SUSTAINABLE HARVESTING OF BAMBOO

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Major classification of Bamboo

Bamboo is based on a rhizome, and the underground structure, which constitutes the structural foundation of the plant, can be classified into the four following types:

1. Pachymorph/sympodial tufted (short-necked pachymorph)/clumping bamboo;

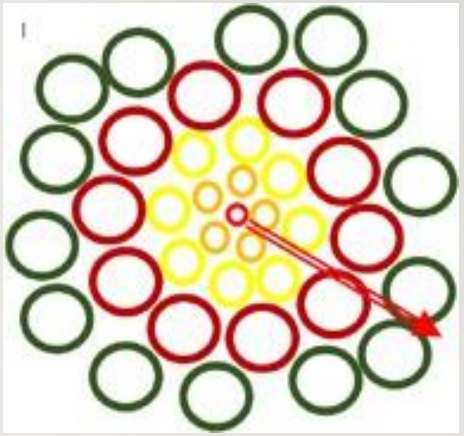
2. Pachymorph/sympodial scattered (long-necked pachymorph)/clumping bamboo;

3. Leptomorph/monopodial/running bamboo; and

4. Amphipodial mixed/mixpodial/clumping and running bamboo

Growth Pattern of Bamboo Clumps

- Most sympodial bamboo clumps require **about four to six years to reach maturity** the bamboo clump reaches its girth); thereafter, they remain more or less static.
- The **number of culms** and **diameter at breast height (DBH)** (1.37 m 0r 4.5 ‘) and **height** gradually increase in subsequent years after planting, reaching the maximum in about five years.
- The expansion of the clump girth is rapid during the first four to six years after planting and then slows down.
- **If there is no harvesting after clump maturity, culm production gradually decreases**. In the case of undisturbed clumps, crowding and congestion happens (new shoots/culms emerge every year and old culms die every year).
- **Due to congestion, yields decrease and culms are more often bent and twisted**, making the plant unsuitable for high-end value addition



Growth pattern of bamboo clumps

- Bamboo clumps produce new shoots/culms/poles annually, and at the same time, old bamboo culms/poles (over five years old) start deteriorating and dying.
- If bamboo poles (mature) are not harvested regularly, the productivity and quality of poles and shoots reduces drastically. **If over-harvested, the productivity drops, which can lead to the degradation of clumps.**
- Therefore, **sustainable and selective harvesting coupled with proper management practices** is key for healthy bamboo clumps, which can provide annual income opportunities for harvesters, growers and processors.

Year-wise Growth

Year !

Year 2

Year 3

Year 4

Year 5

Year 6

Basic Harvesting Rules

1. **No clear-felling** should be allowed.
2. All **older or matured bamboo culms** should be harvested (three years +)
3. **Current-year culms should be retained** for reproduction.
4. At least **a minimum of six culms over one year old**, spaced uniformly over the clump, should be retained. When there are large clumps, proportionately more mature culms can be retained.
5. **The number of harvestable culms should not exceed the number of poles that emerged in the last year**

Basic Harvesting Rules

6. **Digging of young rhizomes is not permitted**, except for propagation purposes. (Old and dead rhizomes can be removed to create space for new shoots).
7. **Culms should be felled/cut at the first inter-node** from the ground (about 10 cm from ground level).
8. A **sharp instrument** (knife or saw) should be used when felling to avoid splitting and damage of culms.
9. **All dead and dry bamboo, as well as all debris** as a result of harvesting and high cuts (due to lopping), should be removed from the clump.
10. Bamboo forests should be protected from **fires.**

Culm Age

- Although individual bamboo poles or culms stand apart, the underground portion (rhizome system) of the bamboo clump is inter- connected.
- Due to annual production of new shoots, different-aged culms/poles are observed in a bamboo clump.
- Age determination of these culms is important to sustainably manage and harvest bamboo, as bamboo culms of different age categories have the following attributes:
  - (a) different physical, mechanical and chemical properties and (b) unique functions in a clump.

Difference in properties for value-addition

1) The **age of the culm** is an important factor for its suitability in different applications. Bamboo shoots emerging from the ground take about 60-120 days to reach their full height, diameter and wall thickness. Thereafter, only mechanical and chemical property changes occur in mature bamboo poles.
2) **Uniformity of raw material** is critical for production of high-quality, standardised/industrial products. Bamboo poles of similar physical, mechanical and chemical properties (with age grading) will ensure production of uniform and standardized products.

Age Marking System

- Bamboos lack the **vascular cambium layer**, and thus, lack the secondary growth in diameter seen in trees. Under field conditions, it is not always easy to distinguish the age of a bamboo culm, since culms in a mature clump tend to have the same girth, length and nodal structure.
- The culm age can be identified based on certain features of the **culm sheath**, development of **branches and leaves**, **external colour of the culm**, **position of new culms** and so on. For example, in sympodial bamboos, younger/current-year culms are usually on the outer side, while older culms are towards the inner side.
- **Culm sheaths are usually absent on older culms**. The accuracy of such a distinction, however, depends on the skill and experience of the person and is not always reliable. Therefore, other guaranteed methods have to be adopted to determine the age of bamboo.
- Age can also be determined by the following methods: (**a) marking the culms with different colour paints, (b) writing the year and month of shoot emergence using colour/paint and (c) inscribing the year of shoot emergence.** Alternatively, other innovative approaches can be adopted.

Different colour paints:

Three different colour paints are required, one for each year of a three-year cycle. Culms that are older than 3-4 years should be logged, as they become weak and brittle and can be expected to die.

After the culms attain full height during the first year, they are marked with paint.

A scheme for identifying culm age is shown in the table below. Please note, this is mostly suitable for on-farm bamboo plantation, as well as intensely managed forest plantation.

Colour schemes for identifying the age of culms

Colour	Age (Year)	Rotation-2
Red	Current: 0-1 years	**Current: 0-1 years**
Yellow	1-2 years (2019)	**1 – 2 years (2022)**
Blue	**2-3 years (2020)**	**2 – 3 years (2023)**

Giving Colours to Mark Age

- **Note:** Marking should be done after the culm attains its full height, that is, after it has stopped growing. The indication of the stoppage of further dimensional growth (length) is when branches begin to appear, normally first in the upper portion of the culm.
- Detach the culm sheath from the culm before beginning to paint
- Mark the different-aged culms with the thick paint by making a 2–3-in band at breast height in the inter-nodal portion of the culm, taking care that paint does not drip down the culm.
- Use different colours (as given in the table and figure above) for marking different ages

Writing the Month and Year

- **Writing the year and month of shoot emergence:** Using single colour paint (black), write the year and month of shoot emergence. This method is widely adopted in China

Bamboo forest/farm Structure Management

Maintaining the:

(a) inter-clump density (number of clumps in a hectare),

(b) intra-clump density (number of poles in a clump) and

(c) age composition (composition of different age-class bamboo culms/poles in a clump) is critical for optimal growth and regeneration.

Inter-clump density/structure of bamboo stands

- Plantations with low clump density will suffer from canopy exposure and short culms due to a lack of light competition, low soil moisture and strong competition from weeds. This may result in poor productivity and necessitate a lot of labour during tending.
- Plantations with high clump density/over-stocking at planting will also result in low productivity from smaller plants due to the intense competition among the plantlets for light, space, soil moisture and nutrients.
- Maintaining an optimal density of the clump is crucial for optimal yields.

Clump Intensity

Low-clump-density bamboo stand with extensive weeds

High-density bamboo stand with stunted growth of clumps and culms

Optimal Inter-clump Density:

Stocking or density of clumps or spacing between clumps varies across sympodial bamboo species

- **Small-diameter bamboo species (< 6-cm diameter DBH):** 4 × 4 m or 3 × 4 m spacing: 600-800 clumps per hectare: Bamboo species like *Oxytenanthera abyssinica, Dendrocalamus strictus* and *Bambusa multiplex* belong to this category.

- **Medium-diameter bamboo species (6–10-cm diameter DBH):** At least 5 × 5 m or 4 × 5 m spacing: 400-500 clumps per hectare: Bamboo species like *Yushania alpina, Bambusa vulgaris, Bambusa polymorpha, Cephalostachyum pergracile, Dendrocalamus hamiltonii, Dendrocalamus membranaceus* and others belong to this category.
- **Large-diameter bamboo species (>10-cm diameter at DBH):** 7 × 7 m or 6 × 7 m spacing: 200-250 clumps per hectare: Bamboo species like *Dendrocalamus giganteus, Dendrocalamus asper* and so on belong to this category.

Intra-clump Density

A reasonable number of standing bamboo poles in a clump is necessary for bamboo shoot/culm production (optimising quantity and quality). Depending on the species, it is recommended to retain 12–20 culms per clump. In the case of large-, medium- and small-diameter bamboo species, about 12, 16 and 20 bamboo culms can be retained.

However, the most critical factor is the age composition.

If clumps are located in a steep slope area, the number of culms in a clump could be 1.5 to 2 times higher for increasing the function of soil erosion control.

Age composition

Year 1: Year 2: Year 3: Year 4 = 1:1:1:1

Why is maintaining clump composition or age structure necessary?

Broadly, an equal number of bamboo poles/culms of different age classes can be retained, as the number of bamboo poles harvested and shoots recruited for growth into bamboo culms could be balanced.

The composition of the clump after harvesting: Current year 1 (0-1 years), year 2 (1-2 years), year 3 (2-3 years) can be in the proportion of 1:1:1. In addition, one of two old bamboo poles (year 4) could also be retained.

To illustrate this, for example, an annual harvesting clump has 12 bamboo poles; the number of bamboo poles for year 1 = 4, year 2 = 4 and year 3 = 4. Allow four strong shoots to grow into a bamboo culm/pole; the clump will have 16 poles, and when harvesting season arrives, harvest four mature bamboo poles that have passed year 3.

- The composition of the clump after **'shooting season'** and before harvesting can vary depending on the harvesting rotation (one, two or three years).

Harvesting Season

- **After the rainy season or in the early dry season is the best time to harvest bamboo poles.** With low starch content and relatively less moisture content, the bamboo poles are least susceptible to attacks by fungi, borers, termites and other pests.
- **Harvesting or felling should not be done during shoot emergence and growing periods** as harvesting operation will damage the tender growing shoots.
- **Harvesting should not be done at the end of the dry season or in the early rainy season** as the bamboo plant body has a lot of accumulated starch and nutrients to feed the emerging shoots. Bamboo poles harvested during this period will be susceptible to borer and insect attacks due to the high starch concentration.

Harvesting Methods

- New culms are commonly produced on the periphery of the clump (young culms/rhizomes are the ones that produce new shoots (one to two years old).
- Mature bamboo poles in sympodial bamboo clumps are commonly found at the **inner core of the bamboo clump**.
- In the case of sympodial bamboo with a long rhizome neck, such as *Yushania alpina*, penetrating inside the clump and harvesting mature bamboo poles is relatively easy due to the sparse nature of the plant's growth.
- In the case of unmanaged sympodial bamboo with a short-neck rhizome (genera like *Bambusa, Oxytenanthera, Dendrocalamus, Cephalostachyum* and others), the bamboo clump is congested, prohibiting the entry into the clump.

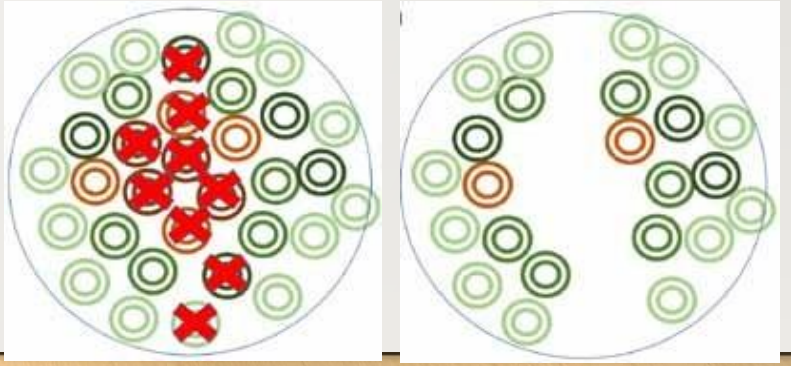
D. membranaceus, younger culm outside the clump

Unmanaged B. vulgaris with dead poles inside the clump

Managing congested or clustered bamboo : two techniques

- **Tunnel technique:**
- Make a 60-cm-wide path from one end of the clump to the other.
- Make sure the tunnel created passes through the central part of the clump.
- As most of the mature bamboo poles are created in the centre of the clump, the tunnel is created so that one can enter, harvest and drag the bamboo poles.

Bamboo clump with tunnel

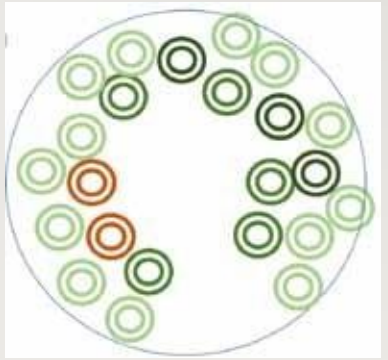


Before

After

Horse Shoe Technique

- Make a 60–100-cm-wide path from the periphery or outside of the bamboo to the centre of the clump.
- Select the location or side of the clump where there is the smallest number of young bamboo poles, to avoid cutting of young poles.



Harvesting Techniques

- **Felling / Cutting method**
- **Cut the culms in a slanting manner** (45°) **at the first inter-node** (about 10–15 cm above the first node) to minimise wastage, avoid sprouting and prevent rainwater from stagnating in the cavity of the stump portion.
- When felling is done far above the ground, buds on the nodes of the cut stump will be activated, producing branches and bushy clumps; this will hinder future harvesting and management operations

Care during felling / harvesting

Branches and twigs from harvested poles need to be cleared from the mother culms.

Dead, rotten and deformed culms and stumps should be cleaned.

Harvesting and felling operations should not be undertaken in the culm emergence period.

Rotational Harvesting in Bamboo Forest Management

- Clear cutting should not be allowed.
- Rotation cycle can be two to three years. **The rotation cycle should not be longer than three years to avoid culm congestion and slowdown of shoot production.**
- Leave all the one-year-old culms and an equal number of mature culms (two and three years combined); harvest the rest.
- In managed bamboo forests, the regeneration (quantity) and quality of bamboo poles will be better.
- In locations with unregulated or over-harvested bamboo forests over years, stopping harvesting for a few years to allow the bamboo forests to recoup.

Sustainable management of bamboo for bamboo shoots

- The primary objective of bamboo shoot clump management is to **maximise sustainable bamboo shoot production.**
- Depending on the species, there are about 6–12 buds or more in each rhizome; among them, several buds will be activated and elongated into shoots or culms. If they are harvested, the remaining ones will be activated and grow as new shoots, enabling harvesting of bamboo shoots and sustenance of bamboo stands.
- The shooting period lasts for about **two to six months** (varying according to the species, site conditions, geographic location and management techniques). It occurs in three distinct phases, which are as follows: **(a) the early phase, (b) peak phase and (c) final phase**.
- Nearly one-fourth of shoots are produced in the early phase, one half during the peak phase and one-fourth during the final phase. Select the best, strongest shoots during the peak stage and leave them to grow into new mother bamboo plants.

Shoot harvesting

1. Depending on the bamboo species, bamboo shoots are harvested when they reach a height of 15–50 cm. In the case of
2. *Dendrocalamus* species, the height is about 15–30 cm; for *Yushania alpina*, it is about 40–50 cm.
3. Soil surrounding the shoots is removed until the shoot buds. Then, the shoots are cut with a sharp and clean knife, without damaging the mother rhizome.
4. Select the best/strongest shoot during the peak stage and allow it to grow into a new mother bamboo.

For example, if we are maintaining an intra-clump density of six culms with a 2:1 ratio, four bamboo shoots should be allowed to grow into a full culm/pole. This will produce bamboo shoots for the coming year.

5. Allow shoots from different locations of clumps to grow rather than allowing all shoots from one location to grow to avoid congestion