifestyle in the region. There is also a competitive market for the bamboo species especially from the furniture industry. Few farmers are growing different bamboo species of which *B. balcooa* is the prime contender, a direct result of extensive availability of this bamboo species. Traditional agricultural crops like paddy have always been grown in the region considering the high rainfall in the region. This is being replaced by growing bamboo. It is undisputed that both bamboo species have the potential to enhance the economic stature of farmers in the region. However, because of higher culm emergence and better culm and clump characteristics of *D. stocksii,* it translates into better financial returns. Better market opportunities in terms of utility and demand also favour this species in the study region. The three villages are geographically close with the same market forces acting on it. The difference primarily emergences between the two species and not so much within species across locations. This may also be attributed to the fact that of the three villages two come under heavy rainfall region having an average annual rainfall of 2742mm as per census 2011 data . The third village Chikhali in Kolhapur Maharashtra may not have such heavy rainfall at 776mm average annual rainfall, which may not be as favourable as the other two regions. However since most farmers practise what is termed 'precision farming', this lack of natural rainfall is compensated greatly by artificial water sources like drip irrigation. Overall, bamboos appear to be lucrative option to farmers across the entire study region. However, the study highlights the need for matching species with site which in addition to giving better growth also translates to better financial returns.

The further positive step taken to declassify bamboo grown outside forest areas from its current definition of tree via The Indian Forest (Amendment) Act, 2017 enables easier transport of bamboos across state boundaries further helping the cause of farmers and stakeholders likewise.

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