Bamboo, a woody grass is one of the fast growing plants in the world. There are over 1600 bamboo species naturally growing in different locations/ agro-climatic conditions of the world (mainly concentrated in tropical and sub-tropical climatic regimes). It is hardy, climate resilient, adaptable and can grow in marginal and degraded land, farm boundaries, slopes, river banks, etc. Different bamboo species are suitable for different agro-climatic conditions ranging from coastal regions (sea level) to high mountains (up to 4000 m above mean sea level).

It is a perennial crop due to its growing nature: every year new bamboo shoots or poles are produced without replanting, which provides opportunity for harvesting annually and non-destructively and thereby annual income for growers.

Bamboo is a versatile multipurpose plant with over 10,000 products and applications ranging from timber substitute, construction materials, food and beverages, bio-energy, pulp and paper, fibre composites, textiles, life style products, traditional sustenance use products, etc. With recent technological innovation a wide range of high end industrial products are been produced and traded globally.

In addition, bamboo is a proven crop for rejuvenating degraded land, contribute to soil erosion control and water recharge.

Till now, bamboo is an untapped resource that can provide job, income-generating and ecosystem services to the people dependent on it.
DIFFERENT MODELS OF PLANTATION

Bamboo planting / plantation can be undertaken adopting different models and/or scale such as:

1) Large scale plantation / wood lots: Bamboo plantation of any scale (from 1 hectare to thousands of hectares) can be possible aimed at commercial production of bamboo poles for production of timber, shoots, pulp, bio-energy, etc; and ecological restoration (degraded lands, mined sites, ravines, river banks, etc).

2) Small holder farm block plantation: Small holder farmer can establish bamboo as agro-forestry or block planting of different scales (few bamboo clumps to any scale).

3) Farm boundary and shelter bed planting: Small holder farmers can plant bamboo in farm boundary, contour lines, shelter belts in case of streams, rivers, etc.
DIFFERENT MODELS OF PLANTATION

4) Household planting: Few bamboo clumps can be planted close to homesteads to meet daily fuel wood, fodder, and other sustenance needs.

CHOICES OF SPECIES

It is important to consider the end use and agro-climatic regime (geographical location (latitude and altitude), climate, rainfall, soil type and other variables). Kindly consult local research agencies to understand the performance of a particular species similar to plantation site. Also find attached a matrix showing bamboo species, its suitable agro-climatic condition and its end uses for reference. (Annexure 1)
SITE SELECTION CRITERIA FOR BAMBOO

When selecting a plantation site, following points must be considered.

1) **Soil:** The most suitable soil type for bamboo is sandy loam to clay loam, due to its porosity (permeability), fertility (high organic content) and water / moisture holding capacity. The depth of soil should be at least 30-45 cm.

   Highly compact or sticky or clayey soil, rocky, and highly sandy soils are not highly suitable.

2) **Light requirements:** Bamboo does not grow well under deep shade. It needs direct sunlight for its rapid growth. It is advised to plant bamboo in an open area (direct sunlight) or in locations with sparse canopy (<10 percent).

3) **Drainage / Water inundation:** Bamboo can survive flash floods (days) but cannot survive under water inundation for prolonged duration (weeks / months). Therefore, select a site which is well drained.

4) **Topography:** Flat land and gentle slopes are best suited.

5) **Ground water level:** Ground water table / level should be lower than 50 cm.

6) **Location and accessibility:** Easy to access and approach by road.

PLANT MATERIAL SELECTION AND PREPARATION

Select healthy plants (6-9 months old; 50 -80 cm height; multiple stem) with well-developed rhizome and root system.

Harden the selected plants in direct sunlight (similar to plantation site) for about 2-4 weeks to acclimatize the plants to field conditions.
HANDLING DURING TRANSPORT

Trim about 50 per cent of foliage to minimize water transpiration loss.
Always carry the plants by holding the poly-bags / pots to minimize disturbance to rhizome and roots; and to avoid breakage of stems.

Wrong / incorrect practice

Right/ correct practice

SITE SELECTION

Site preparation is necessary to ensure better survival, faster growth and to provide optimal conditions for performance of plantation.
Site preparation includes (1) land preparation (bush clearing), (2) soil preparation (soil loosening and weed control), (3) fire prevention, (4) flood or control of water inundation, and (5) fencing to control access for cattle.
Land preparation: Clear shrubs, bushes, weeds and any unwanted vegetation to ensure space availability.

Soil Preparation: Soil preparation should be done at least one month prior to planting in order to provide sufficient time for weathering of soil. Three options are possible, depending on the land and resources, they are (a) ploughing / tillage (b) strip preparation and (c) spot preparation.

a) Ploughing/ Tillage: Plough the plantation site thoroughly (30 cm deep), as it helps in churning /rearranging soil layers, soil loosening and improves soil quality.

b) Strip preparation: In this method, first mark the rows of planting. Clear out the weeds by ploughing, or by clearing vegetation in strips (width at least 1.5 - 2 meters).

c) Spot preparation: This is usually applied in sites where it is impossible to plough. The spots should be large (1 to 1.5 meters in radius) from the center of the pit.
Fencing: Bamboo is a good fodder liked by many small and large ruminants, it is necessary to guard the site by fencing it to prevent any risk from damage by domestic and wild animals (especially when plants are young). Following points must be kept in mind at the time of fencing:

- If barriers already exist, only fence the places where animals can enter in.
- Fencing must be done before any pit digging and planting.

Fire break: Clear all kinds of woody shrubs, grass and other vegetative materials which can catch fire in the 5 meters range around the site.

### SPACING

Spacing is important to reduce above-ground competition for light, and below-ground competition for water and nutrients.

If spacing is too narrow, bamboo will grow mostly tall but will not produce large diameter stems / culms. If the spacing is too large, sunlight will penetrate through the canopy, allowing grass to colonize the site, thus increasing the risk of fire in dry season. Spacing of plants depends on the species as well as purpose.

a) **4 X 4 M**: Small diameter bamboo: 4 - 8 cm (example *Oxytenanthera abyssinica, Dendrocalamus strictus, Bambusa multiplex, Thysrostachys oliveri*).

b) **5 X 5 M to 7 X 7 M**: Medium diameter bamboo: 8 – 15 cm (*Yushania alpina, Bambusa vulgaris, Dendrocalamus asper, Dendrocalamus hamiltonii, Dendrocalamus membranaceus Bambusa tulda, Bambusa polymorpha, Cephalostachyum pergracile, Dendrocalamus brandisii, Bambusa balcooa, Bambusa bamboos, etc*).

c) **7 X 7 M to 10 X 10 M**: Large diameter bamboo: >15 cm (*Dendrocalamus giganteus*).

Two pattern of spacing can be followed namely (a) rectangular spacing and (b) triangular spacing. For large scale commercial planting, it is recommended to adopt triangular spacing as this allows maximum utilization of land area, and spreading space between clumps.
PIT POSTING

A couple of weeks prior to planting, use ropes / measuring tape to accurately position the planting holes in requires spacing. Use bamboo splits or sticks to post or mark the location of pit digging.

PIT DIGGING

The size of the planting pits (length, width and depth) is crucial as it facilitates initial growth of the plant rhizomes and roots. Pits must be prepared at least 15 days before planting to facilitate weathering of soil.

Seedlings / saplings in polybags: 30 cm x 30 cm x 30 cm (L X WX D)

Rhizomes: 60 X 60 X 40 cm (LX WX D).
Thumb rule: size of pit should be two times the size of rhizome.

Ensure top soil and bottom soil / sub soil are kept on different sides of pit.
PLANTING

Manure and fertilizer could be applied during planting. Apply 1 basket (5 kg of manure/compost) to the top soil. Mix them thoroughly.

Fill the top soil mixture, to the bottom potions of the pit prepared and compact it.

Remove the polybags.

Place the bamboo plants on the pit. The neck of the polybag should be on the same level as the top of the pit.

Fill the remaining top soil mixture on the sides; then fill the bottom soil above it.
COMPACT THE SOIL IN THE PIT

Compact the soil in the pit

PREPARE SOIL MOUNDING AROUND THE PLANT; TRENCH AROUND THE PIT TO ENABLE WATER AVAILABILITY.

Prepare soil mounding around the plant; trench around the pit to enable water availability.

BEST TIME FOR PLANTING: Early raining season is the right time for planting, as the plants will have sufficient moisture availability for a longer time to establish itself.

For further information, please contact our

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## ANNEXURE 1: BAMBOO SPECIES, ITS AGRO-CLIMATIC CONDITIONS AND USES

<table>
<thead>
<tr>
<th>Bamboo Species</th>
<th>Ideal altitude range</th>
<th>Introduced or Observed Altitude range</th>
<th>Site Agro-ecological conditions</th>
<th>Specification of bamboo poles</th>
<th>Main Uses</th>
<th>Propagation Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yushania alpina (K. Schum.)</td>
<td>2200 – 3500 M AMSL</td>
<td>1700 – 4000 M AMSL</td>
<td>Sub-tropical bamboo. Commonly found in higher elevations and mountain areas of East Africa including Ethiopia, Kenya, Uganda, Tanzania, Sudan, Burundi, Cameroon, D.R. Congo, Rwanda, Malawi, Zambia. Grows well in mountain and volcanic soils. Rainfall ranging from 1250 - 3000 mm. Temperature is limiting factors, confined to areas of mean annual temperature of 11.6 – 15.9ºC tolerates till – 4ºC.</td>
<td>Height: 2 to 19.5 M Diameter: 5 to 12.5 cm Thin walled with wall thickness ranging from 2 cm in bottom to 0.3 cm at top</td>
<td>Bamboo flooring tiles, timber, handicrafts, furniture, bamboo stick based products, bamboo sliver based products including mats and Bamboo mat board, bamboo shoots, etc.</td>
<td>Rhizome / offsets; seeds</td>
</tr>
<tr>
<td>Oxytenanthera abyssinica (A. Rich.) Munro</td>
<td>1000 – 1800 M AMSL</td>
<td>500 – 2200 M AMSL</td>
<td>Tropical bamboo species. Suitable for low lands and mid elevation with rainfall between 900 to 1400 mm, drier and hot location. It is also found in drier locations of Ethiopia, Sudan, Uganda. It needs minimum rainfall of about 700 mm. It can grow in poor and marginal soil. It is also drought resistant. Prefers comparatively warm temperature Distributed widely in Eastern Africa, this species has been recorded from Ethiopia, Tanzania, Sudan, Uganda, Malawi, Zambia, Zimbabwe, Burundi.</td>
<td>Height: 7 – 10 M Diameter: 5 -10 cm Solid bamboo poles when grown in drier climatic regimes; and slightly hollow in case of wet climatic regimes.</td>
<td>Construction, furniture, basketry and handicrafts, props, agricultural implements, Shoots Edible. Leaves extensively used as fodder. Suitable for biomass, charcoal and energy.</td>
<td>Rhizome, seed, culm cuttings, layering</td>
</tr>
<tr>
<td>Cephalotachyum pergracile</td>
<td>500 – 1200 M AMSL</td>
<td>Up to 1500 M AMSL</td>
<td>Tropical low-land bamboo, thin walled. Commonly found in Indian sub-continent, Myanmar, Laos, etc. C. pergracile occurs in semi-humid to semi-arid regions on a range of soils, it is most common in well-drained loamy soils in Myanmar. Mean annual rainfall: 800 - 1000 mm Mean annual temperature: 22 - 33ºC , Tolerate till - 6 ºC.</td>
<td>Height 7-20 M Diameter: 5 – 7.5 cm</td>
<td>Bamboo stick and sliver based product line, bamboo shoots</td>
<td>Seed, offsets and culm cuttings</td>
</tr>
<tr>
<td>Dendrocalamus membranaceus Cv. Grandis</td>
<td>50 – 1150 M AMSL</td>
<td>Up to 1400 M</td>
<td>Tropical bamboo, growing in mixed deciduous or monsoon forest. Average annual temperature of 22-33 ºC Minimum rainfall of above 1000 mm / annum.</td>
<td>Height: 20-25 M Diameter: 6-12 cm</td>
<td>Construction / pulp and paper; Laminated boards; bamboo shoots</td>
<td>Seed, offsets, branch cuttings, culm cuttings</td>
</tr>
<tr>
<td>Dendrocalamus barbatus</td>
<td>300 - 1,100 M AMSL</td>
<td></td>
<td>Tropical large diameter bamboo with medium wall thickness Minimum rainfall of 1000 mm per annum</td>
<td>Height: 15–18 M Diameter: 10 –15 cm</td>
<td>Craft, Construction Construction, Ply boards, handicrafts, furniture; Edible shoots</td>
<td>Seeds, offset, culm cuttings</td>
</tr>
<tr>
<td>Species</td>
<td>Elevation</td>
<td>Distribution</td>
<td>Characteristics</td>
<td>Height:</td>
<td>Diameter:</td>
<td>Products/Uses</td>
</tr>
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<tr>
<td><em>Bambusa polymorpha</em></td>
<td>0 – 1500 meters AMSL</td>
<td>Grows naturally in semi-humid areas on medium to rich soils, well-developed soils. Grows in moderately high rainfall zones higher than 800 – 6000 mm. Resistant to low temperature (-3 degrees, C) and to high temperature: + 53 ºC. Bamboo branch height of 12-20 meters, a particularly high rate of timber, cutting costs extremely low.</td>
<td>15-25 M Diameter: 5–15 cm Thickness: ~ 2cm at bottom and 0.3 cm at top</td>
<td>Bamboo stick based products; Mats, blinds, chopsticks and handicrafts; Edible shoots</td>
<td>Seed, offset, branch and culm cutting, layering, etc.</td>
<td></td>
</tr>
<tr>
<td><em>Dendrocalamus Yunnanensis</em></td>
<td>80 – 800 M AMSL</td>
<td>Also found in 1700 to 2840 m, in Baimahe (from 1800 to 2300 m and in Xishan (China) around 2000 m.</td>
<td>Tropical large sized bamboo; requires rainfall ranging from 1000 mm – 3000 mm Accumulated temperature is the total daily average temperature (≥ 10 ºC) for the whole year.</td>
<td>18-25 M Diameter: 11-18 cm</td>
<td>Bamboo shoot, construction, construction and paper manufacture Construction; Paperpulp and wood.</td>
<td>Offsets; Culm cuttings, branch cuttings and layering</td>
</tr>
<tr>
<td><em>Bambusa bambos</em> (L.)Voss.</td>
<td>0 – 1500 Meters AMSL</td>
<td>Up to 1800 M in Uttarakhand, India.</td>
<td>Suitable for tropical and sub-tropical climate. Prefers sandy loan and fertile soil. Can withstand frost and it is similar to D strictus in its range. Rainfall between 750 mm – 4000 mm. Both Dendrocalamus strictus and Bambusa bamboos have a wide range and are hardy.</td>
<td>Up to 30 M Diameter: 10 – 18 cm Thick walled bamboo. Very densely tufted thorny bamboo producing large dense clumps of packed culms.</td>
<td>Construction, Furniture, Basketry, edible shoots. Ideal for wind break and boundary fencing (spiny)</td>
<td>Branch cutting and culm cutting.</td>
</tr>
<tr>
<td><em>Bambusa nutans</em> Wallich ex. Munro</td>
<td>600 M to 1500 M</td>
<td>Grows well around 2000 M in Uttarakhand (India) .</td>
<td>Sub-Tropical Bamboo (sub-Himalayan regions). Grows well in moderate and high rainfall regions; It prefers a mean annual rainfall in the range 2,300 - 3,000mm, but tolerates 700 -4,500mm Temperature range from 4 – 37 ºC.</td>
<td>10 - 20 M Diameter: 5 –10 cm Medium thickness and straight bamboo poles.</td>
<td>Construction, Furniture, Basketry.</td>
<td>Offsets, branch cutting, culm cutting and Layering.</td>
</tr>
<tr>
<td><em>Bambusa balcooa</em> Roxb.</td>
<td>0 – 1000 meters AMSL;</td>
<td>Grows well up to 2000 meters (Amhara, Ethiopia; Mbeya, Tanzania)</td>
<td>Grows in high rainfall regions 1500 mm to 5000 mm. Can withstand drought (700 mm rainfall) and temperature up to -5 ºC.</td>
<td>15 -25 M Diameter: 8 – 15 cm Good wall thickness. High biomass production potential</td>
<td>Construction, Furniture, Basketry products. Edible shoots.</td>
<td>Culm cuttings, branch cuttings, layering.</td>
</tr>
<tr>
<td>Species</td>
<td>Altitude</td>
<td>Distribution</td>
<td>Characteristics</td>
<td>Uses</td>
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<tr>
<td>Bambusa vulgaris Schrad ex Wendl</td>
<td>0 – 1500 M</td>
<td>Asia</td>
<td>It is a Pan tropical species. Prefers moist tropical climate. It grows best in low altitudes; above 1200-meter elevation the size of culms reduces. It prefers a mean annual rainfall in the range 1,200 - 2,500 mm, but tolerates 700 - 4,500 mm. Thrives in wide range of soil and moisture conditions. Prefers moist alluvial soil, also grows well in well drained sandy and clayey soils. Tolerant to salinity and water logging. It is drought resistant and frost hardy (-3°C).</td>
<td>Basketry and Handicrafts; Fencing and low cost application. High biomass production capacity – suitable for energy (charcoal and biomass)</td>
<td></td>
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</tr>
<tr>
<td>Dendrocalamus giganteus Wall. ex Munro</td>
<td>0 – 1200 M</td>
<td>Madagascar, India</td>
<td>Tropical to sub-tropical bamboo. Grows well in humid tropical high lands and in low lands with high humidity and good alluvial soil. Can tolerate up to -2 degree C. Prefers well drained loamy soils. It prefers a mean annual rainfall in the range 1,800 - 3,600 mm, but tolerates 1,200 - 4,500 mm.</td>
<td>Construction, handicrafts and furniture. Excellent bamboo shoots. Leaves – good fodder. High Biomass production capacity (charcoal and energy)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dendrocalamus hamiltonii Nees &amp; Arn ex Munro</td>
<td>600 – 1500 M</td>
<td>India, Ethiopia</td>
<td>Suitable for sub-tropical climate. Requires moist and moderately good rainfall; Rainfall varies from 750-5000 mm in its natural range; Temperature maximum 48°C and minimum -5°C.</td>
<td>Construction, handicrafts and furniture. Industrial panel products. Leaves good fodder.</td>
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<td></td>
</tr>
<tr>
<td>Dendrocalamus asper (Schult. f.) Backer ex Heyne</td>
<td>400 – 1500 M</td>
<td>Madagascar</td>
<td>Grows well at an elevation of 2000 meters in Madagascar. Tropical to sub-tropical bamboo. Can withstand frost and cool temperature up to -4°C. Grows well in areas with good rainfall, prefers heavy and well drained soils. It prefers a mean annual rainfall in the range 1,800 - 3,600 mm, but tolerates 1,200 - 4,500 mm.</td>
<td>Construction, Handicrafts and furniture. Excellent bamboo shoots. Leaves – good fodder.</td>
<td></td>
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</tr>
<tr>
<td>Dendrocalamus hookeri Munro</td>
<td>700 – 1500 M</td>
<td>Madagascar, India</td>
<td>Grows well in soil range – sandy loam to clayey loam. Grows well in humid tropical high lands with high humidity; a minimum of 1200 mm rainfall.</td>
<td>Construction, Basketry and panel based products Bamboo shoots High biomass production potential suitable for energy.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dendrocalamus brandisii (Munro) Kurz</td>
<td>700 – 1500 M</td>
<td>India, Kerala</td>
<td>Grows well in moist and well drained conditions. Tropical – sub tropical bamboo, Tolerate frost and cool temperature up to -3°C. It prefers a mean annual rainfall in the range 1,800 - 3,600 mm, but tolerates 1,200 - 4,500 mm.</td>
<td>Construction, furniture, farm implements, basketry and handicrafts. Edible shoots. High Biomass production capacity, suitable for energy.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Guadua angustifolia Kunth

<table>
<thead>
<tr>
<th>Height: up to 30 M</th>
<th>Construction and building material, furniture, handicrafts.</th>
<th>Branch cuttings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter: up to 20 cm. Good wall thickness (short internodes)</td>
<td>Construction, furniture, props, agriculture implements tools. Suitable for farm boundary fencing and agro-forestry. Edible shoots.</td>
<td>Offset planting</td>
</tr>
<tr>
<td>Suitable for tropical climate – high rainfall and deciduous Minimum 1000 mm to maximum 3000 mm+</td>
<td>Height: 15–25 M Diameter: 5 cm Solid bamboo poles</td>
<td></td>
</tr>
</tbody>
</table>

Thyrso stachys oliveri Gamble

<table>
<thead>
<tr>
<th>500 – 700 m</th>
<th>Up to 1000 meters in Uttarakhand, India</th>
<th>Suitable for sub-tropical climate, can with temperature up to – 2 °C Annual average temperature range is 20 – 26 °C. Rainfall range: 1200-2500 mm year.</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 – 1600 M</td>
<td>Coincides with major coffee growing regions</td>
<td>Height: up to 30 M Diameter: up to 20 cm. Good wall thickness (short internodes)</td>
</tr>
<tr>
<td>Suitable for sub-tropical climate, can with temperature up to – 2 °C Annual average temperature range is 20 – 26 °C. Rainfall range: 1200-2500 mm year.</td>
<td>Construction and building material, furniture, handicrafts.</td>
<td>Branch cuttings</td>
</tr>
<tr>
<td>Height: up to 30 M Diameter: up to 20 cm. Good wall thickness (short internodes)</td>
<td>Construction, furniture, props, agriculture implements tools. Suitable for farm boundary fencing and agro-forestry. Edible shoots.</td>
<td>Offset planting</td>
</tr>
</tbody>
</table>