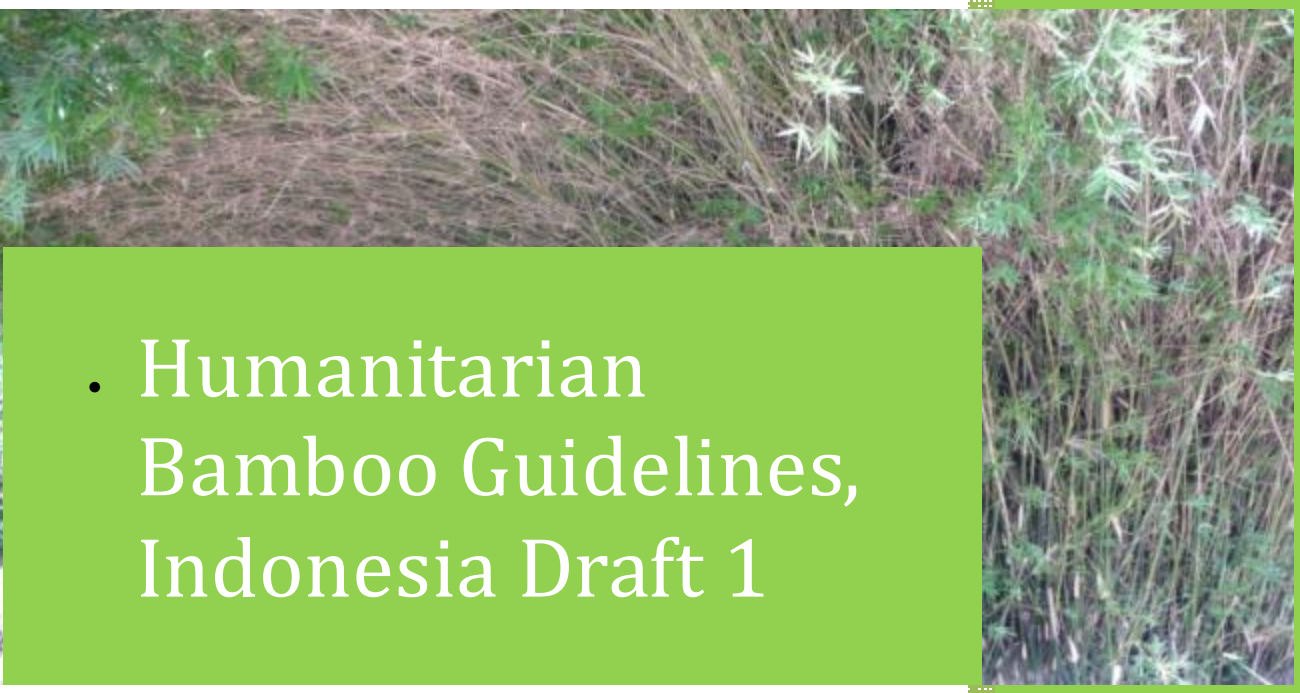
Humanitarian bamboo



2008

Humanitarian Bamboo Guidelines, Indonesia Draft 1

9/2/2008

Humanitarian bamboo

FOREWORD

This Draft 2 of the Humanitarian Bamboo Guidelines is intended to supply a general layout and division of the issues and style of the proposed guidelines. As such the document is very much "up for discussion" any comments will be taken seriously and will input into the second draft

These guidelines are being developed as a NO LOGO project, with the generous financial and support of Oxfam G.B's Prime Project in Jogjakarta Indonesia with contributions and assistance by numerous bamboo and disaster response experts both in Indonesia and India and the support of Shelter Cluster participants globally.

This first draft intended to precipitate discussion and comment, it is not intended at this stage to be a document for use in Humanitarian programming. Any input criticism or feedback into the further development of this document is much appreciated.

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Humanitarian bamboo

ACKNOWLEDGEMENTS AND COPYRIGHT

This document has been developed as a ***NO LOGO*** project through the financial assistance of Oxfam GB's PRIME project in Yogyakarta Indonesia as a contribution to the Shelter Cluster with the main preparation of the document by Dave Hodgkin from Benchmark Consulting.

The author would particularly like to thank Ale Aidid, Kim Williamson and Loren Lockwood for their assistance in research and editing along with Anto, Sebastian and their team from Oxfam for their endless support.

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In no particular order

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- Jatmika and his team at University of Gadja Mada
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LIST TO BE COMPLETED

For a full list of contributors see list on back page

Humanitarian bamboo

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GLOSSARY OF TERMS

TERM	MEANING
Culm	The common term for an individual stick of bamboo within a clump (see diagram ###########)
Clump	A group of culms forming one individual bamboo plant (see diagram ###########)
Running Species	One of the two main groupings of bamboo where fresh shoots travel underground and may spring up, up to 30m from the main clump, allowing the bamboo to spread over an ever increasing area. The fibres of running varieties are generally much straighter than those of clumping species
Clumping Species	The grouping of bamboos that grow with new shoots forming close to the base of existing culms, forming a close knit stand. The fibres of clumping bamboo are generally more intertwined than those of running species
Node	The crosswise element that occurs at regular intervals along a culm of bamboo (see diagram ###########)
Column	Major vertical structural elements of a building
Beam	Major horizontal structural elements of a building
Rafter	Structural roofing pieces that extend from the ridge of the roof down to the external walls and often through to create eaves
Joist	Horizontal structural member that flooring is attached to
Lintel	Horizontal structural member above a doorway or window, designed to ensure transfer the load and any stresses of the structure to either side of the opening
Bracing	Elements incorporated into a building to stop the building from racking (rocking) under changing loads
Peg or Dowel	Small, commonly timber or bamboo element, driven through holes in adjoining pieces of timber or bamboo to pin the two pieces together (see diagram ###########)
Inter-nodal space	Term referring to the hollow section of tube in any bamboo culm that occurs between any two nodes (see diagram ###########)
Node	The solid section that regularly breaks up the hollow tubular section of a culm
Racking	Rocking
Warpage	Twisting and bending of bamboo or timber over time, commonly caused by exposure to adverse effects such as too much load, excess sun,
Ridge	The horizontal member that makes up the highest point of two or more intersecting roof planes
Eaves	The element of a roof that overhangs past the external walls
Under purloin	Horizontal structural elements that support rafters or joists
Fishplates	A bridging element applied to the side of one or two building elements to provide reinforcing and strengthening across a weak point in constrcution
Nogs	Small spacing elements placed between larger construction components such as studs or rafters to prevent them from buckling or twisting

Section A

Introduction

1. Introduction to the guidelines
2. Introduction to bamboo
3. Deciding to use bamboo

Key Points

- These guidelines are intended as an introduction to the key issues regarding the use of bamboo in post disaster humanitarian shelter programming
- Aiming to bridge the gap between humanitarian workers understanding of emergency response and the technical knowledge of technical bamboo experts
- The high strength, low cost, rapid growth and high availability of bamboo across many disaster prone regions makes this an ideal resource for use in humanitarian shelter
- A number of factors need to be considered when considering the use of including availability of resource and skills as well as social acceptance

A.1. INTRODUCTION TO GUIDELINES

A.1.1. OUTLINE AND STRUCTURE

These guidelines are divided into four distinct sections. The first three sections supply an introduction to the main issues around the use of Bamboo in humanitarian Programming, whilst the last section provides a list of additional resources in support of those themes.

A.1.2. RATIONALE

The Humanitarian Bamboo Project (HBP) to develop the humanitarian bamboo guidelines emerged from the 2006 Jogjakarta Earthquake response in conjunction with requests from humanitarian workers further afield. As part of the Jogjakarta earthquake response over 70,000, 24m^2 bamboo transitional shelters were erected over 9months, at an average cost of $1-200, resulting in one of the largest and most rapid post disaster shelter responses in recent history, at relatively low unit cost and with minimal environmental impact.

It became clear after Jogjakarta that although bamboo was a cost effective, strong, cheap, rapidly constructed and readily available material, many humanitarian workers were inexperienced in its use and lacked clear guidance on best practice in bamboo construction.

In response to the concerns above these guidelines have been produced to help guide and direct humanitarian workers make better informed decisions about when and how to use bamboo in post disaster recovery operation. The guidelines aim to provide an "open source", "no Logo" bridge between the technical knowledge of Bamboo experts and the disaster response experience of humanitarian workers.

A.1.3. PROCESS

These guidelines are being developed in conjunction with the website www.humanitarianbamboo.org to provide initial guidance to workers considering the use of bamboo in post disaster response. The guidelines are in no way comprehensive and it is strongly recommended that practitioners seek out the advice of technical experts and local trades-people to provide more specific advice on their individual programs.

The production of these guidelines has been broken into a number of stages,

1) Consultative workshops to advise on the guidelines
    a. Forums have been conducted in Yogyakarta and Pune India
2) Production of Indonesia specific guidelines
    a. First draft in English then translated into Indonesian
3) Development of a website as a repository of information regarding bamboo programming
4) Depending on acceptance and relevance the production of a more international set of guidelines along with expansion of the website to provide a larger collation of international information.

A.1.4. TARGET AUDIENCE

These guidelines are primarily targeted at Humanitarian practitioners in the field, providing them with guidance as to best practice in bamboo usage and construction.
Secondary targets include:

- Members of disaster affected communities looking for guidance on what to expect from humanitarian workers or guidance on things to consider in their own bamboo projects
- To advise donors on what the sector sees as best practice and what to look for in funding proposals that incorporate the use of bamboo

A.1.5. DISCLAIMER

It is an almost impossible to produce a set of guidelines short enough to be read in the limited time available to emergency workers as well as detailed enough to provide clear technical advice on all aspects of bamboo usage. As such these guidelines aim to provide an introduction only to key issues, with references and sources available for further investigation as required.

Post disaster shelter programs aim to assist families on their path from post disaster homelessness to a return to a state of adequate shelter security. As such the design of programs must by necessity include extensive input from the local community. Bamboo construction methodology is intricately linked to local culture and varies greatly from place to place. Base principles as portrayed in these guidelines must be integrated with local wisdom to achieve quality programming.

Although the greatest care has been taken in producing these guidelines, the authors will not be held responsible for any advice given, advice must be checked on a case by case basis.

A.2. INTRODUCTION TO BAMBOO

A.2.1. BAMBOO THE PLANT

Bamboo is one of the most useful plants known to humanity, with all parts of the plant used, providing shoots as nutritious food, leaves as fodder and stalks for construction. Of the more than 1,000 known uses for bamboo, common uses include, post and beam construction, formwork, food, fodder, musical instruments, piping, walling, flooring, mats, baskets, roofing, cooking utensils, medicine, charcoal, etc.

You can watch it grow!

The tallest bamboo can grow at up to 1-2m/day, reaching heights of over 35m within 1 growing season. That's 15-20cm over lunch.

Bamboo is highly versatile, strong and highly renewable, it is an intrinsic part of daily life for most Indonesians, Homes are built from it, floors and walls are covered with it, Bamboo baskets and pots adorn houses while countless bamboo bridges cross the myriad of small streams and rivers that cross this country.

Over 1,000 species of bamboo have been identified globally with more than 100 classified as woody species suitable for construction. Indonesia alone has more than 140 known species, of which at least 16 are commonly used in construction.

COMMON CONSTRUCTION BAMBOOS IN INDONESIA AND THEIR USAGE

INSERT TABLE OF MAIN SPECIES IN INDONESIA AND THEIR USES

For further information redistribution in Indonesia see:

Distribution Map of bamboo in Indonesia

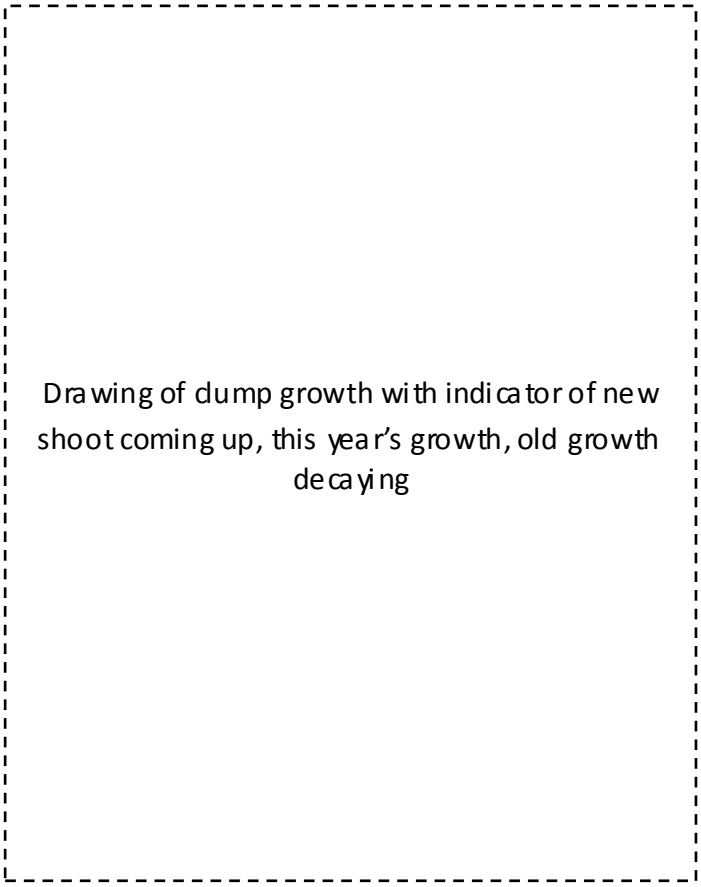
A.2.1.1. GROWTH PATTERN OF BAMBOO

Bamboo, can be divided broadly onto two groups running and clumping. Clumping species sprout their new shoots close to the base of existing culms whilst running varieties may send out shoots as far from the existing clump as the clump is tall.

Full size in 3 months

Unlike timber which may take 10s or 100s of years to reach full height, bamboo reaches its pinnacle in one season, only toughening up over the next years

Bamboo differs greatly from timber both in growth pattern and structure. Unlike timber, *bamboo grows to full height and girth in a single growing season*. Bamboo should not be harvested during this period as the high levels of sugar within the sap make the harvested culms highly prone to pest infiltration. See section: ***0***



Harvesting

Having reached full height within the first few months culms then toughen and harden over the next few years reaching full strength after 2-3. After 5-6, years culms begin to degrade and eventually die off as rot, decay and pest infestation set in, making them progressively less suitable for use in construction. Culling out of older culms within a clump increases overall clump productivity by allowing more sunlight through to younger culms. See section: *0*

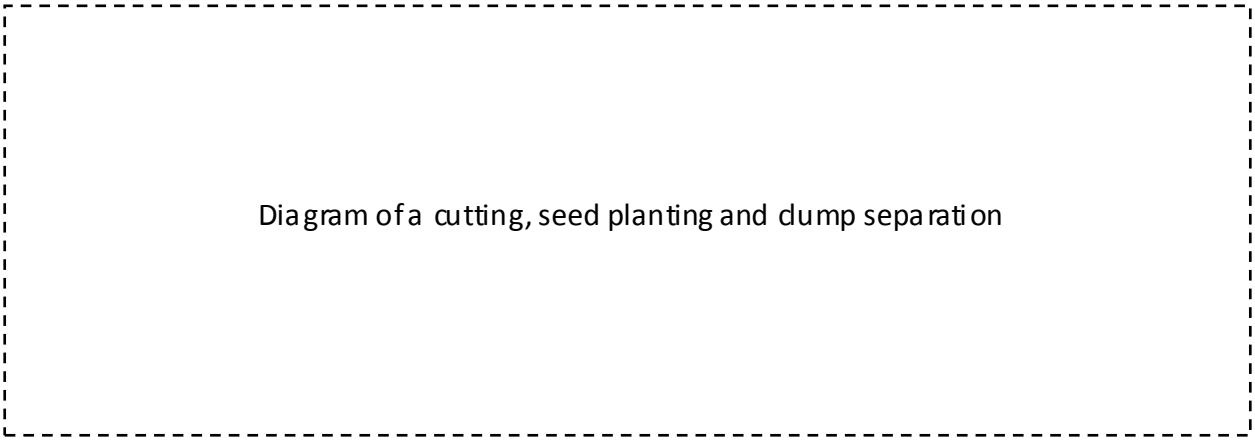
Bamboo Mass Flowering

Bamboo flowering occurs on mass across a species, in cycles from 5 to 100yrs+ depending on the species. Mass flowering events may cause great change to ecosystems and wreak havoc in communities dependent upon bamboo as a resource or heavily affected by ensuing plagues of flower eating pests and their predators such as rats and snakes

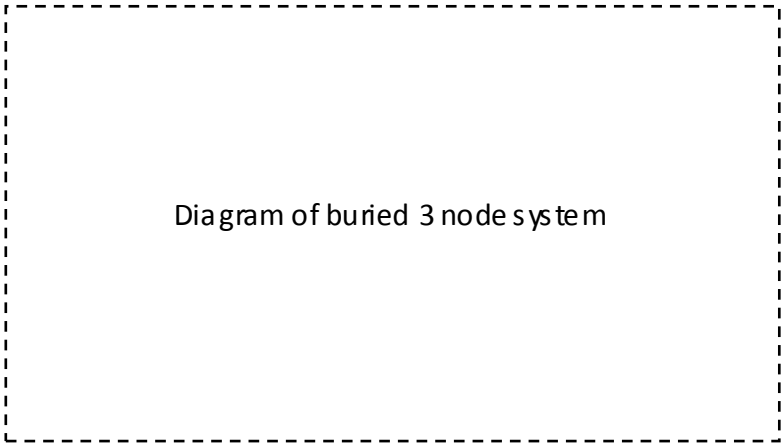
From first planting clumps reaches full productivity in 10 – 12 years and can then be sustainably harvested until the clump eventually flowers and then dies off. Clump flowering occurs en masse across a species within one area, in cycles that vary from species to species but may occur only once in a 100 or more years.

A.2.1.2. CULTIVATION OF BAMBOO

Bamboo may be grown either directly from seed, through cuttings, or by divisions of clumps. As many woody species have long periods between flowerings, with often low rates of germination from seed (below 1%), this is perhaps the least common method of cultivation. Smaller plant varieties are easily handled and therefore commonly cultivated through clump separation, whilst larger varieties are generally propagated through cuttings.



One of the more common commercial methods of propagating woody species involves horizontally burying cuttings that are 3-4 nodes in length around six inches below ground prior to onset of the rainy season. Holes are cut mid way between nodes, with each segment then filled with water prior to burial. New shoots then form from the nodal joints.



Concern about the impact of mass bamboo construction projects on local community stocks may lead agencies to consider community replanting programs. This is outside the primary focus of this document but for more information see: #######

A.2.1.3. DISTRIBUTION

Bamboo occurrence is largely confined to the high rainfall tropical regions though it can grow in colder temperate or sub temperate zones. Bamboo of differing species, quality and quantity occurs across most of Indonesia.
For further detail on distribution in Indonesia see:

Distribution Map of bamboo in Indonesia

A.2.2. INTRODUCTION TO BAMBOO IN CONSTRUCTION

Bamboo's combination of high strength and lightness of weight make it an ideal material for rapid construction of housing, which if well built can be highly resistant to damage by strong wind, floods and earthquakes. These factors, combined with low cost and relative availability in most of the disaster prone tropical regions, make bamboo an ideal material for many humanitarian construction projects.

Housing the world

An estimated 1 billion people across the globe live in homes made from bamboo.

KEY POINTS FOR INCLUSION IN THIS CHAPTER

- Used throughout the world
- Ideally suited to emergency and temporary shelter
- Suited to permanent shelter if treated
- Different construction system
    - Nodal placement becomes important
    - Unlike timber has little or no resistance to crushing between nodes
    - Very high tensile strength
- Can be used:
    - For piping
    - Poles
    - Beams
    - Rafters
    - Batons
    - Cladding
    - Roofing

A.3. DECIDING TO USE BAMBOO

The appropriateness of bamboo for a given humanitarian program needs to be carefully thought out. Factors that must be considered are diverse, and are summarized in the following decision diagram:

DECISION DIAGRAM FOR

Section B

Sourcing

1. Material Sourcing and specifying
2. Crop Management & Sustainable Harvesting
3. Treatment
4. Logistics and handling

Key Points

- The importance of bamboo as a local community resource makes it essential that humanitarian workers consider the effect of large scale procurement on regional bamboo stocks and set in place systems that ameliorate potential negative impacts
- To treat or not to treat bamboo is an overarching decision that will affect all levels of programming and needs to be considered early on in program design and procurement
- Bamboo is commonly a community resource; hence the voice of the community is important at all stages of procurement of bamboo and bamboo products

B.1. MATERIAL SOURCING & SPECIFYING

Sourcing bamboo in sufficient volume and quality proved to be a major challenge for a many agencies during the Jogjakarta earthquake response, with some agencies consuming over 10,000 culms a day at their peak. It is critical when designing large scale programs to carefully consider the impact of such large scale purchasing on both the available resource and the local market.

	Relative merits of Procurement options		
	Community	Local or regional	National
Pros	• Funds injected at the lowest level into a community can produce up to 8 times the economic benefit for the affected population • Quality control enforced by the home owner • Increased "ownership" of the program • Works well with rural communities who have a good understanding of bamboo selection and construction	• Easily centrally controlled • Inspection of suppliers sources, business premises and storage facilities easily conducted • Puts money into local business helping kick-start the economy	• Potentially larger, more professional suppliers • Potentially spreads the environmental impact over larger area • Reduces impact on local markets
Cons	• Requires higher levels of financial control • Requires community training for quality control • Urban communities may have little or no experience in procuring and constructing in bamboo	• High potential for short term impact on the local price of bamboo, potentially pricing self-recovery groups out of the market • Potential for high level short-term and even long term impact on local bamboo crops	• More difficult to inspect offices, storage and transport facilities • Harder to regulate harvesting practices, hence potential for increased environmental impact, though further afield • Requires stricter tendering processes and controls, hence often slower to instigate
Notes	•	•	•

NOTE: If considering treatment of bamboo it is important that this is taken into consideration in designing your procurement solution Many treatment systems require treatment within a few days of cutting, others may require days of water based leaching, yet others are best conducted at the time and source of cutting

B.1.1. SELECTION AND GRADING

The quality of any given construction is only as good as the material its made from. A large range of factors can affect the quality of bamboo, including when it is harvested, its age etc. the following list provides some guidance on bamboo selection, this guidance can never replace the wealth of local knowledge regarding local markets and bamboo species/quality.

B.1.1.1. AGE

Most species of bamboo achieve their peak strength between 2 and 5years of growth.

Checking for Age

- During the first year of growth the juvenile leaves that form as each branch forms are still visibly attached to the main stalk of bamboo. As bamboo ages these fall away
- As bamboo ages it loses its fresh green colour, slowly darkening to pale brown
- As bamboo ages the walls begin to dry out and harden, causing the internodal walls to shrink, showing wrinkles
- Perhaps the surest test of age is tone, younger or older bamboo has a much flatter tone than the much tougher correctly aged bamboo. A small amount of practice will clarify the correct tone for any given species

TOO YOUNG	CORRECT AGE	TOO OLD
Image showing: • juvenile leaves still firmly attached • internodal joints still full	Image showing: • juvenile leaves fallen off • internodal collapse	Image showing: • juvenile cracks and splits forming • Signs of mould and fungal attack • Dull brown

See section: ***0***

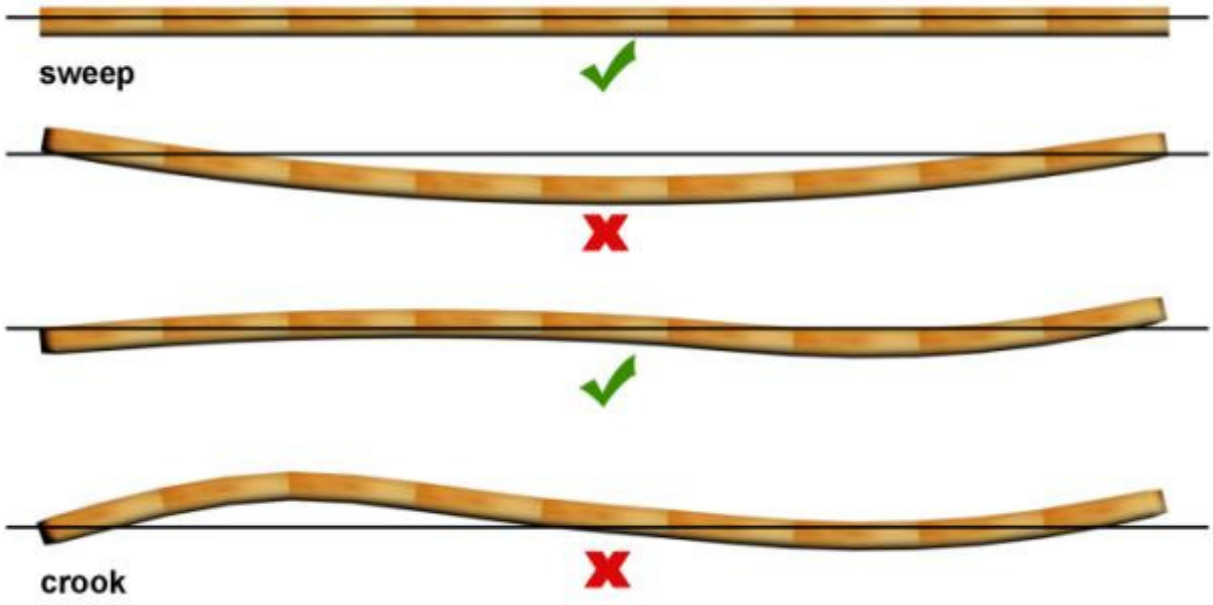
B.1.1.2. SIZE

Bamboo is commonly sold in Indonesia in lengths of 6m in widths, "besar'#####cm, "sedang" ####cm ,"kecil" ######cm. Measurement should taken from the thinnest end of the culm.

3 sizes with measurements

B.1.1.3. STRAIGHTNESS

For predictability of strength loads and replicability of design culms should be of a reasonable level of straightness. Acceptable levels of "sweep" and "crook" may be measured using a stringline stretched from the tip to the butt of the culm. No part of the culm should fall outside of the line of the string.



Note: Mildly bent culms may be suitable for use as shorter members such as nogs and bracing, whilst keeping the straightest sections for longer applications such as rafters and poles

B.1.1.4. TAPER

For ease of construction and consistency of strength, culms should be selected with a minimal level of taper along the length. A maximum taper of 10mm per 3m is commonly considered acceptable

B.1.1.5. NODES

Wic
con
grea
piec
plac

B.1.1.6. SPECIES

Species suitable for use in humanitarian programming vary across the country. The vast variation in characteristics and properties between species, makes accurate selection essential.

Species most commonly selected for poles have thicker walls whilst species for general construction have thinner but denser walls. A large variety of clumping species are used for woven sheeting and handicrafts depending on the exact needs of the product being produced.

The following table provides a list of the common most suitable for humanitarian programming common in Indonesia. Tables such as this and the tables in the Appendix should be used as an indicator only; nothing can replace local knowledge and wisdom

Poles	General construction	Woven Sheeting	Handicrafts
Diameter of 15cm+ Wall thickness 2cm+	**Diameter of 5-10cm Wall thickness 1cm+**		
Ori Petung X X X X X X X	**Apus**	**Wulung Apus**	

See section: *Page 45*

Distribution Map of bamboo in Indonesia

B.1.1.7. INSECT AND FUNGAL ATTACK

Bamboo should be checked carefully for signs of fungal decay or insect attack, such damage is most commonly due to excessive age of the culm or poor storage and handling.

3 Drawings or photos clearly showing borer holes and indication of fungal attack and rot

The three most common forms of attack on bamboo are

1) Powder borer

See section: ***0,***

B.1.1.8. SPLITTING

The majority of Asian clumping bamboo species as used in construction in Indonesia are prone to splitting. Although this proves a great benefit for the manufacture of handicrafts and woven sheeting, excessive splitting can greatly weaken the strength of bamboo in construction. Excessive splitting in bamboo is commonly a sign of poor handling and storage, excessive age of the culm, or overly rapid drying as per freshly bamboo left for too long in direct sunlight.

- Do not use bamboo where splitting continues through the node
- Allow excess at either end of the culm when ordering to allow for natural tendency to split at ends when drying
- Hairline splits are acceptable but should be considered as a warning of potential problem such as poor handling, excess age etc

See section: *0*

B.2. CROP MANAGEMENT AND SUSTAINABLE HARVESTING

Grow your own house?

Simply by managing crops better communities can increase the yield of their bamboo by up to 30%
With a 3-5 year yield time, families can quickly grow an extension to their shelter

Recent research by the Environmental Bamboo Foundation in Bali shows that good crop management practices can increase bamboo crop yields by up to 400% whilst poor practices, as are prone to occur in the rush of construction after a major disaster, can devastate crop output for many years or in some cases permanently.

DETAIL: BAMBOO PLANTS PERFORM AN IMPORTANT ROLE IN DISASTER RISK REDUCTION, REINFORCING RIVERBANK AND PROTECTING AGAINST FLOODS, WHILST BUFFERING STRONG WINDS AS WELL AS PROVIDING A VALUABLE ON HAND RESOURCE FOR RAPID POST DISASTER SHELTER

For many communities bamboo crops perform essential roles in Disaster Risk Reduction, strengthening river banks, buffering strong winds without the hazard caused by trees when blown over, shading and cooling the community's environment. Training communities in crop management and the resultant increased output can provide valuable income generation at a village level, whilst also improving community level disaster preparedness.

Grow your own protection?

Training communities in good crop management can greatly improve resilience in future disasters. As well as being a valuable resource, bamboo provides an excellent buffer for floods and storms

Protecting communities

Over 90% of homelessness through natural disasters is caused wind and flood, bamboo plays an important role in community's resilience to these events

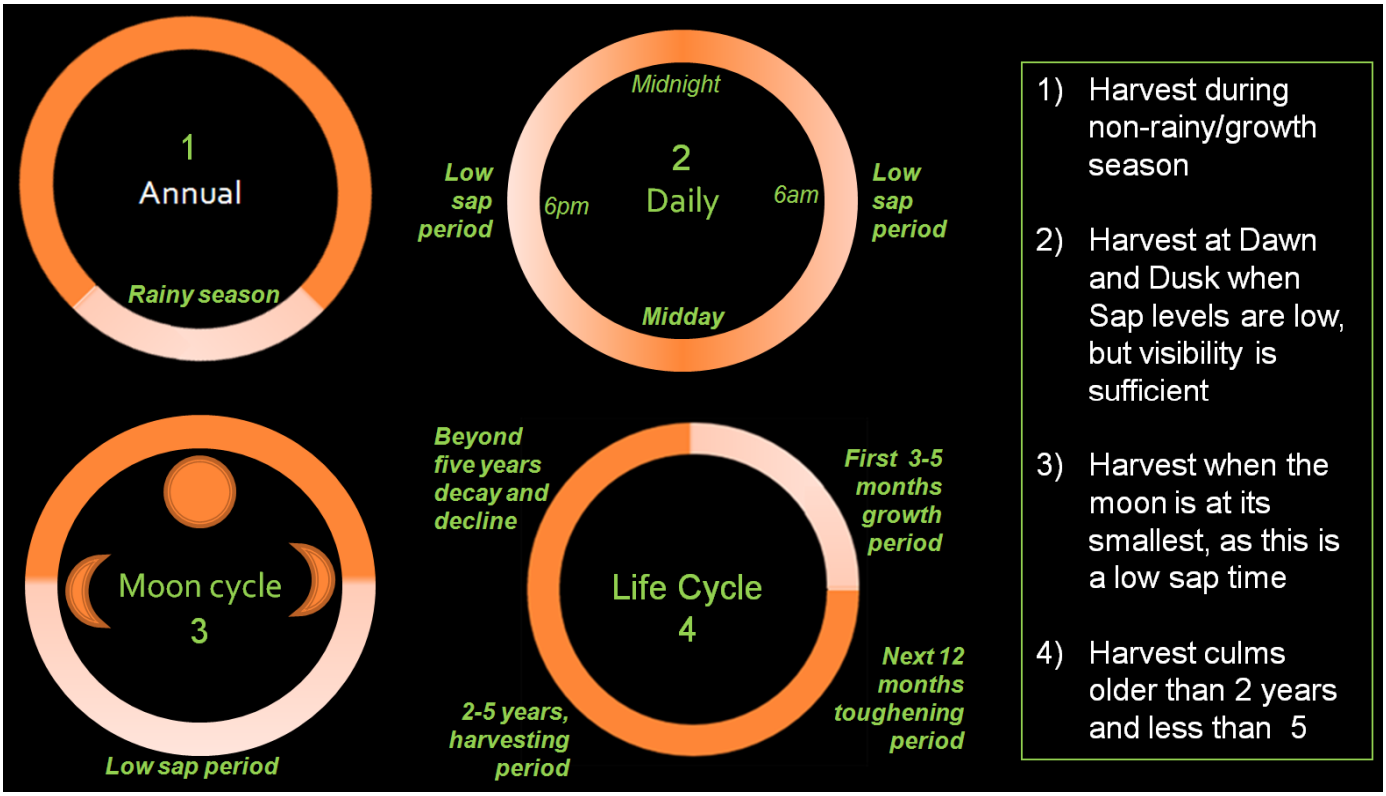
The 2008 Humanitarian Bamboo Consultative Forum in Jogjakarta identified good crop management as one of the most overlooked aspects of bamboo usage in the Jogjakarta Earthquake Response, recommending that all future bamboo based humanitarian programs should include measure to ensure sustainable harvesting as part of their procurement practices.

B.2.1. HARVESTING

Harvesting is often the only time communities engage with their bamboo stocks, hence providing the greatest opportunity for crop management. Although many practitioners agree that in and emergency bamboo crops can be harvested at any time of year, it is clear that harvesting at the correct time of year and in the correct manner will greatly improve both bamboo quality and crop production.

B.2.1.1. WHEN TO HARVEST

The susceptibility of bamboo to pest infiltration is highly influenced by sap sugar levels at the time of harvest. Harvesting at the correct phase of growth and time of year may increase bamboo's usable life span by up to ten fold. Harvesting during the rainy growth season should be avoided as it will damage newly emerging shoots.



B.2.1.2. HOW TO HARVEST

Best practice in bamboo harvesting includes:

- Only harvest culms over 2 years of age See Section ***B.1.1.1 Age of bamboo***
- Cut culms 2-3 nodes above ground to reduce the likelyhood of fungal attack
- Clear out older culms that have begin to decay, this opens up the dump allowing more light in and encouraging growth in new shoots whilst also reducing the risk of fungal infection across the clump.
- Bamboo cells begin to collapse and close within 2-3 days of harvest after which time they are no longer capable of transporting water. Treatment systems that make use of the plants vascular system must be undertaken during this period. Storing freshly cut bamboo under water as is common in sap leaching procedures will increase this interval

Horseshoe drawing of crop harvesting

(in building with Bamboo page 5, but looking like a dump of bamboo)

ONE PAGE INPUT TO BE INSERTED HERE
"GOOD CROP MANAGEMENT GUIDELINE"

B.3. TREATMENT

B.3.1. TO TREAT OR NOT TO TREAT

Perhaps the greatest debate amongst humanitarian workers regarding the use of bamboo, is whether bamboo should be treated or not prior to use in post disaster construction. Arguments for treatment point out the obvious advantages of increased longevity and the ensuing increase in benefit from assistance provided to the affected community, while proponents against treatment point out such factors as cost, time delay and the need for increased technical expertise.

Untreated Bamboo

Cheap, fast, effective, buy it today, use it today. Lasts for 1-3 years depending on exposure, biodegrades

Treated Bamboo

20-30yrs life expectancy if sheltered from weather. Hence a greatly increased contribution to community resource

The decision to treat or not treat needs to be made on a case by case basis and will be based on a range of factors, such as the forecast usage time of the structures being built and the availability of suitable skills and equipment. Much will be must be based on a clear understanding of the profile of any given disaster.

In reality whether deciding to or not to chemically treat bamboo, the greatest defense lies in how bamboo has been handled from the moment of harvest, or even earlier, until its eventual usage in shelter construction. The best treatment systems in the world are easily undermined and leached away through simple errors in design and construction. On the other hand, completely untreated bamboo, correctly harvested, cured, transported and installed may last as long as its poorly handled though thoroughly treated counterpart.

B.3.2. PROTECTION WITHOUT TREATMENT

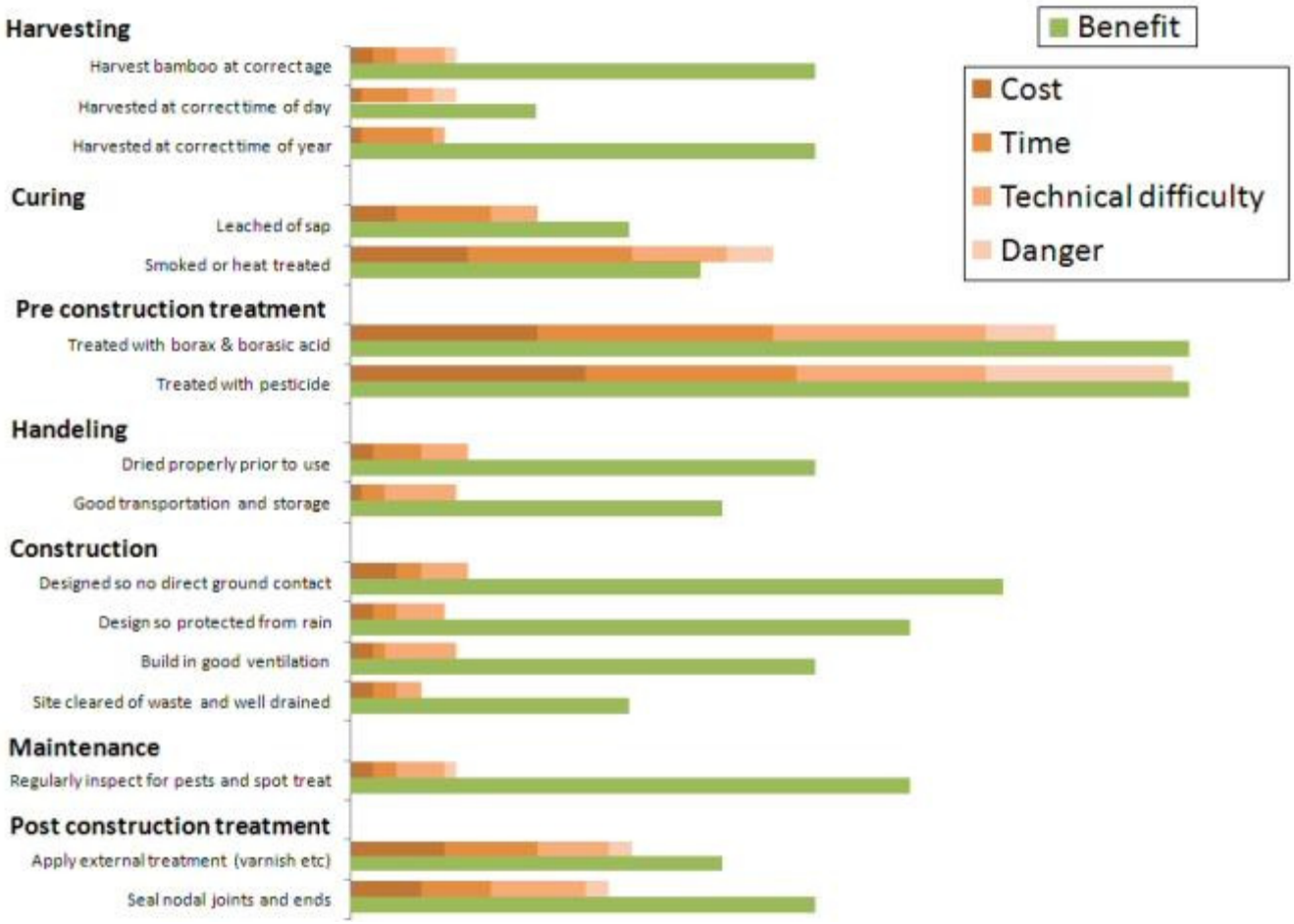
The most important defense in any bamboo structure, whether treated or not, is how its design protects it from the elements. Untreated bamboo in direct contact with moist ground or rain may completely break down in less than a year, whilst building....

To achieve the long life expectancy from a bamboo structure it is firstly essential to follow good harvesting practice to ensure minimal sugars within the bamboo ***See section: B.2.1Harvesting***

THE BEST PROTECTION FOR BAMBOO IS SIMPLY KEEPING IT DRY. ALLOW ADEQUATE EAVES, GOOD DRAINAGE AND KEEP BAMBOO FREE FROM DIRECT GROUND CONTACT

Protect from Rain Adequate Drainage Avoid Ground contact Adequate ventilation

Components of a bamboo protection strategy



B.3.2.1. AIR CURING

Bamboo can be air cured by leaving the branches and leaves on for two to three days after cutting. This allows the bamboo to consume the remaining sugars and starches within the culm reducing its attractiveness to pests. Branches should be kept free of ground contact throughout this period.

B.3.2.2. WATER LEACHING

Curing bamboo through leaching the sap from within the culm removes the sugars and starches that attract most pests. This relatively simple is process is undertaken as quickly after harvesting as possible as cells within the culm begin to close after 2-3 days.

Commonly bamboo is immersed in flowing water for 4-12 weeks depending on the species with stone weights applied above to keep them fully immersed. In some parts of the world bamboo is leached in salt water as the salt offers additional pest resistance. Generally this is not recommended as salt water takes longer to penetrate the culm and the imbedded salts also raise the hydroscopic capacity of the fibers leading to more rapid rotting

An alternative method of leaching out saps involves standing the bamboo upright in large drums full of water for 3-4 days, to allow the bamboo plant to draw in the water and clear out it its own sap. This method can also be used as a low tech method for injecting borax treatment.

B.3.2.3. AIR DRYING VS KILN DRYING

Bamboo that has been properly dried prior to use will have more consistent durability than bamboo dried in position. Air drying of bamboo takes around 6-12 weeks depending on species whilst kiln drying takes 2-3 weeks. Solar kilns offer a low energy cost in-between solution of 3-6 weeks. Kiln drying may be necessary during the rainy season when bamboo may begin to mould before drying out.

When drying bamboo care should be taken to provide regular support and allow sufficient space around the culms for evaporation. The rate at which bamboo can be dried varies from species to species with some species splitting more readily than others. Species prone to splitting can have their drying rate slowed down by the application of a sealant such as paint to the ends

B.3.3. PROTECTION THROUGH TREATMENT

The durability of bamboo can be greatly extended through the application of treatments

B.3.3.1. SMOKING

Smoke from burning timber or bamboo contains a range of preservative and protective chemicals such as creosote. Bamboo is stacked either vertically or horizontally over a fire, rotated regularly for 1-2 days. Although some of the oldest bamboo structures in the world are preserved through smoking, results from this method of treatment are generally more variable than those from borax based systems and may require a lot more research and field testing making this method less suitable for humanitarian response. Expert and local advice should be sought if considering smoke based treatments

Research in Japan and China shows that through smoking and steam heating bamboo with a precise combination of temperature, humidity and timing, the cellulose and lignin within the cellular wall can be made to plasticize making it much stronger across its tubular section and greatly increasing durability.

B.3.3.2. EXTERNAL TREATMENTS

A range of external treatments can be applied to bamboo to reduce its attractiveness to fungus and pest attack. Such treatments may include the application of kerosene, camphor, commercial pesticides and varnish or paint. The high silica content in the outer skin of bamboo commonly results in low absorption rates, with pest resistance being achieved more through the bamboo becoming unattractive to pests rather than actually toxic. External treatments need to be reapplied at regular intervals, once every 2-3 months is common for kerosene or once every six months for varnishes.

In general external treatments are not considered that effective, though paint or varnish can protect treated bamboo from leaching where some exposure to rain is unavoidable.

Treatments such as sump oil, bituminous tar and creosote are often used on bamboo poles inserted directly into the ground. Whilst such treatments do increase the pest resistance of the poles, most bamboo species have very low durability when in direct contact with the ground and such treatments provide far less protection than a raised footing

B.3.3.3. PESTICIDES

A range of pesticides can be used to increase the pest resistance of bamboo, commonly used pesticides include PCP, DDT and Dieldren. Most pesticides provide little further protection than Borax/borasic acid treatments, but have at higher cost with increased environmental and health risks and are hence not recommended for humanitarian programming. One exception may be commercially pressure treated bamboo products using 3rd generation pesticides may be appropriate for some more industrial applications

B.3.3.4. BORAX - BORASIC TREATMENT SYSTEMS

The most common and well documented bamboo treatment systems involve dissolving a combination of borax and borasic acid in water in concentrations of around 1-2% and then soaking bamboo in the liquid until the solution has penetrated completely throughout the bamboo. Penetration time varies greatly depending on the system. Borax is a relatively harmless compound whose minuscule particle size when dissolved allows it to easily penetrate throughout bamboo.

Borax is a naturally occurring boron based compound commonly available as sodium borate, sodium tetraborate, or disodium tetraborate. A common commercial product is Tim-bor It is usually a white powder consisting of soft colorless crystals that dissolve easily in water. Bamboo treatments generally combine a mixture of Boron and Borasic acid for pest resistance with the acid providing an added advantage as a fire retardant.

There are a wide range of well documented systems for embedding borax and borasic into bamboo. It is important to weigh up the relative advantages and disadvantage of each system in relation to the program you are planning. Some systems are better suited to long-term mass production whilst others are better suited to short-term community level production.

Borax treatment systems can be broadly broken into two groups, Pressure Feed and Soakage based systems. Pressure feed systems, such as the well known gravity fed Broucherie method, utilize the fluid transportation system of the plant, by attaching a pipe to one end of the culm and pumping borax solution through the plants vascular system. Pressure treatment methods are conducted within the first few days of harvest before cellular collapse sets in. These systems offer the added advantage of purging the remaining sap from the culm, thus reducing the need for leaching, with the associated disadvantage of needing to be undertaken soon after cutting. Perhaps the best document pressure fed systems is the Modified Broucherie method where a pump is used to force solution from the thick end of a culm. A lesser known system that is better suited for village level production has been developed by ARTI in India, using hand pumps attached to the thin end of the culm.

Soakage systems are generally simpler though slower than pressure fed systems, involving the immersion of bamboo for long enough that the borax solution penetrates throughout the culm. Soakage systems require the punching out of nodes or the drilling of holes between nodes to allow complete penetration of the borax solution. The simplest soakage solutions involve soaking for 3 plus days dependant on species. Perhaps the best documented system in Indonesia is the Vertical Soak Diffusion (VSD) system as practiced and documented by the Environmental Bamboo Foundation and P.T Bambu in Bali. For VSD bamboo culms are stood vertically with all bar the bottom node punched through. The culm is then kept filled with borax solution for a number of days till full dissipation has occurred. Simple testing method

For more details on treatment systems see ####www.humanitarianbamboo.org/treatment

Treatment Type	Physical/ chemical	Best practice (horizontal/ vertical)	P	E	T	D	Time for treatment	Durability (1-10, approx years)	challenges	advantages	opportunities	Cost (1-10)	Accessibility of technology (1-10)	Hazards posed by treatment process (1-10)	Amount of resources needed (1-10)
No treatment	P	H		Y				2	Durability	Quick, low cost		1	10	1	1
Seasoning (moving water)	P	H	Y			Y	3 months	4	Process time, lifespan in the building, availability of water source	Low cost, easy technology		2	8	1	2
Heat treatment	P	H	Y		Y	Y	10 min	4				2	8	2	2
Fuming	C	H	Y		Y	Y	1-2 days	6+	Equipment intensive			4	6	2	6
Smoking	P	H	Y		Y	Y	1-2 days	5+	Equipment intensive			3	6	2	6
Surface coating	P	H	Y	Y	Y		10 min	3				4	7	6	3
SQ treatment	C	V	Y			Y	30 min	7(+)	Mechanical process to learn	Removes sugars completely		5	4	6	8
Vacuum treatment	C	V	Y			Y	30 min	10	Equipment intensive			8	3	6	10
Soak treatment; vertical	C	V	Y		Y	Y	1 day	8	Often still attacked by insects			5	6	6	7
Soak treatment; horizontal	C	V	Y		Y	Y	3 days	6+	Often still attacked by insects	Easy process		7	6	6	6
Transpiration	C	V	Y		Y	Y	7 days	6	Often still attacked by insects	Easy process		6	6	6	6
Combination			Y			Y		10+	Costly, multiple operations so equipment intensive			10	6	6	10

B.4. LOGISTICS AND HANDLING

The care with which Bamboo is handled and transported from the moment of cutting to final placement will have a direct bearing on the usable lifespan of the end product.

Diagram or photo of good handling in practice

B.4.1.1. HANDLING

The waxy layer and fungus on the outer layer of bamboo may cause skin irritation, workers handling bamboo continuously should be provided with gloves.

B.4.1.2. TRANSPORTATION

The need for care when transporting bamboo grows in importance with the duration of the trip.

Bamboo should be:

- Covered during transportation to prevent excessive drying and splitting of uppermost culms
- Protective sheathes should be used between ropes and bamboo to prevent damage
- The bottom layer of bamboo should be checked carefully for crushing, to determine maximum weight loading. The lightweight nature of bamboo means this is generally not a problem

Trips involving transportation by sea need to include adequate steps to prevent mould damage. Bamboo packed inside containers should include some form of moisture absorption strategy, the simplest of which is the inclusion of sacrificial sacks of lime or cement

When loading and unloading bamboo care should be taken to ensure bamboo is not thrown to the ground as this will cause cracking. Such cracks may not be visible at time of unloading but will broaden as the bamboo dries in situ weakening the end structure

B.4.1.3. STORAGE

Bamboo should be stored:

- Free of ground contact to prevent pest infestation
- Stacked horizontally with regular support at 2-3 node intervals to prevent warping
- Under shade to prevent undue cracking
- With adequate air flow around culms to prevent mould

Is community based procurement possible?

Direct procurement by the community may inject up to 8 times as much funds and can reduce unnecessary storage and handling. Consider logistics & procurement training.

Storage yards should be:

- Kept clean and free of sawdust and cutting waste to prevent pest infestation
- Stock should be rotated regularly through the yard ensuring no stock is left for prolonged periods. If storing for more than 1-2 weeks bamboo should be rotated regularly to prevent uneven drying and reduce the potential for mould growth

Section C

Building

1. Design
2. Construction
3. Woven sheeting
4. Maintenance

Key Points

Bamboo is a very distinct construction material with its own unique set of positive and negative characteristics. A good understanding of these fundamental differences is essential when planning projects in bamboo

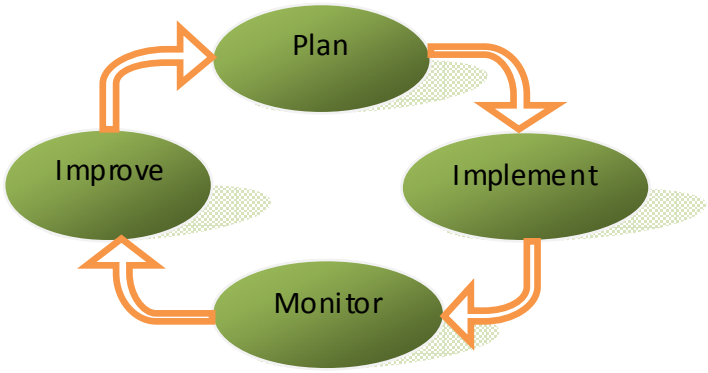
How well a building is designed, constructed and maintained will greatly affect the durability of the structure

C.1. DESIGN PRINCIPLES

C.1.1. DESIGNING A PROGRAM THAT USES BAMBOO

KEY POINTS FOR INCLUSION IN THIS CHAPTER

- Program design considerations include
  - Resource availability
  - Community knowledge and acceptance
  - Organizational knowledge and acceptance
  - What stage of shelter rehabilitation will bamboo be used for, hence does it need treating
- Unlike timber harvesting, crop management and even planting should be considered as part of program design
- Treatment at source or treatment at storage and handling facility or treatment at/by community
- Classic program design loops,



C.2. DESIGNING STRUCTURES IN BAMBOO

Bamboo is a completely different construction material, requiring a set of very different design and construction principles to other common building materials such as timber, steel concrete or bricks. Lengthwise, bamboo has high tensile and compressive strength whilst it is much weaker across its width where it is prone to crushing except at nodes. Hence a bamboo pole in construction will support high loads as long as the building is constructed so the pole cannot buckle.

	BAMBOO	TIMBER	STEEL
STRENGTH			
FLEXIBLITY	• Extremely flexible, particularly in split sections	• Limited to small sections or complex steam bending	• Highly flexible
JOINTING SYSTEMS	• Bamboo is highly receptive to a wide range of glues, though high levels of silica make the outer skin resistant to most glues	• Good though varies greatly dependant on species	•
RESILIENCE	• Poor except at nodal points	• Good, mild depression	•
SUSTAINABILITY	• i)Bolting or pegging • ii) lashing or Tieing	• Screwing, nailing and bolting	•

C.2.1. DESIGN PRINCIPLES

A number of key design principles need to be considered when planning a project in bamboo. To understand these principles it is important to first understand some basic principles of construction

NOTE: This set of guidelines does not intend to be a design book for engineers, but rather, to provide guidance for humanitarian workers to ensure they have asked the correct engineering questions and incorporated simple good practice into their work. Although in general simple emergency and transitional shelter solutions do not require complex engineering solutions, it is clearly best practice to ensure that such mass programs have been checked by a skilled (preferably local) professional. Where such resources are not available consider using plans that have already been designed and tested or consult more detailed technical advice See section: ***D.1 Further resources***

C.2.1.1. LIVE AND DEAD LOADS

Buildings are exposed to two main types of forces, dead loads and live loads. Dead loads are the static forces that apply such as the weight of the roof bearing down on the structure, whilst live loads include the dynamic changing loads that a building will have to cope with over its lifespan, such as the weight of the changing number of people inside it.

When designing a building it is essential to consider the range of live loads the building will be exposed to. This is of particular importance in when working in disaster prone areas where the likelihood of floods, high winds or earthquakes may greatly increase the stress loadings that a building may have to cope with.

Diagram of small house with roof load expressed as dead-load, then wind load on the side expressed as live load

C.2.1.2. MOMENTUM AND BRACING

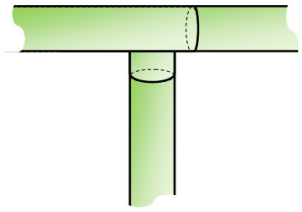
Simple bracing diagram, showing wind loads applied with and without bracing

When buildings suffer sudden loads they move, twist or warp. Such movement, combined with the mass of the structure, can create high levels of momentum, greatly increasing the effective weight or force load that is applied across the building. Much of this force will be transferred to the joints of the building, making them the weak point in most structures. By reducing the amount a building can twist or warp, we can greatly reduce the stress on its joints.

This principle is of particular importance to bamboo structures, where joints are ...

C.2.1.3. DESIGNING FOR BEST UTILISATION OF NODES

Nodes are the strongest point in a culm of bamboo, hence the closer a joint is to a node the stronger it will be. As a rule of thumb an ideal joint should be no further from a node than the width of the bamboo sections. In saying this it is important to recognize that selecting bamboo for exacting nodal placement, although creating a stronger structure, may consume much more time and potentially more bamboo. Hence it is important to focus on joints of higher structural priority, ensuring nodes occur as close as possible to these joints.



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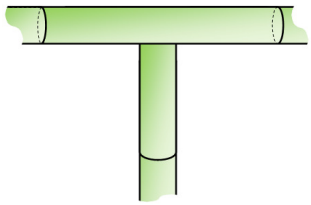

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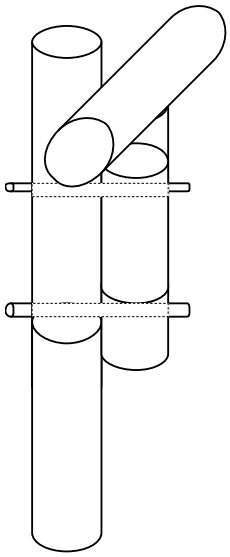
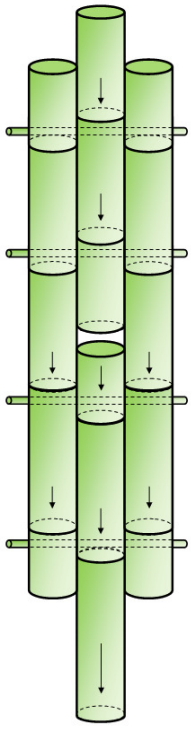
Joint designs can take advantage of the strength of nodes by bearing more directly onto them. Note the two diagrams to the right where pins are located close to nodes to more directly transfer loads to the nodal joints.

NOTE WHEN ANALYZING THE DIAGRAMS TO THE RIGHT NOTE WHERE THE DOWNWARD FORCES APPLY.



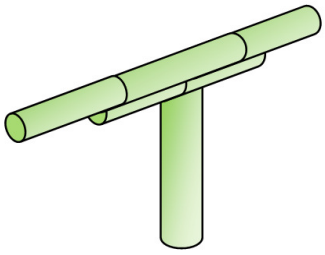
DETAIL: JOINING A FLOOR JOIST OR TOP PLATE TO A COLUMN



DETAIL: JOINING A LOAD BEARING POST TO A SACRIFICIAL FOOTING

Where joints do occur between nodes it is possible to strengthen the joint by using sheathes or fishplates to spread the load across the spacing between nodes

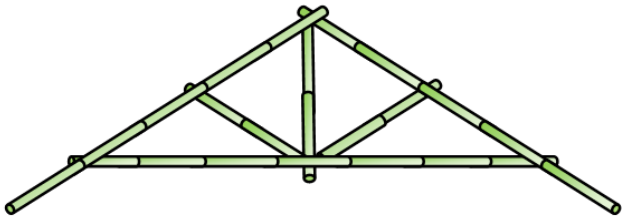
In many cases joint strength can be improved by allowing members of a joint to continue past the joint to beyond the nearest node



DETAIL: Top plate with fish-plated where posts intersect between nodes

It's all about Nodes and bracing

Unlike timber, when designing with bamboo, it's always important to think about nodal placements and bracing. Both of these factors stop bamboo from being crushed Ref



DETAIL: TOP PLATE WITH FISH-PLATED UNDER SUPPORT WERE POSTS INTERSECT BETWEEN NODES

Nodes play a crucial role in the strength of bamboo...

C.2.1.4. DESIGNING FOR CURVED ELEMENTS

One unique aspect of bamboo when compared to timber is its capacity to be bent and used in tension. This is particularly true of small diameter and split sections of bamboo or bamboo that has been steam heated. Unfortunately, little coherent investigation of the potential for this in humanitarian response seems to have been undertaken. Bangladesh transient workers' shelters and woven baskets both point to potential areas for future research, where an extremely low use of material and rapid construction offer great advantages for emergency shelter.

PHOTO: Bangladesh Transient workers huts

PHOTO: Antoon's Bamboo and rubber band structures

PHOTO: Woven bamboo basket for Chickens

C.3. CONSTRUCTION

KEY POINTS FOR INCLUSION IN THIS CHAPTER

- Bamboo construction can be broadly broken into a few key jointing types or combinations there of
- Which type used depends on a number of factors
- Strength required
- Ensuring use of cCommunity knowledge
- Prefabrication
- Resource availability
- Budget
- Common materials include:
- Natural fibre ropes such as Hemp, Coconut fibre rope
- Pegged joints
    - Bamboo or timber pegs
- Commonly used in conjunction with bolting systems

RULES OF THUMB about bamboo sizing

GLUEING

SKETCH

NAILED

SKETCH

SCREWED

SKETCH

WIRED

SKETCH

TIED

SKETCH

PEGGING

SKETCH

PEGGED & TIED

SKETCH

BOLTING

SKETCH

FILLED & BOLTED

SKETCH

C.3.1. JOINTING SYSTEM TYPES

Different jointing systems offer different relative merits, see below for comparison

Relative merits of bamboo jointing systems

Best — Worst

Joint Type	Notes	Strength				Usability			Cost		
		Durability	Rigidity	Strength	Flexibility	Ease of use	across joints	Speed	Low labour	Cheap material	Few tools
Bolts	• Crushing of the bamboo must be avoided • Only as strong as the bamboo they pass through • Best when braced in all directions	5	5	5	2	3	4		2	2	2
Fill & bolt	• Creates a very rigid joint, particularly well suited to footing connections and industrial loads	5	5	5	2	2	3		1	1	1
Glue	• The outer skin of bamboo is highly resistant to glue whilst the inner layers glue well	4	4	4	1	2	1		2	3	3
Inner tubes	• A range of rubber can be used, some will break down under UV • Heavily dependent on how it is attached to the bamboo (often nailed) • Hard to find consistent supply	3	2	2	5	4	4		4	4	4
Nails	• Prone to splitting particularly in running species • Pre drilling or chiselling will reduce tendency to split	2	1	2	3	5	4		5	5	5
Pegs & rope	• See pegs and rope notes	4	3	4	4	2	5		2	3	2
Pegs	• Commonly timber or Bamboo • Require pre drilling • Strength dependent on nodes	3	2	3	3	3	4		3	4	3
Plywood & bolts	• Commonly for trusses or structural load • Bolt locations should still align to nodes	5	5	5	3	2	4		2	1	1
Rope or Rattan	• Often well known at village level • A range of materials can be used see section #######	3	2	3	5	3	4		4	5	5
Screws	• Prone to splitting requires pre-drilling	2	2	2	2	3	4		4	4	4
Wire	• Prone to rust ate ends and knots • Can be improved by protective painting Will 'dig in' under high load	3	3	3	4	4	5		5	5	4

C.3.1.1. COMMON JOINTS

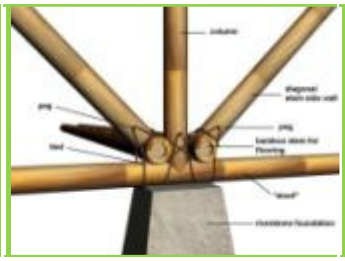
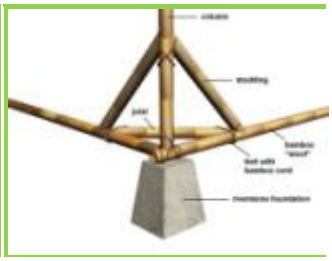
I. FOUNDATIONS

II. POLES TO BOTTOM PLATE

III. RAFTER TO TOP PLATE

IV. TRUSSES

C.3.2. EXAMPLES OF COMMON JOINTS

FOUNDATION			Photo	
POST TO BOTTOM PLATE JOINT			Photo	SKETCH
POST TO TOP PLATE		SKETCH	Photo	SKETCH
LINTEL DETAIL		SKETCH	Photo	SKETCH
BRACING DETAIL		SKETCH	Photo	SKETCH
RAFTER TO TOP PLATE		SKETCH	Photo	SKETCH
ROOFING TO BATON		SKETCH	Photo	SKETCH

C.4. WOVEN BAMBOO SHEETING

How much information needs to be included regarding bamboo sheeting???

C.5. MAINTENANCE

C.5.1. POST CONSTRUCTION TREATMENT

...

C.5.2. DESIGN FOR ADAPTABILITY – DECONSTRUCTION

KEY POINTS FOR INCLUSION IN THIS CHAPTER

- Design for Protection
- Good boots and a good hat
- Treated bamboo needs to be undercover
- Design structures so all key structural elements can be replaced over time
- Incorporate design theory into all training to ensure communities have the skills to replace and up grade
- Accept the biodegradability of bamboo
- Examples of simple oil treatments
- Recommendations on varnish type

Section D

Support

1. Further resources
2. Programming tools
3. Other uses for bamboo
4. Map: bamboo in Indonesia

Key Points

This document offers only a brief introduction to the use of bamboo in humanitarian shelter programming.

To undertake a large scale program it will be important to seek more detailed information specific to the context of the project being undertaken. This section of the guidelines supplies some additional resources or linkages to those resources.

There are a range of other uses for bamboo that may be worth considering in humanitarian programming such as composite panels and laminated bamboo beams

Understanding where bamboo resources are available may influence decisions regarding the suitability of using bamboo in any given humanitarian response

D.1. FURTHER RESOURCES

- For a more up to date list of available further resources please visit
- www.humanitarianbamboo.org/resources
- All contributions or suggestions truly welcomed

D.1.1. INTERNET RESOURCES

BAMBOO

- www.inbar.org
- www.bamboofoundation.org

SHELTER

- www.humanitariantimber.org
- www.sheltercentre.org

D.1.2. ORGANISATIONS AND EXPERT INDIVIDUALS

A broad range of organisations exist that may be able to supply additional information to humanitarian practitioners on the use of bamboo, these include

INDONESIA

- **Environmental Bamboo Foundation, Ubud Bali**
- **P.T Bambu Bali**
- **UGM Department of Engineering and Architecture**
- **Bandung Institute of Technology**
- **Department of Public Works, Building Research centre, Bandung**

INTERNATIONAL

- **INBAR The International Network for Bamboo and Rattan**

For a more up to date list see ***www.humanitarianbamboo.org/contacts***

D.1.3. BOOKS AND JOURNALS

Affordable Bamboo Housing in Earthquake Prone Areas: An International Workshop Organised by CBTC, Government of Mizoran, and International Network for Bamboo and Rattan. India: CBTC, INBAR, and Government of Mizoram, 2001.

Manual De Construcción Sismo Resistente De Viviendas En Bahareque Encementado ,F, Josef Farbiarz., R, Samuel Dario., and S, Damio Mogollón. Columbia: Editorial Carrera.

The Book of Bamboo : A Comprehensive Guide To This Remarkable Plant, Its Uses, and Its History. Farrelly, David. San Francisco: Sierra Club Books, 1984.

Building With Bamboo: A Handbook , Janssen, Jules J.A. Warwickshire: ITDG, 2007

Appropriate Building Materials: A Catalog of Potential Solutions. Stulz, Roland, and Kiran Mukerji. Switzerland: SKAT Publication, 1993.

Grow Your Own House. Vélez, Simón and Bamboo Architecture. Vitra Design Museum.

IL 31 Bambus Bamboo. Dunkelberg, Klaus, and The Institute of Lightweight Structures, University if Stuttgart Germany: 1985.

Bamboo: A material for cost effective and disaster resistant housing. India: BMTPC.

Training Manual : Building with Bamboo. National Mission on Bamboo Application. New Delhi: Tulika Print, 2004.

Environmental Bamboo Foundation. Petunjuk Kerja Pengawetan Dengan Sistem Boucherie. Jawa Barat: Yayasan Bambu Lingkungan Lestari, 1994.

For a more complete list see www.humanitarianbamboo/resources

D.2. PROGRAMMING TOOLS

D.2.1. SPECIFICATION TOOL

KEY POINTS FOR INCLUSION IN THIS CHAPTER

A simple tool or checklist for specifying Bamboo

- Colour
- Age
- Diameter
- Species
- Length
- Condition

Link to online downloadable documents in Word and Excel

D.2.2. PROCUREMENT TOOL

KEY POINTS FOR INCLUSION IN THIS CHAPTER

Decision tree for local vs community procurement

Check sheets for

- Pole Bamboo
- General use bamboo
- Treated Bamboo
- Gedek

Link to online downloadable documents in Word and Excel

D.2.3. CHECKLIST

D.3. OTHER USES FOR BAMBOO

Although these guidelines focus on the use of bamboo in post-disaster shelter construction many other applications of bamboo may be appropriate for use in humanitarian programming. With well over 1,000 known uses for bamboo it is impossible to list all of the possibilities.

For more information on the products below see ***www.humanitarianbamboo.org/alternatives***

D.3.1.1. BAMBOO COMPOSITE CONSTRUCTION PRODUCTS

The excellent gluing properties of the inner fibers of bamboo make it ideally suited to the production of a wide range of composite products including:

- Parquetry flooring
- Laminated beams
- Woven bamboo tiles
- Bamboo reinforced concrete
- Bamboo based fibrocement
- Bamboo polystyrene composite panels
- Bamboo Plaster panel construction

Much research on bamboo composites has been undertaken by Indonesia's leading universities and research institutes. One example of this research is the work conducted by the Department of Public Works Research Center in Bandung, where Pak Purwito has produced a number of composite materials and model houses. Similar levels of research have also been conducted at Bandung Institute of Technology, UGM and Muhamddyah in Yogyakarta and EBF in Bali amongst others. Much of this research offers real potential for use by the humanitarian sector in Indonesia.

DETAIL 1 2 3: DPU BUNDUNG RESEARCH CENTER- BAMBOO FIBRE POLYSTYRENE COMPOSITE PANEL, HOLLOW CORE BAMBOO PANEL, BAMBOO PLASTER HOUSE

DETAIL 4: BAMBOO RESIN COMPOSITE TRUSS, INDIA

D.3.1.2. BAMBOO WATER TANKS AND PIPES

Bamboo has long been used for a range of plumbing and irrigation purposes. A number of successful designs exist ...

D.3.1.3. BAMBOO CRAFTS AS LIVELIHOODS

In many disaster prone regions the manufacture of handicrafts from bamboo forms an important part of community livelihood strategies. Often bamboo craftwork is produced through small home based industries supplying supplemental or fulltime income to those who may not have access to more mainstream employment. Common bamboo handicrafts include the production of:

- Woven matting
- Baskets
- Edible shoots and food products
- Brooms, tool handles

D.3.1.4. ALTERNATIVE USES OF BAMBOO

Bamboo has been used for such a wide range of that it is difficult to summarize those that may or may not be of interest to the humanitarian sector

D.4. DISTRIBUTION MAP OF BAMBOO IN INDONESIA

The Humanitarian bamboo project is hoping to develop 4 separate maps that show areas of availability of bamboo species suitable for use in Humanitarian Shelter programs across Indonesia, broken up by usage type:

Map 1 Species suitable for Structural poles

Map 2 Species Suitable for general structural use

Map 3 Species suitable for woven bamboo sheeting

Map 4 Handicraft species

Maps to provide:

- Shading indicating how commonly available the material is in each area
- Names of the most common species that are suitable for each area

These maps are not intended to represent any form of detailed research and may well include areas listed as unknown. This is a simple exercise as requested through consultative forums by humanitarian practitioners and intended solely as a tool for base decision making.

Note:

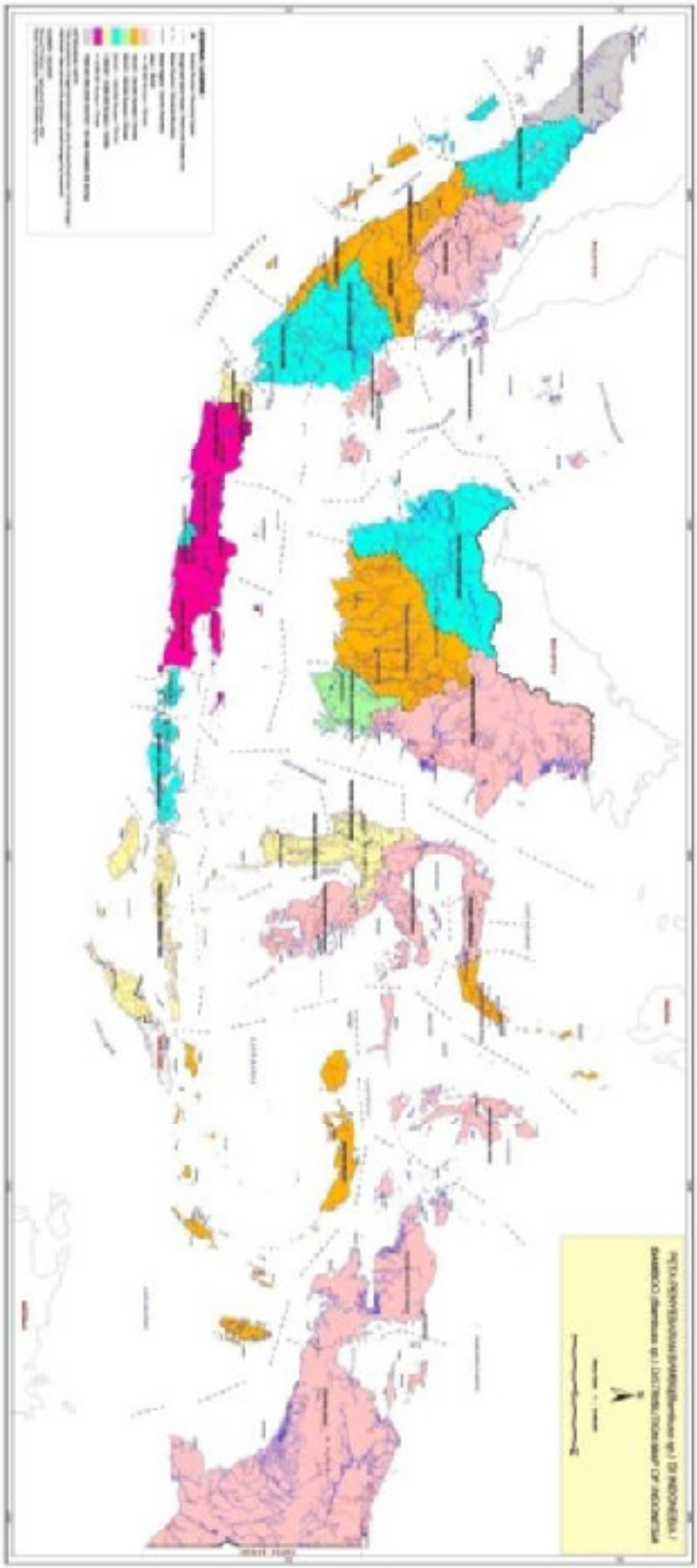
These maps are not intended as a definitive source of information on bamboo availability. Actual availability may vary greatly depending on a number of factors including:

- Changing availability over time (map accurate at 2009)
- Changing patterns of usage and therefore market availability
- Damage to resource by disaster events
- Environmental or political constraints

No map can hope to replace the detailed information that can be gathered through good community consultation.

LAMPIRAN I. JENIS BAMBU DI INDONESIA

No.	Nama botani	Nama lokal	Daerah ditemukan
1	*Arundinaria japonica* Sieb & Zuc ex Stend.	-	Jawa
2	*Bambusa arundinacea* (Retz.) Wild.	Pring ori	Jawa, Sulawesi
3	*Bambusa atra* Lindl.	Loleba	Maluku
4	*Bambusa balcooa* Roxb.	-	Jawa
5	*Bambusa blumeana* Bl. ex Schul. f.	Bambu duri	Jawa, Sulawesi, Nusa Tenggara
6	*Bambusa glaucescens* (Wild) Sieb ex Munro.	Bambu pagar, cendani	Jawa
7	*Bambusa horsfieldii* Munro.	Bambu embong	Jawa
8	*Bambusa polymorpha* Munro.	-	Jawa
9	*Bambusa tulda* Munro.	-	Jawa
10	*Bambusa vulgaris* Schard.	Awi ampel, haur	Jawa, Sumatera, Kalimantan, Maluku
11	*Dendrocalamus asper*	Bambu petung	Jawa, Bali, Sumatera, Kalimantan, Sulawesi
12	*Dendrocalamus giganteus* Munro.	Bambu sembilang	Jawa
13	*Dendrocalamus strictur* (Roxb) Ness.	Bambu batu	Jawa
14	*Dinochloa scandens* O.K.	Bambu cangkoreh, Kadalan	Jawa
15	*Gigantochloa apus* Kurz.	Bambu apus, tali	Jawa
16	*Gigantochloa atroviolacea*	Bambu hitam, wulung	Jawa
17	*Gigantochloa atter*	Bambu ater, jawa benel, buluh	Jawa
18	*Gigantochloa achmadii* Widjaja.	Buluh apus	Sumatera
19	*Gigantochloa hasskarliana*	Bambu lengka tali	Jawa, Bali, Sumatera
20	*Gigantochloa levis* (Blanco) Merr.	Buluh suluk	Kalimantan
21	*Gigantochloa manggong* Widjaja.	Bambu manggong	Jawa
22	*Gigantochloa nigrocillata* Kurz	Bambu lengka, terung terasi	Jawa
23	*Gigantochloa pruriens*	Buluh rengen	Sumatera
24	*Gigantochloa psedoarundinaceae*	Bambu andong, gambang surat	Jawa
25	*Gigantochloa ridleyi* Holtum.	Tiyang kaas	Bali
26	*Gigantochloa robusta* Kurz.	Bambu mayan, temen serit	Jawa, Bali, Sumatera
27	*Gigantochloa waryi* Gamble	Buluh dabo	Sumatera
28	*Melocanna bacifera* (Roxb) Kurz.	-	Jawa
29	*Nastus elegantissimus* (Hassk) Holt.	Bambu eul-eul	Jawa
30	*Phyllostachys aurea* A&Ch. Riviera	bambu uncea	Jawa
31	*Schizotachyum blunei* Ness.	Bambu wuluh, tamiang	Jawa, Nusa Tenggara Timur, Sumatera, Kalimantan, Sulawesi, Maluku
32	*Schizotachyum brachycladum* Kuez.	Buluh nehe, awi buluh, ute wanat, tomula	Jawa, Sumatera, Sulawesi, Maluku
33	*Schizotachyum candatum* Backer ex Heyne	Buluh bungkok	Sumatera
34	*Schizotachyum lima* (Blanco) Merr.	Bambu toi	Sulawesi, Maluku, Irian Jaya
35	*Schizotachyum longispiculata* Kurz.	Bambu jalur	Jawa, Sumatera, Kalimantan
36	*Schizotachyum zollingeri* Stend.	Bambu jala, cakeutreuk	Jawa, Sumatera



The Map to the left shows a rough approximation of bamboo distribution across Indonesia as reported by the state census.

The detailed map can be downloaded from:

The Humanitarian Bamboo project would like to thank the following Individuals and organisations for giving so freely of their time and effort to support this project:

From the Bamboo forum in India:
...
From the Bamboo Forum in Jogja
...
Dave Hodgkin, the author of these guidelines wishes to thank... Apologise... encourage ongoing participation and sharing...