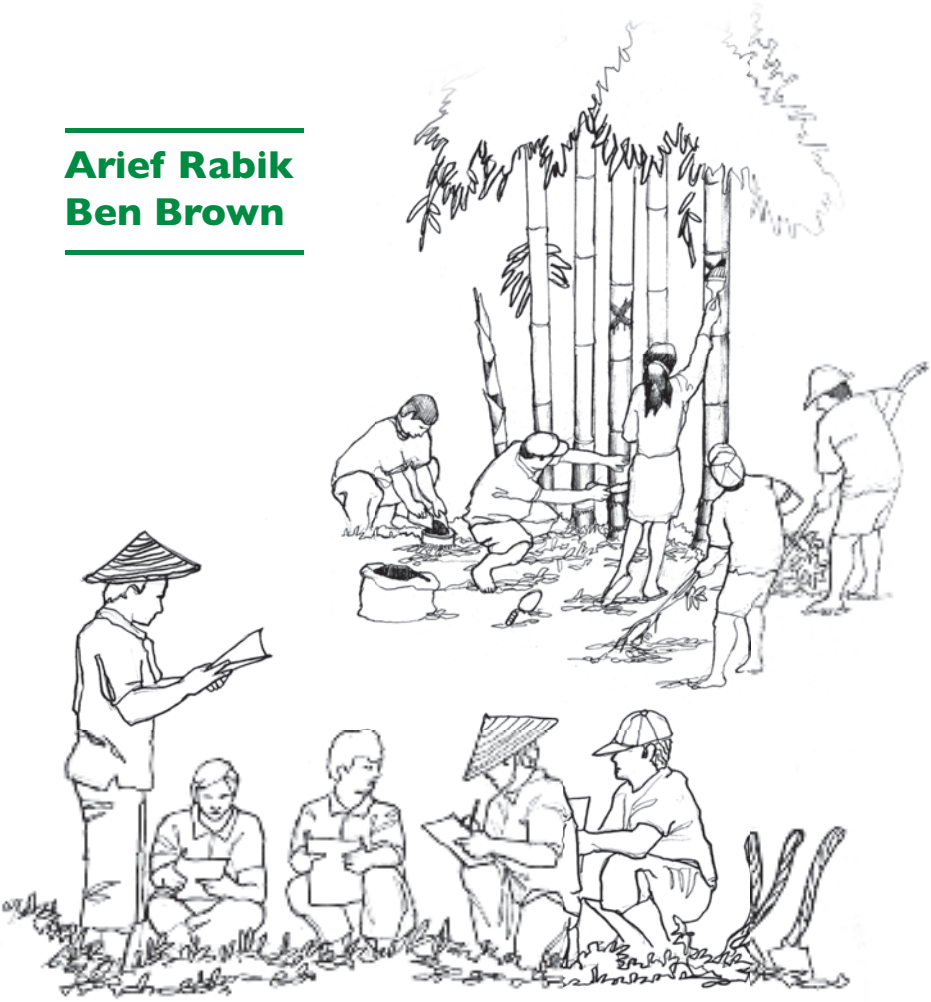
TOWARDS RESILIENT BAMBOO FORESTRY

A Reference Guide for Improved Management of Clumping Bamboo for Timber Bamboo

Arief Rabik
Ben Brown



A LANDSCAPE OF THE FUTURE

ENVIRONMENTAL BAMBOO FOUNDATION

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Environmental Bamboo Foundation
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A LETTER FROM THE FOUNDER

In this time of continued environmental degradation, with all of its negative social and economic feedbacks, I feel that this resource will provide truly positive contributions to the lives and livelihoods of many.

If improved bamboo forestry management can help remediate environmental degradation by rebalancing the Earth's ratios of carbon sequestration versus emissions, then this book is of great value. All life revolves around water, and bamboo naturally protects our water reserves through shading, wind reduction, and the huge capacity of it's root system to hold water in the soil.

This book is a pragmatic and user-friendly "HOW–TO" manual, but not in the usual sense. It does not merely provide six, how-to steps of improved bamboo management, but also a way of thinking about bamboo forestry which draws on the best practices from many disciplines of social and physical science. A how-to of both thought and action!

I would like to make very clear two simple guidelines in the promotion of bamboo as an appropriate material, especially for architecture. First, it must be appropriately preserved against pests and deterioration with such methods as immersion, the vertical soak diffusion method (available online as the treatment manual: http://www.bamboocentral.org/index1.htm), pressure treatment, or boiling. And second, the source of the bamboo must come from sustainable bamboo forestry techniques, which is the topic of this manual.

The Environmental Bamboo Foundation is committed to updating and editing the information within this manual, which will be available for free download on-line. We are not, by any means, saying that this information is conclusive, but a work-in-progress that needs your feedback. We are interested in setting up online forums in conjunction with global bamboo organizations and businesses. Be you a bamboo farmer, scientist, outreach worker or simply a bamboo enthusiast, with knowledge, skill, insight and experience, these guidelines will mature and continue to be of use to the world and its inhabitants.

Linda Garland, Founder
The Environmental Bamboo Foundation
Ubud, Bali, Indonesia

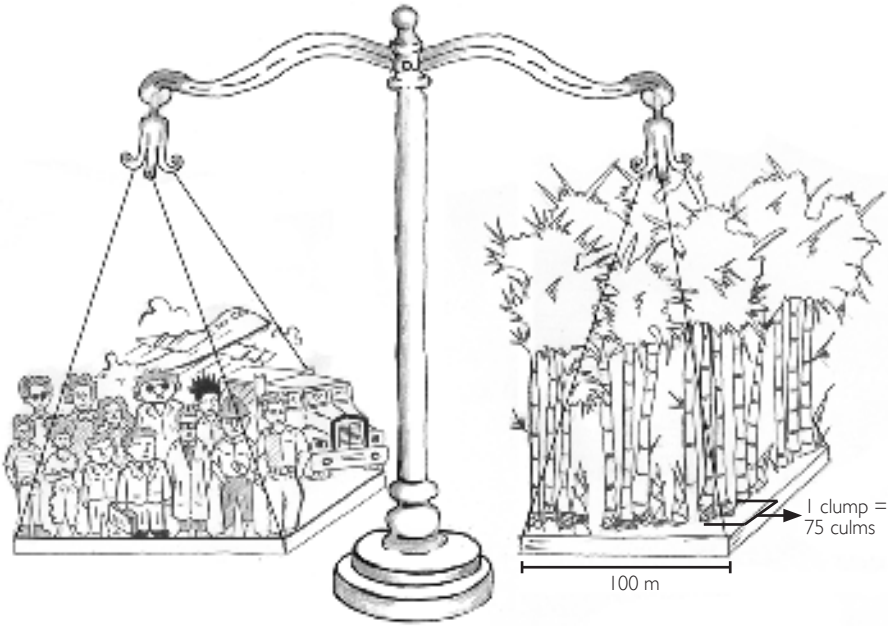
PREFACE

The primary aim of this manual is to provide the reader with basic information on how to improve the health of bamboo clumps and the interdependencies within prodominantly bamboo-based agroecosystems, in turn increasing the sustainable yield of quality bamboo culms. As managers we can analyse, understand, and enhance this system so that human inputs are minimized and thus management costs are too. We assume that the reader agrees whole heartedly that a managed bamboo forest system is far more productive than one which is unmanaged.

This book does not attempt to deal with the well covered subjects of bamboo propagation or planting of clumping bamboo, which have been significantly dealt with in the literature, such as in Elizabeth Widjaja's bamboo propagation guide-book "**Panduan Membudidayakan Bambu"** (published in the Indonesian language by the Indonesian Institute for Research (LIPI)). This sustainable bamboo forestry manual focuses on two areas: first, the initial maintenance of sympodial (clumping) bamboo and second, the annual management of the bamboo clumps within a stand (referred to in this book as either an agroecosystem or a natural bamboo forest).

As bamboos are the world's fastest growing land plants, more management of bamboo-based agroforestry to buffer against global climate change will be needed. By increasing the grower's awareness and management of the many ecosystem components that affect the bamboo positively or negatively, the Resilient Bamboo forestry management system offers a holistic solution to increasing the yield of carbon-rich bamboo culms. Most references in this book are to Asian clumping (sympodial) bamboo.

BAMBOO AND THE CARBON FOOTPRINT



"Assuming each person from a developed nation enables the emission of 5.6 tons of CO_2 into the atmoshphere in order to live their normal lifestyle, and that one clump of bamboo absorbs 337.5 kg of CO_2 per year.

With an average of 200 clumps per hectare, one hectare of bamboo can absorb 67.5 tons of CO_2 per year. That is the same as the carbon emitted by 12 people from a developed Nation

note: This rate of carbon absorption (sequestration will only be achievable in mature bamboo clumps)."

Tropical bamboo forest cover is sure to increase as governments seek to develop sustainable resource bases while mitigating the effects of climate change. This book gives specific guidelines to bamboo farmers and foresters on how to achieve sustainable productivity of bamboo clumps through appropriate management, while improving the socio-economic status of rural communities and enhancing goods and services provided by bamboo agroecosystems and surrounding forest areas.

Many parts of SE Asia have suffered from past deforestation. Improved management of existing resources should be prioritized over reforestation to provide more immediate and proven social, economic and ecological benefits.
This book was written for bamboo forestry cooperatives; more specifically, educated individuals actively managing clumping species of bamboos, capable of disseminating this information into regular practice for bamboo foresters.

Case studies have been included to provide a sense of how bamboo assessment and subsequent management steps are prescribed and used in practice. Although the case studies take place in Indonesia, the premises within the book can easily be adapted in other parts of the world which maintain tropical and sub-tropical sympodial bamboo resources.

Much of the technical information in this book was imparted to the authors by leading bamboo researchers. This reference guide delves into bamboo clump management. It underscores the need to perform a simple guided assessment of bamboo clumps in a rural community setting. It also highlights the various social, economic and ecological indicators, which must be strengthened in order to synergize the natural resilience of the ecosystem within and surrounding a bamboo clump. The process of assessing bamboo clumps is more straight forward than generating management solutions, as it is the bridge between community foresters. Bamboo assessment is dependent on locally defined socio economic factors and available resources.

Examples of applying scientific trials are presented after important management steps in the management section (Chapter 3) for this purpose. The manual is highly illustrated (in black and white line drawings for ease of photocopying) in the hopes that the pictures will make difficult concepts understandable to readers who are not used to lengthy text descriptions. Visual images are used to cover the topics so that bamboo foresters can easily recall key points while in the field. Field guides are included throughout the manual to assist foresters in implementing the principles and practices presented in this book. This manual contains activities and tools that can be used by a forestry extension worker to facilitate bamboo growers in the development of a bamboo forestry system. Routine management is the key to ensuring resilient bamboo forestry.

Maintenance and management of a bamboo clump gets easier over time. Increases in yield of 2-4 fold can be the expected outcome of good, routine management. One final thing to remember is to enjoy the experience of managing your bamboo. Bamboo cultivation has been practiced for thousands of years,

and its study reveals a deep, ecological inter-relationship with nature. Local knowledge is an extract of living experiences from the biotic and abiotic factors affecting bamboo resources. This local knowledge, passed down from generation to generation, is a continuing story of how spending time in nature is one of the joys of bamboo forestry.

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Widjaja, E. A., Utami, N., Wikin S., 2004. Panduan Membudidayakan Bambu. http://www.fao.org/docrep/010/a1243e/a1243e00.htm

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CHAPTER DESCRIPTIONS

INTRODUCTION (1-13) -

provides background to the reader on bamboo, highlighting the role of bamboo in sustainable community based forestry, which is promoted by the Environmental Bamboo Foundation as the most important development sector.

CHAPTER ONE (14-30) -

provides technical information on the growth and ecology of bamboo in order for the reader to gain necessary perspective and better understand subsequent sections on assessment and management.

CHAPTER TWO (31-85) -

is a guide to easily understand the condition of a bamboo resource in a rural community setting, assessing the condition of the bamboo resource area intended for improved management. Assessment activities, also provide a base-line for comparing future progress, not only in terms of bamboo health and yields, but in building social, economic and ecological resilience.

CHAPTER THREE (86-221) -

provides a six-step method for managing bamboo clumps in order to improve both health and yield. Many bamboo growers will want to skip directly to this chapter, which can be considered a stand-alone field manual.

This chapter addresses management of both previously managed and previously un-managed bamboo clumps.

Ongoing management focuses on factors within the agroecosystem that sustain the health of the bamboo.

Some of the six steps (culling of problematic culms, improving spacing etc.) are most useful when conducting initial management of a previously un-managed bamboo clump. By undertaking these steps, a dramatic increase in the health and yield of a bamboo should take place in the first one to two years. Once the growth of the clump has been "corrected" by initial management, subsequent steps focus on a whole ecosystem approach to raising healthy bamboo in a forest or agroecosystem setting. Key to this success, is lessening the dependence

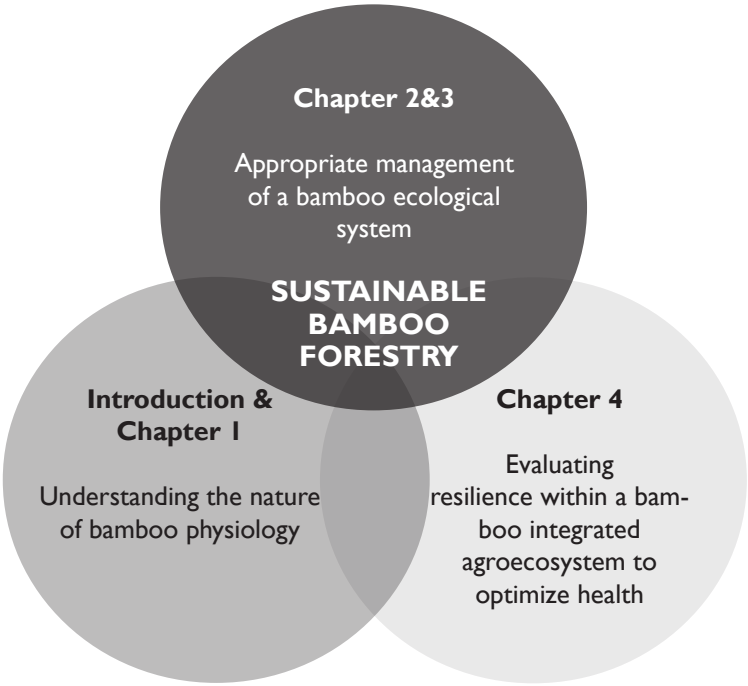
on external inputs, and maximizing the synergistic potential of other biotic factors within the ecosystem.

CHAPTER FOUR (222-261) -
Moves from assessment (which is the topic of Chapter 2) and interventions and management actions (the topic of Chapter 3) into applying agroforestry techniques with bamboo-based management.

APPENDIX A (262-282) -
Contains a Participatory Rural Appraisal (PRA) for Iseh, Bali, showing an example of how data can be compiled to begin structuring a bamboo cooperative system for long-term utilization of bamboo resources.

APPENDIX B (283-290) -
Introducing Marketing Concepts Exercise

APPENDIX C (291-307) -
Vertical Soak Diffusion Method



INTRODUCTION

Bamboo, Community Forestry, Resilient Forest Management, and Resilience Building

Resilient Forestry Management (RFM)
RFM is based on three principles:
4 General Community Based Forestry Objectives
Specific challenges facing RFM
Buffering Capacity and Threshold (adapted from www.resalliance.org)
How Is Resilience Lost In Bamboo Systems?
Expanding buffering capacity…
Unresilient Bamboo Forestry and Crossing the Threshold
Resilient Bamboo Forestry Program

CHAPTER LAYOUT

INTRODUCTION

1. Bamboo, Community Forestry and Resilient Forest Management
2. Resilient Forestry Management (RFM)
3. RFM is Based on Three Principles
4. Four General Community Based Forestry Objectives
5. Specific Challenges Facing RFM
6. Buffering Capacity and Threshold
7. How Is Resilience Lost In Bamboo Systems?
8. Expanding Buffering Capacity
9. Unresilient Bamboo Forestry and Crossing the Threshold
10. Resilient Bamboo Forestry Program

INTRODUCTION

Bamboo, Community Forestry and Resilient Forest Management

More than any other plant on earth, bamboo has a great variety of uses to people and their environment. It is an integral part of forest ecosystems that provides crucial environmental services and very much deserves to be recognized as one of nature´s great providers.

From birth to death, humans use bamboo and bamboo products. Confuscious (Kung Fu Tze) once said that "man without bamboo is not man." Bamboo shoots are consumed worldwide, but markets for other bamboo-related products are developing year by year; including bamboo charcoal, bamboo leaf humus, and silica rich medicinal crystals (tabashir) formed within bamboo. Mature bamboo culms are becoming one of the most important building material in the world, as they are long lasting and durable if properly treated. The demand for bamboo construction, furniture, and handicrafts is growing. Modern products, such as engineered lumber or ceramic building materials extruded with bamboo fibres, are under development in many countries.

Bamboos supply life-giving oxygen and help purify the air. They provide shade and add beauty to the landscape. They serve as protective barriers for crops and animals against destructive winds. The roots and rhizomes of the bamboo clump holds the soil together and help minimize erosion. Bamboo leaves, including fallen leaves piled as duff on the forest floor, increase the absorption of water into underground aquifers and reduce the runoff of precious rainwater into rivers, reducing the incidence of flood in the rainy season. Groundwater from recharged aquifers is released slowly throughout the year and made available for a longer time during the dry season to humans, river life, trees and croplands. Bamboo forests provide better watershed services than all other major production forest types (but not as good as natural rainforests).

One of the most important characteristics of bamboos is their ability to be harvested continuously once established, without the need for replanting. This means that bamboos can continue to provide environmental services while at the same time being directly utilized by humans at all

scales of economies, from rural village use to industrial manufacturing. However, the long life and use of a bamboo clump also means that bamboo owners need to be careful in maintaining the health and vigor of their plants.

BAMBOO COMMUNITY FORESTRY & RESILIENT FOREST MANAGEMENT

Although many books exist on the subject of bamboo propagation and planting, there is little information available on proper management of bamboo clumps and forest stands. What is available is hidden in scientific texts as well as internal documents coveted by bamboo plantation managers. This manual was created to help bamboo growers, extension workers and foresters follow a simple process to get the most out of their bamboo. If the principles and steps delineated in this manual are applied to an existing bamboo clump, the owner of the clump will see a significant increase in bamboo yield over the years, providing improved social, economic and ecological benefits.

Application of the following bamboo management techniques over a 4-year period, will help the bamboo farmer increase their yield. This is really the first book that tackles comparative productivity of different bamboo management systems. We estimate a 2-4 fold increase in bamboo production through carrying out the action plans in this manual. Coupled with appropriate preservation of bamboo, improved utilization and/or linkage to emerging bamboo markets, rural economies can achieve a high degree of sustainability and independence.

Although this manual has a strong technical focus, it is important to see the forest through the trees, or as the case may be; "see the bamboo stand through its clumps." In order for bamboo to provide both economic benefit and environmental services, it has to be part of a larger, holistic approach to resilient forest management, which places local communities at the center of both management and use.

RESILIENT FORESTRY MANAGEMENT (RFM)

"Resilient Forestry Management" is a new concept emerging out of the school of Resilience Thinking. Whether labeled sustainable or resilient, the forestry management scheme depicted in this manual seeks to guarantee access and control over forest resources for people living in and around forests who depend on them for their economic, social, cultural and spiritual well-being. These forests need to be managed to provide inter-generational security and increase the likelihood of sustainability.

RFM IS BASED ON THREE PRINCIPLES:

1. The rights and responsibilities over forest resources must be clear, secure and permanent
2. The forest must be properly managed so that there is a flow of benefits and added value
3. Forest resources must be transferred in good condition to ensure their future viability.

This manual places its technical focus on the second principle listed above; "proper" management of bamboo in a forest setting for improved economic and environmental benefit, as well as added value. The need for a popular manual, with clear instructions on how to get the best productivity out of tropical bamboo, became apparent over the years as the Environmental Bamboo Foundation and its partners began to develop its own community based bamboo forestry trials in Indonesia. The following text builds on lessons learned during this trial period.

FOUR GENERAL COMMUNITY BASED FORESTRY OBJECTIVES

1. Establishment and protection of a functional forest ecosystem
2. Sustainable use of natural resources
3. Protection of rights of local communities
4. Increasing economic prosperity

Modern day community based forestry, even in areas where local culture and customs are strong, has been influenced greatly by the outside world; technology, trends, globalization and development. These new cultural influences are much more materialistic and individualistic than pre-existing customs and culture.

This general change that has taken place toward individualism and materialism also gives rise to increasing conflicts over land, forests and other resources (internally amongst communities as well as amongst multiple stakeholders both internal and external).

This leads us to promoting a new model of Community Forestry Management, different than those of the past which were based largely on restoring access of traditional communities to their forest resources and promoting more communal types of management. In the era of community managed forests, community and individual needs must be addressed.

Securing rights for local people is much easier said than done, and although excellent examples of community based forestry exist worldwide, there are many cases of failure and a host of real obstacles still in place.

BAMBOO COMMUNITY FORESTRY & RESILIENT FOREST MANAGEMENT

SPECIFIC CHALLENGES FACING RFM

1. **The weakness of local institutions (especially lack of conflict resolution mechanisms and enforcement systems).**

It is difficult for local community institutions to adapt to new changes and opportunities. These changes will likely bring about internal conflict. A special focus on conflict management with regards to forestry is a necessary part of any resilient bamboo forestry venture.

2. **The limit of technology and methodologies on RFM.**

Large-scale government and concession practices are based on large-scale, centralized operations with significant investment. The RFM model is small-scale with small-investment. As such, forestry techniques and technologies needed for processing must be developed at appropriate scales, usable by the forest communities themselves.

3. **Lack of supporting systems**

A support system is needed to help communities with capacity building, access to market information, technical assistance, credit facilities and the development of supporting regulations.

4. **The issue of social entitlement and particularly lack of tenure security.**

In many countries, indigenous people have been living in their forest regions for countless generations before witnessing large-scale demarcation of state forest in the 20th century. The state now decides whether or not, and where to and where not to allocate exploitation rights, or decides to establish a conservation area without proper, full, prior consent from local communities. Local communities have very little power in securing the source of their economic livelihoods against external stakeholders and investors. The legal recognition of indigenous claims and property rights to provide long term security is an essential part of resilient forestry. Twenty-five year leases for local communities, which are often granted to forestry concessions, are not adequate to secure access to resources.

One key in achieving equitable and economically viable community based forestry lies in social organization. A healthy forest will require a healthy mix of agencies and organizations, each intent upon preserving forests for long-term existence and sustainable use. This will require the strengthening of community based organizations, as well as government institutions at various levels (village,

district, province, national), each with the ability to check and balance one another. What used to be seen as overlap in jurisdiction, can actually be a benefit to the forest by providing many different supporting social institutions. Redundancy leads to greater resilience in not only ecosystems but social system as well, so that when one organization breaks down, others can play a stronger management role.

In order to achieve resilience of social systems protecting the forest, government needs to truly understand the necessity of involving and empowering communities and community based organizations to become efficable forest managers.

"Civil society organizations and a growing number of funding agencies recognize that consistent support for forest peoples to develop their own strong, dynamic, inclusive and democratic organizations, is vital to gain wider support for community-based forest management and effect a shift away from the "timber mining" regime that has proven so disastrous until now." (WRM Bulletin #60, July 2002)

BUFFERING CAPACITY AND THRESHOLD (ADAPTED FROM WWW.RESALLIANCE.ORG)

Resilient bamboo forestry uses the principles within this book to manage existing bamboo clumps so that they are regenerative bamboo systems. Ecosystems can tolerate disturbances and manage to return to the same recognizable state. If there is too much disturbance within the system then the structure will collapse, unable to repair itself. The ability to tolerate disturbances is termed buffering capacity, while the point at which disturbances produce permanent damage is called a threshold. Operating within the buffering capacity, we can make predictions and plans with bamboo natural resources to sustain and not harm our environment. Understanding how ecological systems can operate within buffering capacity, and below threshold, is resilience. The resilience of a bamboo forest as a complex social-economic-ecological system depends largely on underlying, slowly changing variables such as climate, land use, water balance, human values and policies. A resilient ecosystem can rebuild itself after shocks.

Development of social organizations which form bamboo-based businesses or cooperatives are in better positions to incorporate appropriate ecological practices and designs than communities engaged in environmental programs without a solid socio-economic base.

Ultimately, three sub-systems are integrated to create a resilient bamboo forestry program:

Social Systems: Development of socially resilient bamboo forests, culturally in-line with local traditions, education, available infrastructure, and appropriate skill base.

Economic Systems: An economically resilient farming system that allows for good business processes that are created and run by members of the local community. This involves;

- Identification of the appropriate carrying capacity of local natural resources to support farming businesses.
- Building an integrated network of farmers that collaborate to process sustainable yields of local raw materials.
- Processing of local raw materials in a highly efficient and effective manner.

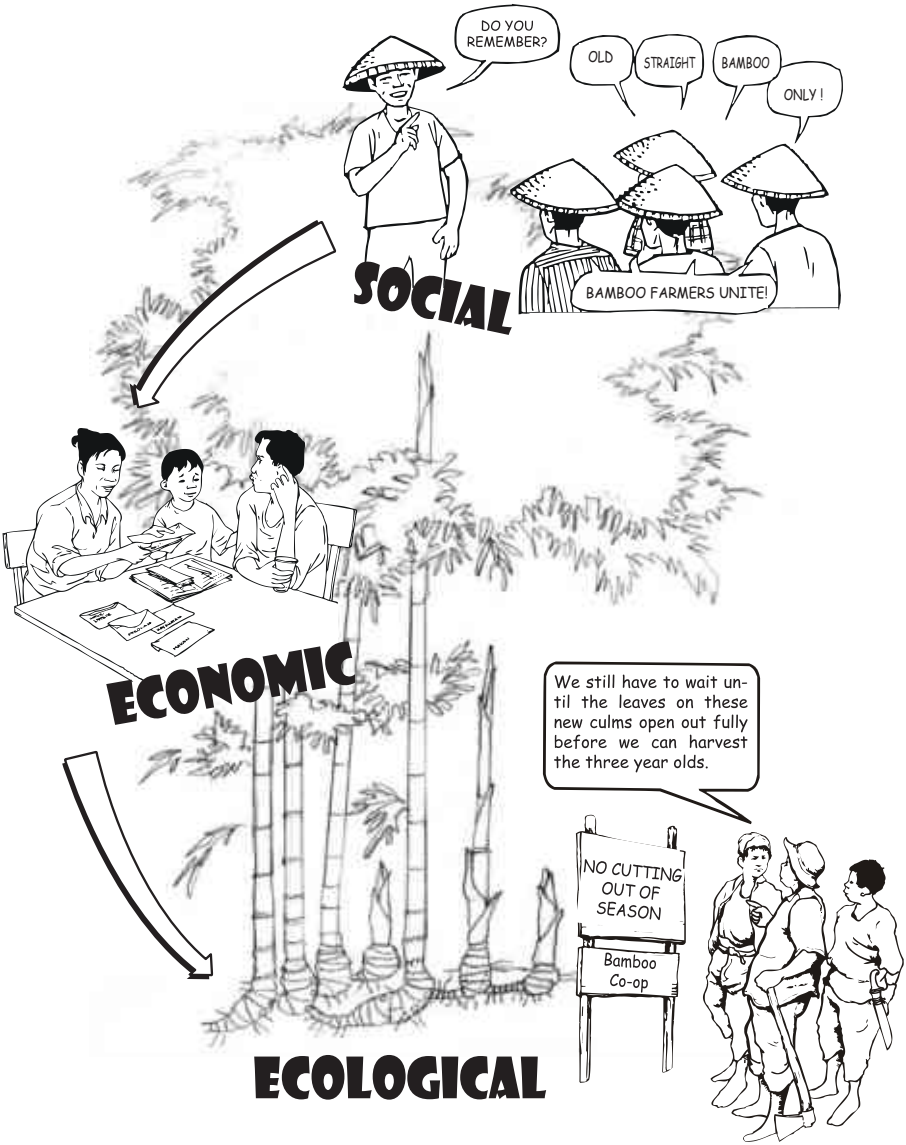
Profit, in a resilient forestry scheme, is calculated by the extent to which profit benefits and improves the community. Socio-economic indicators (see chapter 2) are used to determine this.

Ecological Systems: Developing the ecological resilience of bamboo forests in order to improve productivity with minimal, human provided, external inputs. This is achieved by re-establishing the interdependent elements of natural systems that allow for a resilient bamboo forest system to maintain itself (natural carbon cycling, water cycling, nutrient cycling, etc.)

We apply resilience to bamboo forestry in three ways:

1. Assessing the amount of change a bamboo forest can undergo through improved management and periodic program monitoring and evaluation.
2. Promoting diversity of ecological components beyond bamboo and a diversity of sustainable economic activities for continued self-organization of people and their bamboo forests.
3. Integrating bamboo resource management with small business management to engage in hands-on learning so that lessons learned during field activities are reflected into continuous cycle management systems known as adaptive management.

SOCIAL ECONOMIC ECOLOGICAL PARADIGM



HOW IS RESILIENCE LOST IN BAMBOO SYSTEMS?

A bamboo system will shift into a different state after resilience is lost to human disturbance or gradually changing conditions. Small disturbances can accumulate to the point that the system can no longer cope and risks changing into a new, often undesirable state. Erosion, irregular river flows, and habitat fragmentation can surpass threshold levels, triggering a magnitude of disturbance that causes an abrupt bamboo agroecosystem response. For instance, significant soil degradation of a *Dendrocalamus asper* forest may no longer support the growth of this giant bamboo, or reduce culm diameter and hence its economic value. Decreased value often leads to replacement by other species and resultant change in the entire eco-type. The resultant forest may no longer support the same bamboo species. Restoring such a bamboo forest could be complex, expensive, and sometimes even impossible.

Resilience can be degraded by a large variety of factors including:

- loss of biodiversity
- disturbance to natural hydrology
- soil erosion
- inflexible, closed institutions
- perverse subsidies that encourage unsustainable use of re sources
- a focus on production and increased efficiencies of a specific part of the bamboo system

EXPANDING BUFFERING CAPACITY

Bamboo forests are already resilient. The issue is their buffering capacity against disturbance. If the threshold for disturbance is not reached then the bamboo forest will remain intact and functional. We can increase the buffering capacity in social-ecological systems with diversity. Biodiversity plays a crucial role by providing functional redundancy. This means that more than one species can fill an important ecological role when other species may be absent or unable to fill their role. In a bamboo forest one can look at the different species of natural undergrowth on the forest floor. The leaves and stems of many of these species break down more rapidly than bamboo twigs (high in lignin) and leaves (high in silica). These undergrowth species provide more rapid renewal of soil organic matter, which is especially important when bamboo biomass is removed from the system by commercial logging. Improving the diversity and health of undergrowth can improve soil structure and reduce the likelihood of forest degradation. Conversely, a bamboo forest clear-cut after a natural disaster for immediate shelter building may regenerate naturally, but lose a valuable species

or exhibit a decrease in soil organic matter and water holding capacity.
Diversity and redundancy are also important in socio-economic systems. When more than one government agencies are tasked with community outreach for bamboo forest utilization and protection there are more opportunities for dialogue with farmers who are constantly interacting with the resource. In the same way, a farmer, who sells not only bamboo poles, but makes use out of bamboo residues, has an economic advantage over other farmers who rely on store bought inputs with fluctuating prices and availabilities.

UNRESILIENT BAMBOO FORESTRY AND CROSSING THE THRESHOLD

There have been several conflicts of management of bamboo resources in Southeast Asia that, when examined, help point the way forward to a new approach for ecosystem management.

1. East Java, Indonesia – A natural bamboo forest of about 30,000 hectares existed in the 1960's in West Banyunwangi, East Java. This forest was considered robust, and consisted nearly entirely of the species *Gigantochloa apus*. It is unclear what the status of this forest was, before being colonized by this monospecific stand. The natural stand was subsequently managed as a plantation. It is reported that poor harvesting and extraction practices using mechanized tractors led to serious damage of the clumps. Natural regeneration ceased and the forest was degraded. This forest has been converted into a monocultural plantation of *Pinus merkusii*, with degraded ecological functions, and relatively low economic value.

2. South Sulawesi, Indonesia – A forest area around Malino, contained a significant area of *Bambusa vulgaris,* and *B. bambos*. A Russian-Indonesian paper mill was developed and further *B. vulgaris* was planted, until bamboo resources grew to over 20,000 hectares. Lack of bamboo management practices led to the decrease in productivity of the forest, to the point where the paper mill was forced to close in the 1980's. This area has since been converted largely to a tree plantation, managed semi-extensively by and Indonesian government forestry concession (Inhutani). Productivity of this timber forest has been decreasing over the past two decades. Currently, less than 600 hectare of bamboo currently exist in the region.

3. Central Java, Indonesia – In the highland area surrounding Mt. Telomoyo, a 300 hectare mixed bamboo forest *(D. asper, G. atter, G. atroviolacea, G. apus)* exists, owned and managed by 5 rural villages. Nearly all bamboo clumps are over-harvested in this region. D. asper clumps average only 6-8 culms,

with 1-3 harvested each year. 17 meter tall poles of the other three species are purchased for only $0.40 a pole. Because of both low productivity, and the low market price, communities are replacing their bamboo clumps with fast-growing *Albizia spp*. These trees are harvested on 5-7 year cycles, further degrading soils in the highly sloped area due to erosion. Water resources are increasingly scarce in this region, with incidence of springs drying up, and significantly lower volumes of river flow.

4. Perak State, Malaysia – A mixed tropical rainforest was historically cleared, and pioneered largely by *Gigantochloa scortechinii.* Monospecific bamboo stands exist in a mosaic with tropical rainforest in this region, totaling an area of 70,000 hectares, with perhaps 20,000 – 40,000 hectares of bamboo. This resource is as yet, unmanaged, and no harvest of bamboo takes place. The Forest Research Institute of Malaysia is interested in appropriate management, harvest and utilization of the resource, but no human resource has been identified for the tasks of management and harvest. It is feared that, in lieu of engaging local communities to undertake appropriate management, a large-scale clear-felling operation may be undertaken, to the potential detriment of both bamboo and other forest resources.

In each of the above cases, a specific resource of tropical timber or bamboo has been identified and controlled for specific uses, with the result of system degradation. Uncertainty in nature is presumed to be replaced by certainty of human control. Social systems initially flourish from this ecological stabilization and resulting economic opportunity. Paradoxically in each case, initial success creates its own failure.

The Pathology of Regional Resources and Ecosystem Management

Many natural resource management problems can be analyzed from an economic and human behavioral standpoint. According to this view, resources are appropriated by powerful minorities who are able to influence public policy. Hence inappropriate measures such as perverse subsidies are implemented that deplete resources and create inefficiencies. A fundamental cause of the failures is the political inability to deal with the needs and desires of people. That pattern is common and gives pause to any quick and easy predictions of collapse and disaster.

Observation: New policies and development usually succeed initially, but they lead to agencies that gradually become rigid and myopic, economic sectors that become slavishly dependent, ecosystems that are more fragile and a public that loses trust in governance.

RESILIENT BAMBOO FORESTRY PROGRAM

In Indonesia's bamboo forests, we are just now experiencing the formation of meaningful networks of stakeholders coming together for watershed conservation and inclusion of bamboo on the agenda. Such a case exists in the highlands of Central Java, where the USAID Environmental Service Program repeatedly brought together communities, NGOs, government and academics, over a 5 year period to discuss and create action plans which led to bamboo planting, bamboo field school, improved bamboo utilization, linkage of bamboo farmers and markets, and inclusion of bamboo on the agendas of more than seven different government agencies.

The EBF now focuses on two main programs:

- Sustainable Bamboo Processing: Focusing on use of appropriate technology for bamboo processing and utilization to improve livelihoods in forest communities.

- Resilient Bamboo Forestry.

The EBF is focusing on resilient bamboo forestry through Farmer Field Schools which serve to educate communities with much of the same focus as this manual, working towards watershed protection and carbon capture.

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BAMBOO GROWTH & ECOLOGY

Introduction
Glossary
1. Bamboo Growth
2. Elements of a Sympodial Bamboo Clump
3. Growth & Environment
4. Ecological Cycles in Bamboo Stands
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CHAPTER 1 LAYOUT

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1.2 ELEMENTS OF A SYMPODIAL BAMBOO CLUMP

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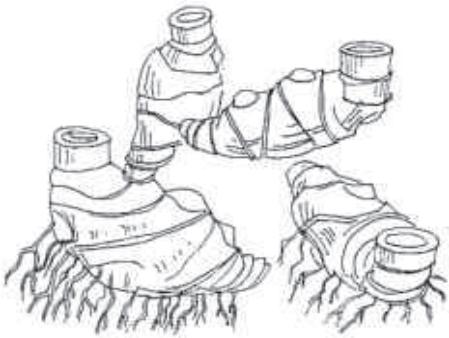
1.1
BAMBOO GROWTH

The following section provides information about the elements of a sympodial bamboo clump, bamboo growth, and ecology within the bamboo agroecosystem. The term agroecosystem is used in this book to describe bamboo mixed with other agricultural crops (agroforestry), bamboo in a forest setting, and bamboo in a pure stand.

For more complete information on any of these, topics, refer to the list of resources at the end of this manual. Better understanding of bamboo, both as a plant and as a member of an agroecosystem, will help the manager or farmer make better decisions regarding bamboo clump management.

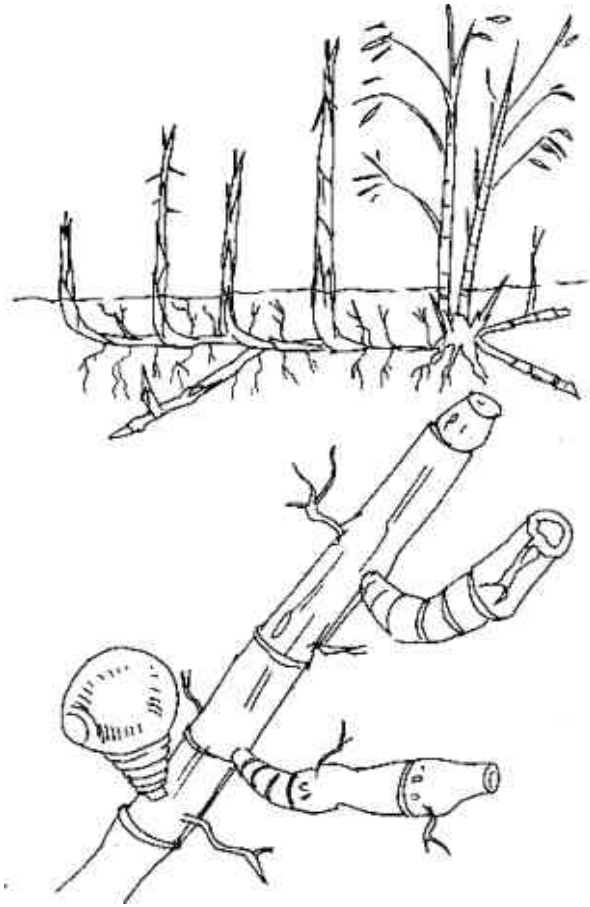
Sympodial and Monopodial Bamboos:
There are two major groupings of bamboo, sympodial (Clumping) and monopodial (Running).

Sympodial (One mother many offspring):
The underground stem of a sympodial bamboo is called a rhizome and is made of a network of what look like inter-connected umbrella handles (other rhizomes). Buds (called rhizome buds) sprout off of these rhizomes, turn into shoots when they emerge from the soil and then into culms as the extend into the canopy The distance between mother and offspring is small, and thus sympodial bamboos grow in clumps.



Sympodial bamboos are the dominant type of bamboo in the tropics. This book explains how to manage tropical sympodial bamboo clumps for a sustained increase in shoot production, and an increase in water and nutrient availability in the network of rhizomes. This will optimize the successful growth of more then ninety percent (90%) of shoots into mature culms.

Monopodial Bamboo (One mother, one offspring):
Monopodial bamboos are known as running bamboos, because their rhizomes extend far from the origin of the bamboo plant. Buds emanate from nodes on the rhizome, and can either emerge from the soil as a bamboo shoot or turn into another rhizome. Monopodial bamboos are infrequent in tropical and sub-tropical forests.



Amphipodial bamboo (one mother several [maximum 6] offspring):
The third type of bamboo called is known as amphipodial bamboo, (a mix between sympodial and monopodial bamboos), and will not be discussed any further in this manual.

1.2
ELEMENTS OF A SYMPODIAL BAMBOO CLUMP

Clump - The entire sympodial bamboo plant is known as a clump. Bamboo clumps may exhibit up to 300 culms if left unharvested. A regularly managed clump can maintain upwards of 100 culms.

Culm - This is really the above-ground stem of the plant. In botanical terms, this stem is really a branch. The culm grows to full height in 6-8 months
The culm is split into three parts;
1) upper, 2) medial and 3) basal.

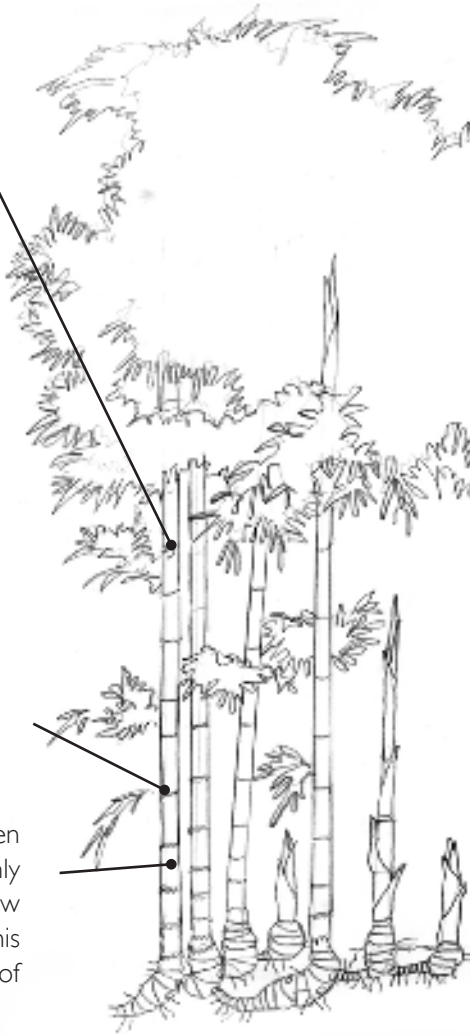
1) The **upper** culm consists of branches and leaves and maintains an amazing degree of flexibility to withstand high winds.

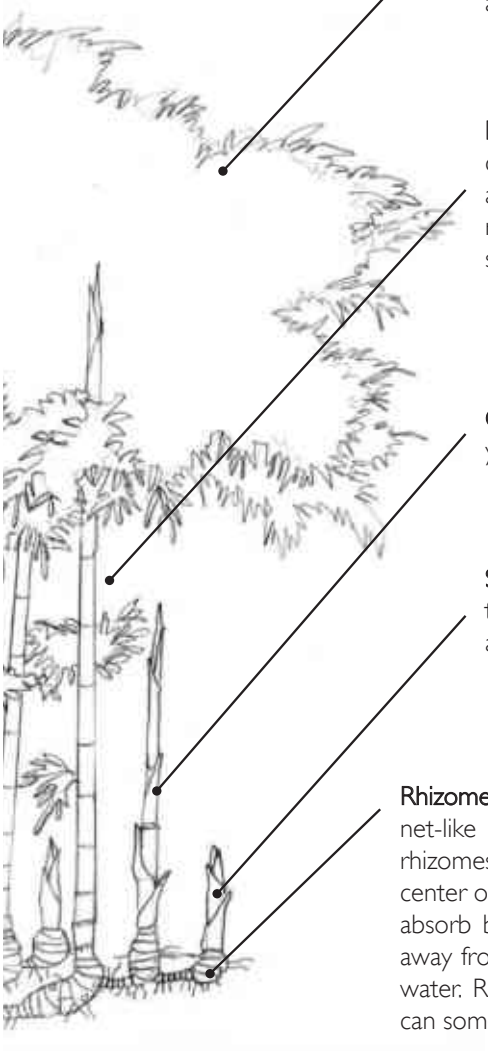
2) The **medial** section provides the rigid structure which allows the culm to grow high into the canopy in search of sunlight for photosynthesis.

3) The **basal** section (known as culm-base) contains the roots and buds (which become rhizomes once sprouted).

Nodes - The divisions between individual segments on a culm. Nodes make the bamboo culm rigid, and are the point on a bamboo containing horizontal radial fibers.

Internodes - The segment on a culm between two nodes. The fibers in the internode are only vertical, and wrap into the above and below nodes forming a basket of tensile fibers This provides bamboo with a maximum amount of strength using a minimal amount of material (fibers).





Leaves - The size, angle and waxiness of bamboo leaves differs amongst various species, based on the bio-region from which they originate. Silica in the bamboo leaves allows them to withstand high heat and increases light absorption to achieve phenomenal rates of photosynthesis and growth.

Branches - Branches emanate from buds on the culm. They are useful in determining the age of a culm, enhancing soil structure when incorporated into mulch, and also in propagation (using sub-branches).

Culm Sheath - Protects the bamboo shoot and young culm and is crucial for species identification

Shoot - The young culm, when it emerges from the soil. Many species are highly edible although a few can be extremely bitter.

Rhizome/Roots - Sympodial bamboos have extensive net-like root systems emerging from underground rhizomes. The roots spread up to 15 meters from the center of the clump. Roots closest to the clump (<5m) absorb both water and nutrients while roots farthest away from the clump (>5m) mainly function to gather water. Root systems are relatively shallow, although they can sometimes delve 2 meters deep into the soil.

1.3
GROWTH & ENVIRONMENT

1.3.1
MAIN PHASES OF GROWTH OF A BAMBOO CULM

START HERE

1a- Shoot Bud Differentiation
This occurs at the onset of the rainy season and lasts 1-2 months. Lateral buds of the rhizomes, differentiate into culm buds. Culm's aged 1-4 years old can produce swelled buds, which may or may not turn into viable bamboo shoots.

1b- Shoot Bud Burgeoning
This phase occurs in the 3rd month after initial bud differentiation. In this phase, culm buds swell, and turn into a young, small shoot.

1c- Initial Shooting
Here the shoot swells underground, and breaks. New shoots emerge from the soil, with full complement of nodes already contained in compressed buds the surface and grows to a full-sized shoot (max 30 cm tall - Gigantochloa, 50cm - *Dendrocalamus*), this phase usually lasts15 days. This is when the blue-print of the bamboo culm is formed.

2- From Shoot to Culm
From shoot to culm in 30-45 days. The bamboo culm undergoes about 80% of its growth in this period and requires significant nutrients and water. The culm will grow in a slow-fast-slow rhythm

2a- Slow Culm Growth
Upward growth rate is weak while the horizontal growth rate of the internodes is pronounced (giving the culm increased diameter)

END HERE

5- Asexual Reproduction
Sub-branches especially, which have formed aerial roots may fall and grow into new bamboo clumps. Other parts of fallen culms which land in amenable soil also undergo asexual reproduction.

4- Mature Growth
This is characterized by lignification as well as other physiological processes.

Booming shoot growth of D. giganteus in Central Java.

3- Leaves
Leaves develop slowly in the first year, with full leaf-out taking place in the third year. Maximum photosynthetic potential is only reached by mature culms, after lignification ensures that the culm can withstand significant swaying due wind in the leaves.

2c- Slowing Down Again
Internodes grow steadily and a decrease in culm growth rate. Buds along the culm expand and develop into branches. These may further experience sub-branching and development of small aerial roots.

2b- Booming Growth
The internodes below the soil surface stop growing, and the bamboo roots dominate growth. The bamboo begins sweating. At the same time, the culm internode growth accelerates upwards at its peak. This usually takes place around the time of the full moon in the tropics.

1.3.2
ENVIRONMENTAL FACTORS

KEY ENVIRONMENTAL FACTORS

Some key environmental factors which dictate bamboo growth are:

Rainfall - Especially during shooting season and the booming growth phase, bamboos require adequate moisture to properly develop,

Soil Moisture - This differs amongst species. Maintaining soil moisture around the clump into the dry season is an important management step achieved by mulching and increase of soil organic matter.

Drainage - Too much soil moisture, or waterlogging is a problem for bamboo and gives rise to fungal attacks. Appropriate drainage of a bamboo stand is a priority when standing water is affecting bamboo growth.

Temperature - In the tropics, temperature may be less of an issue than in temperate zones.

Sunlight - This is dependent on the density of the bamboo stand canopy, or other tree canopy in a mixed forest. Bamboo culms growing on a steep slope will have to grow taller (and usually straighter) to seek adequate sunlight.

Soil - Bamboos grow on a variety of soils, but many of the tropical sympodial bamboos useful for construction prefer heavier soils rich in organic matter. A large portion of this manual is dedicated to soils and soil nutrient management.

Topography - Various bamboos grow better or worse depending on topography. Some bamboos thrive in the lowlands, in rich alluvial soils which can often have high water content. Other bamboos do better at altitude on sloped, well drained lands. *Dendrocalamus* and *Gigantochloa* bamboos, growing on slopes, tend to grow straighter (in search of sunlight) providing superior quality timber.

Human Influence - Bamboo, especially in a managed stand or agroecosystem, will be dependent upon human factors, primarily social acceptance of bamboo. This will depend largely on greater perceived economic value of bamboo coupled with better understanding of environmental services provided by the bamboo forest.

1.4
ECOLOGICAL CYCLES

Ecological Cycles in Bamboo Stands

Like any ecosystem, both natural bamboo forests, as well as bamboo agroecosystems, are controlled by a number of cycles, each with a few key variables (factors) that regulate the cycle. These cycles may range from rapid biotic cycles taking place within a bamboo clump (insects, animals, micro-organism etc.), to the slower abiotic processes (water, carbon, nitrogen, phosphate) taking place at the ecosystem level. Bamboos living in a forest setting actively affect natural cycles which lead to an amount of stability in terms of micro-habitats (within soils underneath the plants, as well as moist micro-habitats under the bamboo canopy), as well as larger scale systems (the forest itself) which can be seen as a type of self-regulation. That is, bamboos enhance their own habitat, stabilizing the amount of environmental fluctuations that take place in the system. A bamboo forest, therefore, has a high degree of ecological resilience.

The following are depictions of key processes and variables which determine the dynamics at both the plant level (an individual clump) as well as the forest level.

1.4.1
KEY PROCESS #1

Key Process #1 Slow decomposition of leaf mulch due to high silica content, leading to a stable micro-habitat.

Energy is stored as organic matter in the soil and brought into the system by micro-organisms, detritous-eating insects and the actions of worms. Organic matter is largely derived from residues of the bamboo plant itself (bamboo leaves, culm sheathes, dead stumps and roots) as well as other forest vegetation. Organic material also comes into the forest brought by rainwater and other allochthinous (from outside the system) sources.

The residues from the bamboo plant itself, take a considerably long time to decompose in a natural situation, largely due to a high proportion of silica within the fibers of a bamboo and on the outer skin layer of a culm. Silica is not only hard for most plants to absorb (except grasses, like bamboo, which are good at it), but it is also hard to break down, so decomposition takes a long time. This means its durable fibres will improve soil structure for longer and the nutrients held in its fibres will be released slowly over a longer period of time. This limits

the nutrient availability so the system is never flushed with nutrients in excess of plant needs. This enhances the soils fertility for longer and ensures there will never be a total loss of nutrients, for instance during heavy rains, by leaching, as any losses will be replaced as soon as more are released. This creates a top-soil environment in which is quite stable over a long period of time, more stable than one fertilised with the quickly rotting residues of many plant species. (eg. where more nutrients than the plants can absorb are rapidly released and the excess is easily leached and lost to the system).
This slow decomposition, and stability is one key factor which makes the bamboo soil ecosystem unusual and allows for the phenomenal growth rate and overall biomass of the bamboo plant.

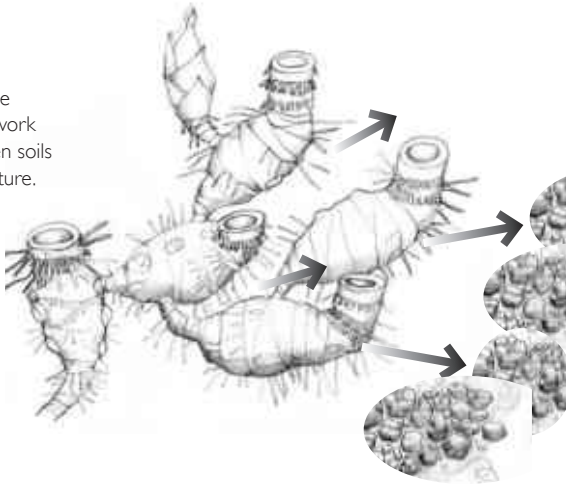
1.4.2
KEY PROCESS #2

Key Process #2 Physical action of roots and rhizome network, improving soil structure and water infiltration.

Another key factor allowing for the exuberant growth of sympodial bamboos must be credited to the physical action of the bamboo's root and rhizomic network.

The shallow root and rhizome system is highly dispersed underground. This system acts to improve the soil due to physical action. Fine roots spread out far into the surrounding soil, 15 or more meters from the center of the bamboo. These hairs act to catch water, turning the ground around the bamboo into a

Vigorous growth by the root and rhizome network acts to physically loosen soils and improve soil structure.



sponge. When the root hairs die and decay, the space they used to occupy become soil pores. Increased porosity leads to improved soil aeration and drainage which enhances the soil micro-organism habitat. It also allows the soil to retain and store more water which is crucial.
With regards to bamboo's rhizomic network, few plants maintain such a large amount of dense underground structure. These large strong rhizomes break down soil to an extent not exhibited by other plants or plant communities. This physical action creates a highly porous soil layer with good drainage.
The cumulative outcomes of Key Process #1 (a rich, stable, organic layer due to highly siliceous, slowly decomposing bamboo material) and Key Process #2 (porous, aerated soil) give rise to conditions where micro-organisms, which are fundamental to the breakdown and decomposition of the leaf litter and soil organic matter, thrive. In addition, when degraded heavy clay tropical soils (often red) increase their organic matter content significantly, Aluminum gets locked into organic compounds (through a process of chelation) so the plants are protected.

Soil aeration also helps in the oxidization and chemical breakdown of soil minerals.
The action of micro-organisms further improves soil health by making nutrients available to the plant. All of these factors, help bamboo achieve a rate of growth unparalleled by other members of the plant community (up to 1.5 meter a day in *D. asper*)

Leaf fall, along with other decaying parts of the bamboo plant, decompose slowly and create a stable organic soil layer (a)

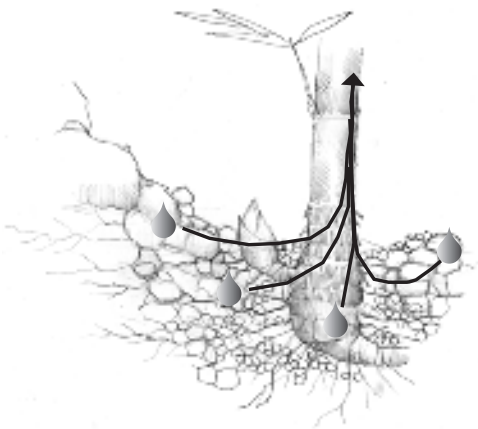
Coupled with the soil loosening action of the bamboo's rhizome and root network (b), soil conditions become optimal for proliferation of micro-organisms, which in turn improve soil texture and make nutrients available to the bamboo.

1.4.3
KEY PROCESS #3

Key Process #3 - Water storage capacity of root systems.
A third key process which allows for superb bamboo growth has to do with the water storage capacity of the root system. Bamboo root hairs have an exceptional ability to expand in size which gives the bamboo plant itself a high water holding capacity. In essence, the bamboo acts as a living aquifer, storing water for later use.

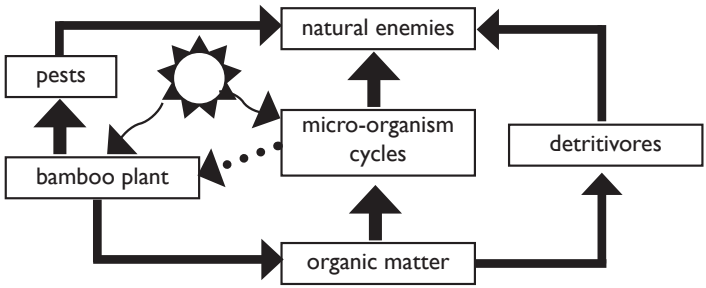
1.4.4
ENERGY FLOW

In order to undergo their "booming" growth spurt, bamboo culms need to attain a high hydrostatic pressure. Soil water coupled with water retained in the vast, shallow root system is essential to achieve this type of growth.



The energy flow in a bamboo system begins with microorganisms (bacteria and fungi) breaking down organic matter. The diversity of microorganisms in soils is tremendous. Soil depleted of micro-organisms is like a person with a failing liver. Bamboo-specific mycorrhyzal symbiotic fungi have been found to improve bamboo growth, while bamboo growth in a wasteland is likely stunted by a lack of soil microorganism diversity. Effective microorganisms (EM) are marketed for agricultural use to revitalize soils (www.emrojapan.com) and are being looked at for bamboo afforestation. Analog forestry techniques used to recreate already functional forest systems may use soil from the original forest, or specifically a bamboo clump exhibiting excellent health and growth, to inoculate the soil of the new forest. This is an area due for more experiments

and research. One especially beneficial fungi found in many sympodial bamboo soils is Trichoderma spp. Products of microbial decomposition of decaying matter directly feed worms and detritus-eating insects (small particle eaters), such as beetle larvae and fly larvae. The following diagram illustrates the flow of energy throughout the bamboo clump.



1.4.5
NATURAL PEST DYNAMICS

Natural Pest Dynamics

In addition to exceptional conditions for growth, due to beneficial nutrient availability, naturally occurring bamboo clumps and forests generally have a high degree of resistance to pests and disease. Pests and disease can afflict all parts of a bamboo plant, but in a healthy functioning bamboo forest or agroecosystem, pests seldom have the chance to dominate.

Consistently low pest populations in bamboo forests stem, in part, from the fact that natural enemies (especially generalist predators like wolf spiders) are not directly dependent on pest populations. Rather, there are three separate avenues for energy flows to natural enemy populations:

1. From organic matter via micro-organism cycles
2. From organic matter via detritous-eating insects,
3. From the bamboo plant via herbivores.

This means that whether or not pests are in abundance in a bamboo forest, natural enemies of pests, such as the wolf spider, can exist on other prey. When outbreaks of pests do occur, their natural enemies are still around to control pest numbers.

Where pests and disease do have a chance to dominate, there have typically been changes in the natural environment. One example of negative changes may

be application of pesticides which can harm natural enemies of pests and induce an increase in pest population. Removal of organic biomass needed for nutrient cycling (especially leaves) is another form of disturbance, which weakens the bamboo plant and makes it more susceptible to disease. Changes in forest hydrology, such as decreased drainage to an area and increased amounts of standing water, could cause an unnatural increase in attacks by deleterious fungi. These three cases are further discussed in the next section when we see how an understanding of the key factors and processes enhancing bamboo growth can affect our management.

Chapter 3, Section 6 on Pest Management for Bamboo goes into greater detail regarding integrated pest management solutions for bamboo.

1.4.6
MANAGEMENT IMPLICATIONS

1.4.6.1
BAMBOO MANAGEMENT IMPLICATION #1 - NUTRIENT RECYCLING

Replenishment of soil nutrients in a large part comes from the bamboo itself, along with other vegetation growing in a natural forest or bamboo stand.

In an agroecosystem setting, these autochthonous nutrients (coming from within the system, in this case the bamboo plants themselves) are likely to be removed from the forest. Certainly most culms are removed, for their high economic and use value. Aside from culms, bamboo leaves are often removed by farmers for fodder, compost, or bedding for livestock. Even culm sheaths are removed from the forest in some areas for their economic value.

Bamboo farmers from rural areas in developing nations seldom replace these valuable nutrients. Providing fertilizer, compost or even mulch to tropical bamboos is seen as a waste of resources, time and money, as "bamboos grow fine on their own,."

In order to improve management and yields from bamboo stands, it is important to understand what a crucial role organic material, from the bamboo plant, plays in maintaining the health of the soil ecosystem, and in turn, the bamboo forest or agroecosystem. This understanding underpins the importance of promoting management practices which ensure replenishment of organic material.

1.4.6.2
BAMBOO MANAGEMENT IMPLICATION #2 - NATURAL PEST CONTROL

The existence of diverse populations of natural enemies, supported by abundant alternative food species, assures that populations of pests are consistently maintained at low levels. In effect, the structured biodiversity of arthropods in tropical bamboo clumps functions to consistently suppress pest populations by denying pests refuge in time or space. Pest populations explode causing serious damage when key variables found in the tropical bamboo ecosystem are disrupted.

Given this, the following implications for pest management in bamboo can be determined. The use of insecticides, as is practiced on bamboo plantations in industrialized countries, disrupts and destabilizes natural enemy populations. These kinds of pest outbreaks are generally referred to as "pesticide-induced resurgence." Several factors combine to enable resurgence to occur:

- Eggs of many pests are not susceptible to chemical sprays.
- Insecticides create a refuge for the development of pest populations by reducing the abundance of their natural enemies.
- Migratory abilities of pests are generally better than those of their natural enemies, thus they can easily re-colonize an area treated with pesticides
- Pests have shorter life cycles than their natural enemies, so they become immune to the effects of pesticides more quickly than their natural enemies.

Use of pesticides are not necessary in a bamboo agroecosystems. They present an unnecessary expense and are also not effective in the long-run. Proper management of the stand, growing healthy bamboos in a natural forest or agroecosystem setting, is a more viable means of pest control.

1.4.6.3
BAMBOO MANAGEMENT IMPLICATION #3 - SOIL EROSION

Even in a natural bamboo forest system, with the recycling of soil organic matter and the presence of vegetative understory to bind soils to the forest floor, soil erosion takes place. This is especially true in highly sloped areas. Although it may seem that the expansive root network of a bamboo clump would hold soil in place, the physical action of bamboos large rhizome network can considerably loosen soils. During the rainy season, in areas of high slope, soils on the downhill side of a bamboo clump can be prone to erosion. This can significantly decrease the productive potential of the bamboo clump, due to loss of top-soil (needed to cover apical buds which give rise to shoots) as well as soil nutrients.

The dangers of soil erosion increase in a frequently harvested bamboo area, due to intensity of human traffic, eradication of ground cover, felling of bamboo culms, etc.

One of the management actions recommended later in this book is the mounding of soil around the bamboo clump, to promote maximal shoot production. But in order to mound soil, you need to have sufficient soil on site. Therefore, in areas where soil erosion is likely (high slope, intensive harvest), soil erosion measures must be taken. *

REFERENCES CHAPTER 1

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*For more information on soil erosion control, refer to "Management of Soil Erosion Consortium," MSEC Program (http://msec.iwmi.org).

2

BAMBOO ASSESSMENT

1. Assessing Resilience
2. Why Assess Your Bamboo Resource?
3. Community Involvement - Semi Structured Interview
4. Conducting a Bamboo Resource Survey
5. Bamboo Resource Survey Indicators
6. Survey Forms
7. Bamboo Resource Mapping
8. Seasonal Calendar
References

CHAPTER 2 LAYOUT

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- 2.1.2 Economic System
- 2.1.3 Ecological System

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- 2.2.1 Why Perform an Assessment?
- 2.2.2 Who Uses Information From Assessments?
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2.6 Survey Forms
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CHAPTER 2 LAYOUT

2.7 Bamboo Resource Mapping
2.7.1 Resource Maps
2.7.1.1 Approach A
2.7.1.2 Example of Bamboo Resource Sketch
2.7.1.3 Approach C: Gendered Mapping
2.7.1.4 Approach D: Two-stage resource mapping

2.8 Seasonal Calendar
2.8.1 Example 1 - Central Java Highlands, Indonesia
2.8.2 Example 2 - Southern China

2.1
ASSESSING RESILIENCE

In order to understand the resilience of a bamboo forest, an assessment of the bamboo resource must integrate social, economic and ecological parameters. The key step in integrating these parameters is to identify how they are interdependent. Based on the way different parameters affect each other, parameter should be prioritized and weighted. See Example Report of Participatory Rural Appraisal in Iseh, Bali-Indonesia 2007 in Appendix A.

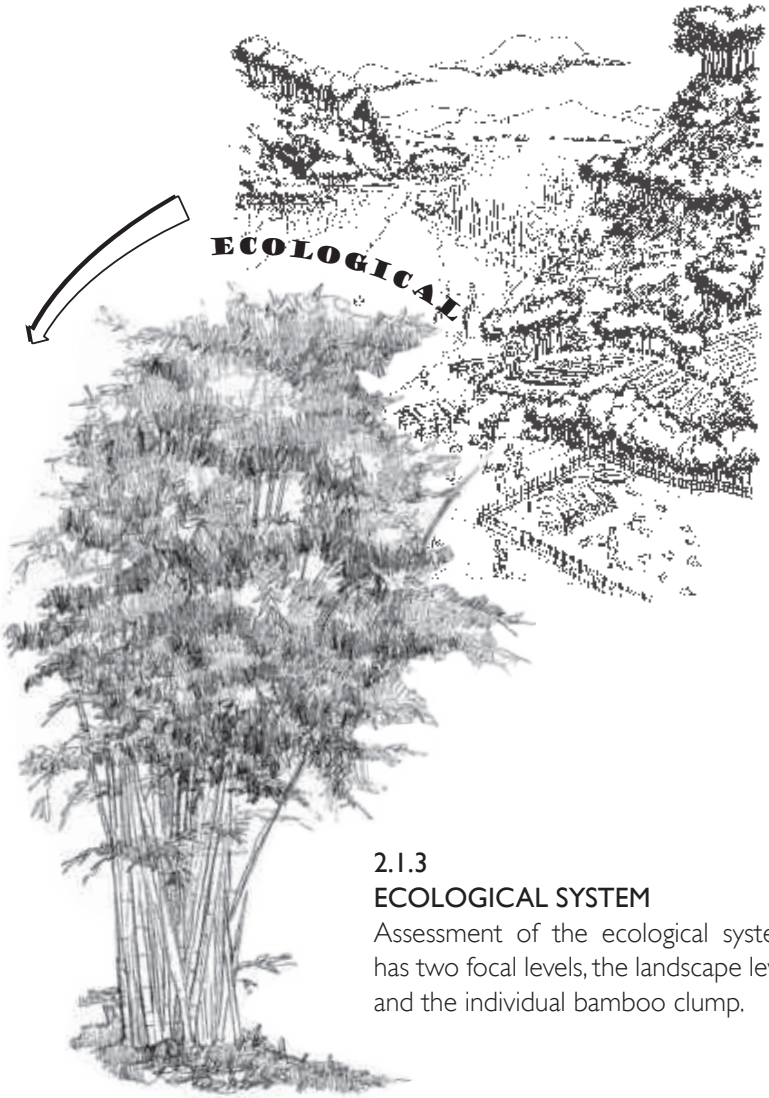
In this chapter you will consider the health of three interconnected systems;

2.1.1
SOCIAL SYSTEM

The community of people involved in bamboo growth, management and use, this includes bamboo growers, purchasers, forest managers, government and academia.

2.1.2
ECONOMIC SYSTEM

Follows a commodity chain, from bamboo production in the forest to end use.



2.1.3
ECOLOGICAL SYSTEM

Assessment of the ecological system has two focal levels, the landscape level and the individual bamboo clump.

2.2
WHY ASSESS YOUR BAMBOO RESOURCE?

2.2.1
WHY PERFORM AN ASSESSMENT?

- To identify at an early stage, remedies to problems caused by lack of management or inappropriate management.
- To act as baseline data for evaluation of the bamboo's performance under new management practices.
- To provide policy makers and development planners a sound basis in formulating and revising policies and programs.

2.2.2
WHO USES INFORMATION FROM ASSESSMENTS?

- Bamboo growers,
- Development workers and forestry extension agents,
- Researchers,
- Policy makers and planners.

2.2.3
QUALITATIVE VS. QUANTITATIVE ASSESSMENT

Qualitative measures, are those measures with general answers, such as; "highly-erosive, some erosion and little erosion" when determining the amount of erosion taking place in a bamboo forest.

Quantitative answers are much more precise, with answers such as "2.5 tons of soil loss per hectare per year."

The indicators and data sheet on the following pages are adequate for qualitative tests only. In some cases, quantitative analysis is recommended. In the column entitled "Source of Information - Means of Collection & Verification" tips and resources for conducting quantitative assessment are provided for indicators that usually require precise measurement.

2.2.4
A TWO-PART BAMBOO RESOURCE ASSESSMENT: SURVEY & MAPPING

The following assessment method is split into two parts; 1) a bamboo resource survey and 2) bamboo resource mapping. These two parts can be considered tools which will help you achieve a comprehensive assessment. The bamboo resource survey and mapping activities, are really two parts of the same whole (assessment), and have been broken down only for ease of explanation.

Before going into the assessment, a section on community involvement and semi-structured interviews, is presented to highlight the importance of putting the community at the center of your assessment.

2.3
COMMUNITY INVOLVEMENT

SEMI-STRUCTURED INTERVIEW

2.3.1
ON COMMUNITY INVOLVEMENT

Participation is not just a catch-phrase, but a deeply meaningful concept crucial to the success of a sustainable bamboo forestry venture. Full support, both from, and for, local communities, will help build the long term resilience of a forestry venture. In order to achieve community support, local communities need to be involved in all processes from early planning and assessment, through actual implementation of forestry practices, as well as for monitoring.

With regards to undertaking a bamboo resource assessment, engaging local community will be essential for an accurate picture of the past and present condition of social, economic and ecological issues and parameters. In addition, much useful knowledge on traditional bamboo management practices may be learned, which can later be scientifically tested for integration into forest management practices.

Extracting interesting information from community members, especially in rural areas with people that perhaps have not had contact with scientific researchers, foresters, extension workers etc., is not as simple as asking a set of technical questions.

2.3.2
SEMI-STRUCTURED INTERVIEW

A semi-structured interview differs from a structured interview, in that it involves the use of a set of guide questions or discussion points, rather than a set list of questions. The interviewer, uses guide questions in a setting familiar to the interviewee, to initiate a dialogue, or story telling sessions. New questions arise during this process as a result of responses from the interviewee.
The fact that the process is organic, evolving, and takes place in familiar surroundings, should lead to free-flowing information, stories, myths and facts about local bamboo species, forests and forest communities.

Purpose:
A semi-structured interview is a way of generating data or information by providing opportunity for the interviewer to do the following:

- To probe answers
- To open up new dimensions of a problem
- To secure vivid, accurate and inclusive accounts based on personal experiences
- To uncover unique local traditions, some of which may have been lost, and to begin to probe into the roots of traditional practices.

Approach:

2.3.2.1
PREPARATION FOR THE INTERVIEW

Gather and review available information about the region and people.

For a more meaningful conversation, observe people beforehand, be familiar with local terminology, and understand cultural gestures and other symbols.

Remember that your sex, background, age and personality, will all affect the interview. For example, rural women may feel uncomfortable talking to a man, even if no personal questions are asked. An elder may feel less willing to

talk to a younger person who is overly talkative.

Prepare a notebook, pen or pencil but ask for permission to take notes. A mini digital tape recorder is also useful, and can provide a more comfortable atmosphere for discussion, if you are granted permission. Prepare an agenda and list of topics.

Phrase questions that require participants to tell a story and avoid asking questions that can be answered with a simple YES or NO.

Arrange for a place for the interview where the informants will feel at ease.

Example of a good question (open-ended)
How often do you harvest bamboo culms?

Example of a bad question (leading)
Do you harvest bamboo only in the dry season?

2.3.2.2
TYPES OF QUESTIONS TO ASK

1) Descriptive Questions - These prompt informants to describe their activities.

Example: Could you describe what happened after the government planted 100,000 bamboo seedlings on this mountain?

2) Structural Questions - These attempt to find out how informants understand their situations and organize their knowledge.

Example: Has the oil palm plantation adjacent to your forest affected your bamboo? If so, how?

3) Contrast Questions - These encourage informants to discuss the meanings of situations and provide an opportunity for comparisons to take place between situations and events in the informant's world.

Example: How would you compare the value of bamboo with the value of bamboo 20 years ago?

4) Probing Questions - These allow informants to analyze and reflect on the deeper causes of a particular situation. Probing questions usually start with 7 key words:
"Who", "Where", "When", "What", "Which", "Why" and "How."

Example: Why are many local people replacing their bamboo clumps with other tree species or crops?

- ☑ *Start with general questions and then get more specific*
- ☑ *Ask questions in different ways to probe deeper into a certain issue.*
- ☑ *Make links between observations and information given during the interview..*
- ☑ *Write up the interview as soon as possible when it is still fresh in mind.*

Considerations:

2.3.2.3
STRENGTHS

+ Semi-structured interviews can generate perceptions and emotions in detail.

+ If done well, and cross-checked with other information, semi-structured interviews can provide an excellent assessment of a bamboo resource. The interviews can particularly be effective for revealing social dynamics, and how these affect the topics under discussion.

+ Interviews with community on bamboo can generate new hypotheses to be scientifically tested with regards to techniques for bamboo management.

2.3.2.4
WEAKNESSES

- Some responses may be influenced by personal bias, e.g., people may use the interview to talk about personal grievances, etc.

- People may give answers which they think you expect to hear.

- Contradictory information may be presented.

For example; in the Central Java Highlands, seven communities interviewed had traditional practices relating harvest time to moon phase. Four of the villages surveyed recommended harvesting all month long except around a full moon (when the bamboo is "sweet" and attractive to bugs), while three villages stated that the best harvest of bamboo took place during full moon. This uncovers the need to investigate the effect of moon phase on sugar content in the bamboo culm.

2.4
CONDUCTING A BAMBOO RESOURCE SURVEY

Bamboo Resource Survey

Intent:

- To generate basic information on the quantity, species, location, ownership, general health and management practices of a bamboo resource.
- To collect indicative data on trends in bamboo resource changes and exploitation.

To obtain feedback from the community regarding local bamboo resources.

Approach:

A bamboo resource assessment is a direct method used to collect information on various aspects of a local bamboo resource; such as amount, species, location, ownership, health etc. This assessment initially aims to rapidly gather information from a group of people with the help of a facilitator, familiar both with participatory processes as well as bamboo. The second aim of the assessment is to provide baseline data for a long-term study of the change in your bamboo resource.

Prerequisites For Site Selection

- Choose sites with pre-existing bamboo clumps where bamboo growers are supportive of improved clump management.
- Clarify land ownership status and receive appropriate permissions to extract data from the site.
- Locate the site on local maps. Satellite images from Google Earth are an excellent tool for orientation. Maps can also be procured from local government offices (Forestry Department, Planning Agency, etc.).
- Creating a sketch map is a requisite of a bamboo resource assessment. More detailed, community-produced maps may be desired as well. Contact a local NGO for methods and facilitation assistance. For more assistance in mapping, refer to section 2.7 on Bamboo Resource Mapping

***Approach (Continued)*:** The health of your bamboo, the condition of the forest, and the ability of local stakeholders to sustainably manage bamboo resources can not be determined in a single survey. Nonetheless, data from an initial resource survey is invaluable as it will serve as a baseline for future comparisons. Regard the indicators on the following pages, and use the data sheets provided to begin an survey based on the following steps.

1. Identify the objectives of your assessment and select appropriate indicators.
2. Test the indicators and modify them to suit your objectives
3. Arrange for the team to go to the bamboo forest and record information
4. Validate the information by checking against other sources.
5. Set up baseline data and identify specific indicators and parameters.
6. Rate the general state of the indicator you are measuring using the following grading system

   1 = not resilient (healthy over long term)
   2 = building toward resilience
   3 = resilient
7. Interpret rated indicators through discussions.
8. Repeat steps 3-7 each year.
9. Check for changes in the ratings from year to year. If a rating falls over time, the system is becoming less resilient.
10. Propose changes in policy and program strategies to improve resilience.

REQUIREMENTS:

HUMAN RESOURCES

- Facilitator with basic skills in bamboo or forestry survey methods, participatory rapid assessment methods, and mapping skills
- Team members from the community able to identify local bamboo species using local names and with knowledge of local land use and land ownership.

MATERIALS

- field notebook
- checklist of local names and scientific names
- bamboo field guide
- paper
- pencil
- pocket calculator
- mural paper
- markers or crayons

OUTCOMES:

- Baseline data on individual bamboo clumps,
- Baseline data on environmental conditions of the bamboo forest/ agroecosystem,
- Baseline data on socioeconomic status of the local community.
- Trends related to the bamboo resource and local community after several years of replication and analysis.

2.5
BAMBOO RESOURCE SURVEY INDICATORS TO BE USED IN CONDUCTING A BAMBOO RESOURCE SURVEY,

2.5.1
SOCIAL INDICATORS.
RECORD SCORE ON SURVEY FORM - SOCIAL 2.6.1. PAGE 64. TO TRACK CHANGES OVER TIME

Indicator	Rating	Score
SOCIAL		
Settlement Pattern	Frequent migration	1
	Seasonal/temporary migration	2
	Permanent settlement	3
Food, nutrition and sanitation	Severe shortage of food	1
	Insufficient/permanent	2
	Sufficient and balanced diet, good condition of shelter	3
Structure/condition	Temporary/poor condition	1
	Semi-permanent	2
	Permanent	3
Peace and order	Unsafe	1
	Somewhat safe	2
	Safe, peaceful and orderly	3
Access to support services (credit, extension service, inputs)	Few or no support services	1
	Less than adequate support services	2
	Adequate support services, self-help	3
People's participation in natural resource management	No participation	1
	Little participation, active but few participants	2
	Active participation	3
Local rules and regulations on the use of natural resources	Rules or regulations inadequate	1
	Adequate rules and regulations, no implementation or enforcement	2
	Good implementation and enforcement	3
Participation by government offices in extension work and active co-management	No participation	1
	Little participation, active but few participants	2
	Active participation	3
Integration of appropriate cultural and traditional practices into natural resource mgmt	No integration	1
	Adequate integration	2
	Highly integrated	3

Source of Information - Means of Collection & Verification
SOCIAL - records/reports on landlessness from public welfare department, local government - permanent migration, seasonal migration and relocation policy - records/statistics on health and well-being (e.g. health, food shortage, condition of shelter and other social services. - key informant interviews - field observations - statistics/spot maps/social maps from local government/NGO's - field observation - records/reports on criminal events - key informant interviews - field observation - surveys/records/reports on yield and production by agricultural extension officers - list of support groups working in the community from local government - key informant interviews - field observation - research/evaluation reports from community development offices, NGO's - review of rules/regulations - evaluation reports from NGO's - key informant interviews - historical/existing information on the rules and regulations being imple mented in the community over natural resources management - key information interviews - field observation - research - key informant interviews - field observation

2.5.1
SOCIAL INDICATORS. TO BE USED IN CONDUCTING A BAMBOO RESOURCE SURVEY, RECORD SCORES ON SURVEY FORM-ECONOMIC ON PAGE 65, SECTION 2.6.2 TO TRACK CHANGES OVER TIME

Indicator	Rating	Score
SOCIAL		
Community takes long-term perspective of livelihoods and environment	Short-term decision making dominates Some long-term vision Long term vision and action/spatial plan	1 2 3
Community aware of its rights and the legal obligations of government and other stakeholders to provide protection	Lack of awareness of rights and responsibilities Some awareness Highly aware and active in ensuring rights	1 2 3
Access to government funds and services for CBNRM and livelihood support.	No access, few funds and services Some access, some funds and services Clear access and adequate funds and services	1 2 3
Local stakeholders committed to genuine partnerships (with open and shared principles of collaboration, high levels of trust).	Low participation, no collaborative mechanisms available Some participation and collaboration Adaptive collaborative management occurs	1 2 3
Community and local groups have capacity to recruit, train, support and motivate community volunteers for CBNRM and Livelihoods development, and work together to do so.	No to low genuine volunteerism Volunteerism exists, but seldom for CBNRM and livelihoods Active volunteer base for CBNRM and livelihoods	1 2 3
Participatory monitoring & evaluation systems to assess resilience and progress in CBNRM and livelihoods.	No monitoring Monitoring, but community participation low, not involved in initial planning Consistent monitoring, outcome mapping	1 2 3

Source of Information - Means of Collection & Verification
SOCIAL - research - key informant interviews - field observation - pre/post tests - government loan records - cooperative records - bank records - attendance sheets - interviews - attendance sheets - reports - data sheets - before and after photos

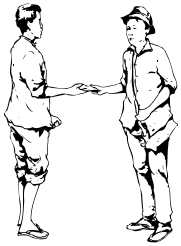
2.5.2
ECONOMIC INDICATORS

Indicator	Rating	Score
ECONOMIC		
Level of local economic activity and employment (including among vulnerable groups);	Low – much unemployment Medium – some unemployment, few local businesses High – numerous small businesses and cooperatives	1 2 3
Stability in economic activity and employment levels.	Constantly changing profession or resource base Adequate Highly stable professions – resource base	1 2 3
Distribution of wealth and livelihood assets in community	Concentrated wealth with many poor Some rich and poor families, large middle class Equitable	1 2 3
Livelihood diversification (household and community level), including on-farm (fish farm and dry-land farm) and off-farm activities in rural areas.	Uniform Medium Highly diverse	1 2 3
People engaged in unsafe livelihood activities (e.g. mining, illegal logging) or hazard-vulnerable activities (e.g. rain-fed agriculture in drought-prone locations).	Many hazardous and risk professions Few participants, but highly risk professions Non-hazardous, low-risk professions	1 2 3
Small enterprises have business protection and continuity/recovery plans.	Vulnerable Adequate Resilient	1 2 3
Local trade and transport links with markets for products.	Low local trade, few transport links Adequate Thriving local trade, adequate transport to outside markets	1 2 3

2.5.2
ECONOMIC INDICATORS

Source of Information - Means of Collection & Verification
ECONOMIC economic surveys business plans cooperative records government trade records
resource surveys household livelihood strategy surveys
wealth ranking
surveys analysis of cooperative/business structures
surveys
updated commodity chain
gender analysis legal study

2.5.2
ECONOMIC INDICATORS



Indicator	Rating	Score
ECONOMIC		
Mechanisms for women to inherit property, ponds, housing.	No mechanisms, vulnerable women Adequate Clear mechanisms in placed and practiced	1 2 3
Household and community asset bases (income, savings, convertible property) sufficiently large and diverse to support crisis coping strategies.	Vulnerable Adequate Resilient	1 2 3
Costs and risks of disasters shared through collective ownership of group/community assets.	No risk sharing, individualistic Risk sharing through family and non-formal structures Formal structures for risk sharing	1 2 3
Existence of community/group savings and credit schemes, and/or access to micro-finance services.	Non-existent Non-formal structures Formal structures	1 2 3

Source of Information - Means of Collection & Verification
ECONOMIC - surveys - resilience assessment - resilience assessment - bank statements - cooperative book-keeping records

2.5.3
ECOLOGICAL INDICATORS TO BE USED IN CONDUCTING A BAMBOO RESOURCE SURVEY
RECORD SCORES ON SURVEY FORM-ECOLOGICAL, PAGE 66. SECTION 2.6.3 IN ORDER TO TRACK CHANGES OVER TIME

2.5.3.1
LANDSCAPE LEVEL INDICATORS

Indicator	Rating	Score
SOIL		
Soil loss	Serious erosion (gullying)	1
	Moderate erosion (rill, sheet erosion)	2
	Less erosion	3
Soil Productivity	Low productivity	1
	Somewhat reduced average production	2
	High productivity	3
Problem Soils	High occurrence	1
	Medium	2
	Rare	3
WATER		
Streams	Overflow after rainfall	1
	Dry in dry season	2
	Consistent flow year round	3
Occurrence of flood, drought	Often	1
	Moderate	2
	Rare	3
General Drainage	Poor, much standing water after rain event	1
	Average	2
	Good drainage	3
FOREST		
Percentage & status of conservation areas	Poor condition (encroachment, conversion)	1
	Average condition (infrequent encroachment & conversion)	2
	Intact forest	3
Tree/plant species in natural forest areas	Few species	1
	Average number of species (trees for commercial purposes)	2
	Diverse species, multi-level canopy	3
Non-timber forest products	None	1
	Few	2
	Diverse	3
Wildlife	Few species (degraded habitat, hunting)	1
	Average species (hunting)	2
	Diverse species (good reproduction, abundant habitats, no destructive hunting)	3

Source of Information - Means of Collection & Verification
SOIL - sediment in streams - top soil thinning - database/information from records/reports of concerned agencies (forest and agriculture department) - field observation/ visual inspection - loss of vegetation / bare earth - records/reports on annual yield and production of some selected crops from agricultural extension offices. - records/reports on the area and effects of problem soils
WATER - records/reports on stream flow from irrigation stations - records.reports from the irrigation department, community development, etc. and key information interviews. - records, reports from the irrigation department, community development, etc. and key information interviews -visual inspection
FOREST - statistics/records/reports of local forestry office and conservation NGOs on forestry - field observations - statistics/forest inventory reports - local NGO interviews with foresters and villagers - field observation - records/reports, research papers from local universities, research institutions, NGO's - interviews with villagers - market survey -visual inspection

2.5.3.2
ENVIRONMENTAL MANAGEMENT

Indicator	Rating	Score
ENVIRONMENTAL MANAGEMENT Community understanding of characteristics and functioning of local natural environment and ecosystems (e.g. agroecosystems, forests) and human interventions that affect them (e.g. large-scale monocultures, conversion of forests, erosive farming practices).	Vulnerable Some awareness Aware	1 2 3
Adoption of sustainable environmental management practices (ecologically friendly agriculture, maintenance of shelter belts, natural forests, etc)	Low amount of eco-friendly practices Medium High amount of eco-friendly practices	1 2 3
Understanding of relevant biodiversity and preservation of biodiversity	No intentional biodiversity protection Some intentional biodiversity protection Biodiversity surveyed, monitored and protected	1 2 3
Use of indigenous knowledge and appropriate technologies relevant to environmental management.	Eroding traditions Strong tradition – little incorporation/ credibility Incorporation of traditional practices into modern management of resources	1 2 3
Access to community-managed common property resources that can support coping and livelihood strategies in normal times and during crises.	Low access Some access by some members Full access of most/all members	1 2 3
Local (community) management plans feed into local government development and land use planning	No local plans Local plans but no coordination Local plans feeding into gov't planning	1 2 3

Source of Information - Means of Collection & Verification
ENVIRONMENTAL MANAGEMENT Pre-post data from awareness campaign survey Resilience assessment
Resilience assessment
Participatory biodiversity survey
Survey Resilience assessment
Community maps
MOU's between community and government Government management plans, land use plans

2.5.3.3
AGROECOSYSTEM LEVEL INDICATORS

Indicator	Rating	Score
Agroecosystem		
Water sources for agriculture	Mainly rainfall Mainly rain and some irrigation Well developed irrigation, large dam, central or communal wells, catchment basins	1 2 3
Weed and pest controls	With chemicals Biological/mechanized Ecological, alternative pest management	1 2 3
Animals/livestock	Raised separately Some are separated, others are integrated Integrated on farm	1 2 3
Cropping system	Mono-cropping, market-oriented More species but repeatedly cultivated Crop-rotations and diversified cropping	1 2 3
Labour and capital	Outside the community Family, within and outside the community Family, hired labour within the community	1 2 3
Source of capital for farming	External sources Family, co-op Credit institutions/coop, own enterprise, family	1 2 3
Harvesting methods	Destructive, causing erosion, with burning Tolerable erosion, little burning Conservation, no burning of farm residues	1 2 3

Source of Information - Means of Collection & Verification
Agroecosystem - records/statistics/information on agriculture from agricultural extension offices, NGO's research institutions, development agencies, etc. - key informant interviews - field observations

2.5.3.4
BAMBOO CLUMP LEVEL INDICATORS

Indicator	Rating	Score
Canopy - Upper Culm		
Leaf robustness	Sparse/ without leaves	1
	Average	2
	Full and robust leaves	3
Leaf tips	Many burnt, yellow or dry leaf tips	1
	Some burnt, yellow or dry leaf tips	2
	3) Mostly green leaf tips	3
Witches broom (mistletoe-like parasite)	Abundant witches broom on many culms	1
	One to two witches broom	2
	No presence of witches broom	3
Grey micro-tendril fungus	Abundant grey micro-tendril fungus at top of bamboo culm/leaves	1
	Some grey micro-tendril fungus	2
	No presence of grey micro-tendril fungus	3
Mid Culm		
Permanently crossed bamboo culms	Abundant crossed and twisted bamboos	1
	Some crossed and twisted bamboos	2
	No crossed bamboos	3
Bent, collapsed and broken culms	Abundant bent, collapsed and broken culms	1
	Some bent, collapsed and broken culms	2
	No bent, collapsed and broken culms	3

Source of Information - Means of Collection & Verification
Canopy - Upper Culm - Qualitative - visual estimation - Quantitative - cutting of one culm - counting leaves - multiplying by total culms; grid held to sky to estimate percent leaf coverage; convex mirror - Qualitative - visual inspection - Qualitative - visual inspection - See section 4.1.1 for illustration of Witches Broom - Qualitative - visual inspection - See section 4.6.8.1 for more information on fungus
- Qualitative - visual inspection - See section 4.1.1 for information on crossed bamboo - Qualitative - visual inspection - See section 4.1.1

2.5.3.4
BAMBOO CLUMP LEVEL INDICATORS

Indicator	Rating	Score
Lower Culm		
Small lateral branching near base (indicates stress)	Abundant lateral branching at base Infrequent lateral branching No lateral branching	1 2 3
Fungus (black rot, brown rot, soft rot, etc)	Abundant fungus on in-tact culms, stumps and/or aerial roots Some fungus on culms/stumps/aerial roots No incidence of fungal rot	1 2 3
Crowding	Many culms touching one another, culms twisted seeking space and light Few culms touching or twisted Appropriate spacing	1 2 3
Formosan termites and powder post beetles	Severe infestation Presence of termites/powder post beetle but tolerable No presence of termites/powder post beetle	1 2 3
Lichen (white circular discoloration or other)	Abundant lichen on culms Some lichen on culms but tolerable, not economically significant No lichen	1 2 3
Harvest damage	Many stumps hacked with machete, sawed mid-culm, cut too close to ground (at ground level or underground) Some stumps hacked with machete, sawed mid-culm, cut too close to ground (at ground level or underground) All stumps with clean cuts just above first or second internode.	1 2 3
Over-harvest	Most culms cut, young and old, clear-cutting Large sections of clump clear cut, uneven distribution of culms in terms of space and age Most 3-4 year old bamboos harvested, all 1-2 year old bamboos left in place, even distribution of culms within clump.	1 2 3

Source of Information - Means of Collection & Verification
Lower Culm - Qualitative - visual inspection - Qualitative - visual inspection, interview with farmers - Quantitative - positive identification of fungal species, check with local University or Agriculture Extension Department for assistance - Qualitative - visual inspection - See section 4.1.2 on Appropriate spacing - Qualitative - visual inspection, interview with farmers - See section 4.6.8.2 for more information insect pests - Qualitative - visual inspection - See section 4.6.8.1 for more information on lichens - Qualitative - visual inspection - See section 4.5 for more information on appropriate harvest - Qualitative - visual estimation - See section 4.5 for more information on appropriate harvest

2.5.3.4
BAMBOO CLUMP LEVEL INDICATORS

Indicator	Rating	Score
Ground Level		
Soil humidity	Dry and cracked, waterlogged	1
	No cracking or standing water but dry at depth	2
	Well drained, always moist at 15cm depth	3
Exposed Root and Rhizome Network	Exposed roots and rhizomes due to erosion	1
	No exposed root and rhizome network	2
	Exposed root and rhizome, due to swelling and growth	3
Fungus	Abundant fungus including mushrooms on ground or culm base	1
	Some fungus including mushrooms on ground or culm base	2
	No incidence of fungus or mushrooms at ground level	3
Distance of root hairs (light colored, fine, running close to surface of ground) from clump center	Root hairs present only 1-5 meters from clump center	1
	Root hairs present at least 5-10 meters from clump center	2
	Root hairs extending beyond the furthest overhanging culm	3
Number of healthy, robust rhizome buds on bases of mother culms	0-3 healthy rhizome buds per mother culm	1
	4-7 healthy rhizome buds per mother culm	2
	8-12 healthy rhizome buds per mother culm	3
Condition of Understory	Full with weeds and other competing plants	1
	Tolerable amount of weeds and other plants	2
	No weeds, and only recognizable companion plants (e.g. gingers, legumes, watermelon etc)	3
Leaf Litter Thickness	No leaf litter on ground, burnt leaves only or > 30cm leaf litter in and around bamboo clump	1
	1-9 cm leaf litter or 20-30 cm of leaf litter in and around bamboo clump	2
	10-20 cm leaf litter in and around bamboo clump.	3

Source of Information - Means of Collection & Verification
Ground Level - Qualitative - estimation, interview with farmers - Quantitative - use of a soil moisture meter, also use dip wells to estimate the ground water level
- Qualitative - visual inspection, interview with farmers - Quantitative - Erosion measurements to determine if erosion is significant factor
- Qualitative - visual inspection, interview with farmers - Quantitative - positive identification of fungal species, check with local University or Agriculture Extension Department for assistance
- Qualitative - visual inspection - Quantitative - biomass studies on root ball, involves digging up, drying and weighing all roots.
- Qualitative - visual inspection - See section 3.3.4 for more information on apical buds
- Qualitative - visual inspection, interview with farmers - See section 3.2 for more information on companion plants
- Qualitative - estimation - Quantitative - direct measurement, leaf litter biomass study - See section 3.4 for more information on leaf litter and mulch

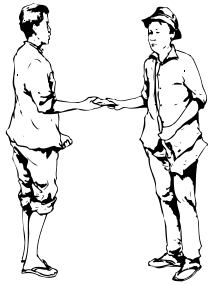
2.6
SURVEY FORMS

2.6.1
SURVEY FORM SOCIAL

SOCIAL - Indicators	Year				
Settlement Pattern					
Food, nutrition & sanitation					
Structure/condition					
Peace and order					
Exposure to toxic chemicals and pollutants					
Access to support services					
People's participation in NRM					
Government participation in co-management					
Integration traditional practices into NRM					
Long-term perspective					
Awareness of rights and legal obligations of stakeholders					
Access to gov't funds for CBNRM and livelihoods					
Stakeholder partnership					
Volunteerism					
Monitoring & Evaluation					

2.6.2
SURVEY FORM ECONOMIC

ECONOMIC - Indicators	Year				
Economic activity & employment					
Economic stability					
Distribution of wealth					
Livelihood diversification					
Unsafe livelihood activities					
Protection for small enterprise					
Local trade and transport linked to markets					
Mechanisms for women to inherit property, land use					
Household asset bases convertible					
Costs and risks of disasters shared through collective ownership					
Community/group savings, credit schemes, micro-finance services					



2.6.3
SURVEY FORM ECOLOGICAL

FOREST - Indicators		Year				
Soil	Soil loss					
	Soil Productivity					
	Problem Soils					
Water	Streams					
	Occurrence of flood, drought					
	Drainage					
Forest	Percentage and status of conservation areas					
	Tree/plant species					
	Non-timber forest products					
	Wildlife					
Environmental Management	Understanding of environment					
	Sustainable environmental practices					
	Conservation of biodiversity					
	Preservation of indigenous knowledge					
	Access to natural resources					
	Integration, local/ gov't mgmt plans					
Agroecosystem	Water sources for agriculture					
	Weed and pest controls					
	Livestock					
	Cropping system					
	Labour and capital					
	Source of capital for farming					
	Harvesting methods					

2.6.3
SURVEY FORM ECOLOGICAL

BAMBOO Indicators		Year				
Canopy / Upper Culm	Leaf robustness					
	Leaf tips					
	Witches broom (mistle-toe like parasite)					
	Grey micro-tendril fungus					
Mid Culm	Permanently crossed bamboo culms					
	Bent, collapsed & broken bamboo					
Lower Culm	Small lateral branching near base					
	Fungus					
	Crowding of Culms					
	Termites & Beetles					
	Lichen					
	Harvest damage					
	Over harvest					
Ground Level	Soil humidity					
	Exposed Root and Rhizome Network					
	Fungus					
	Distance of root hairs from clump center					
	Number of healthy apical buds					
	Condition of Understory					
	Leaf Litter Thickness					

2.7
BAMBOO RESOURCE MAPPING

Resource mapping allows information, which has been generated and collated from the bamboo resource survey, to be presented in a visual way that less literate people find much easier to understand and add to. Information includes occurrence, distribution, access and use of bamboo resources within the economic and cultural domain of a specific community. Variations are introduced in selecting particular participant groups (e.g. gender-based) or in adding a further stage to generate a topographic map or a community based GIS map including layers of information. Resource mapping has the following purposes:

- To allow bamboo growers to identify, locate and classify past and present bamboo resources, distribution, use, and perceived value.
- To uncover land tenure and tenure issues, access and land uses.
- To allow the establishment of relations between information sets (generated in the bamboo resource survey) and their spatial location. This includes establishing visual relationships between resources and issues.

Resource mapping may be run as a one-off activity, in which a simple sketch map is created. Resource mapping, however, is ideally preceded by a bamboo resource survey (section 3.4-3.5), in order to provide more detailed information for the map.

2.7.1
RESOURCE MAPS

- May be used by the community itself (with or without facilitator) for internal discussions or to relate bamboo resource conditions to outsiders.
- Depict essential information for both insiders and outsiders for planning, management, and monitoring purposes.
- Help bamboo growers predict bamboo stocks for both current and future sale

IMPORTANT

Resource mapping is best associated with other information gathering tools, such as a bamboo resource survey or a forest transect walk, which can contribute to a more critical analysis of the bamboo resource.

Resource mapping should be conducted at the onset of a sustainable bamboo management program (or a Bamboo Field School) but only after rapport has been established with the local community.

Knowledge of the social structure of the bamboo growing community is a prerequisite for an outside facilitator. This is because resource distribution, use and access may be considered as sensitive issues by the community. At given intervals, similar exercises can be repeated for monitoring and evaluation purposes.

Bamboo resource mapping can apply to all scales of bamboo forestry, from a home garden, bamboo stand, community bamboo forest to a large-scale plantation.

REQUIREMENTS:

HUMAN RESOURCES

- facilitator (preferably with community forestry and participatory mapping skills and experience)
- co-facilitator
- documenter – someone documenting

MATERIALS

- mural paper
- markers, crayolas (assorted colors)
- masking tape
- compass
- 100m tape
- stakes
- ruler

OPTIONAL MATERIALS

- base maps of area
  - topographic map
  - satellite images
- camera
- Global Positioning Unit (GPS)

2.7.1.1
APPROACH A:

1. Identify the participant group. Describe the purpose and scope of the mapping exercise. Invite the group to select key informants who are knowledgeable about the bamboo resource (elders, bamboo growers, local forestry officials, etc.) If resource access and use is affected by cultural and social variables, and these variables play a key role in determining future bamboo management, then participants may be grouped further according to these variables eg. By ethnicity, gender or age and followed by a stratified mapping procedure.
2. Collate checklist of resources or features to be mapped (choose from Bamboo Resource Survey Indicators, section 3.5) Consider that only a limited number of features can be mapped.
3. Position the paper in a place which has a good view of the area to be mapped.
4. Facilitate the preparation of a base map on craft paper. A base map may be prepared by the group before-hand, with use of a GPS or compass if the facilitator or group members have basic mapping skills. (Note: many NGO's have members who can assist with boundary mapping). Make sure that participants have a common understanding of the orientation. The size of the map (1m x 2m) should allow several people to contribute at the same time. Ask the participants to draw landmarks, reference points or reference lines.

Sequencing is important. Start with a hill or river, follow with foot paths, human settlements, roads, etc. Agree on the local name for each feature.

> Make sure that the process is properly recorded by the documenter and that issues debated among participants are noted down.

> Any surface can be used for the initial map. It can be drawn with chalk on a concrete floor, or on the ground with a stick. Resources and features may be pictured by the use of local materials like stones, leaves, sticks, etc. But these kind of maps need to be transferred to a more durable and mobile base (paper) to preserve the generated information over time.

5. Ask participants to locate on the map, the listed resources and features. Allow for additions the participants think are important in relation to the resource's occurrence, distribution, use or access. Use symbols and colors to represent various sets of information and generate a corresponding legend.
6. Allow for validation of the information by a wider forum.
7. Draw copies of the maps. Leave the original with the community and, if necessary, copies with other concerned parties.

OUTPUTS

- A map and a written report of the process.
- The composition of the map reflects the perception and vision of the participants about the various resources and features they have been portraying and provides an insight into the intimate relation between the participating group and the resource.

For example, things that have been mapped that are important to the participants might appear exaggerated in size or color, versus things less important will be drawn in a much smaller scale.

The most important resources or features will appear first on the map. Documenting this process is an essential part of the output.

STRENGTHS

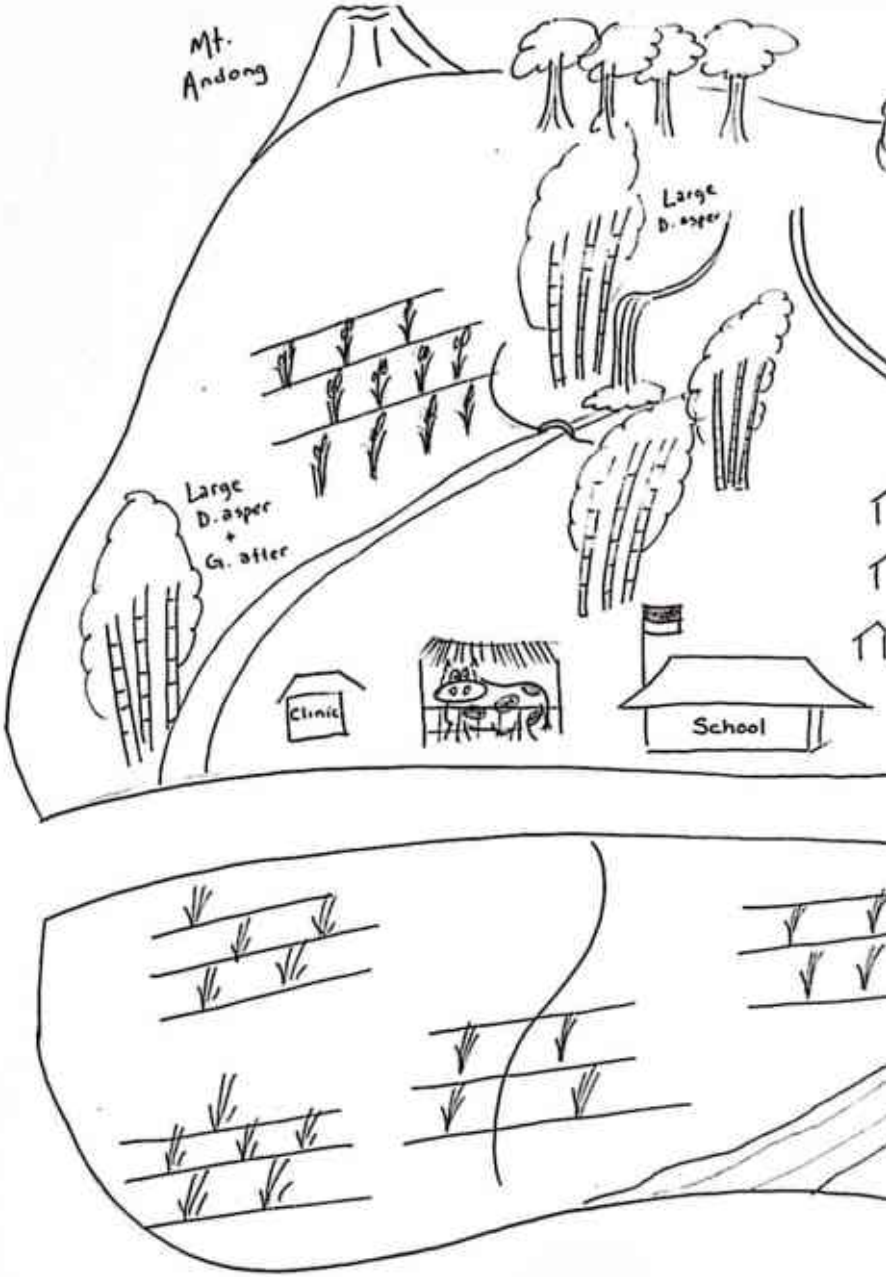
+ Provides visual representation of resources and their uses
+ Represents a good starting point for participatory problem analysis and planning.
+ It is easily understood and implemented

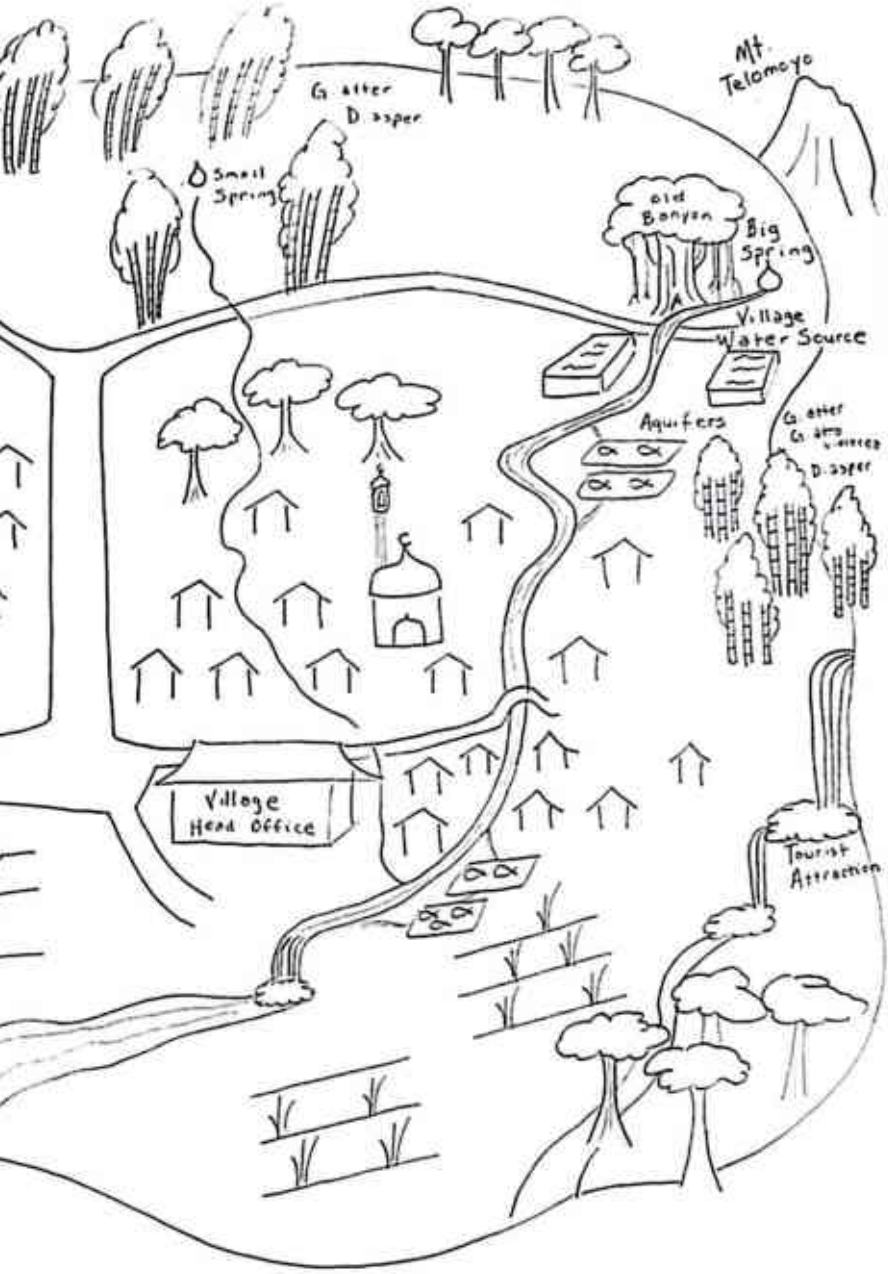
LIMITATIONS

- Difficult to use as supporting documentation in formal or legal contexts, which require professional mapping.
- May contain a limited number of indicators (less than 10 usually)

This manual also explores the use of bamboo for agroforestry. This manual also covers several other topics such as; the socio-economics of bamboo forestry; how to enhance ecological services provided by bamboo and some activities for engaging rural communities in bamboo forestry.

2.7.1.2
EXAMPLE OF BAMBOO RESOURCE SKETCH MAP
SELOPROJO VILLAGE, CENTRAL JAVA, INDONESIA




Mt. Telomoyo
Small Spring
Big Spring
Village Water Source
Aquifers
Village Head Office
Tourist Attraction

2.7.1.3
APPROACH B: STRATIFIED RESOURCE MAPPING (RESOURCE MAPPING AS PERCEIVED BY DIFFERENT SOCIAL GROUPS)

Stratified resource mapping involves dividing participants into groups according to gender, age, ethnic origin or other categories. This is extremely useful in identifying relationships between social groups and resources. This knowledge is essential for planning purposes, especially when selected strata of the community have exclusive or limited access to forest resources.

This approach generates stratified information of valuable use in identifying customary rights in resource use, access and tenure and in the allocation of resource management responsibilities.

The steps in conducting stratified resource mapping are similar to the steps described before. But the facilitator needs to conduct a preliminary assessment of the community to get a deeper insight into its social structure, to identify appropriate venue and timing for gathering the selected group of participants.

OUTPUT
Stratified resource maps based on gender, ethnicity or age-related resource maps. The outline of the resources strongly reflects the domains of interest of the participating groups.

2.7.1.4
APPROACH C: GENDERED MAPPING

This is the variation that highlights men's and women's access to, control over, and perceptions regarding the importance of bamboo and other forest resources. There are women's and men's spaces in the forest/agroecosystem, as well as resources and practices that are associated with men or women.

For example, the harvest of bamboo culms for timber is usually associated with men, while women more commonly harvest bamboo shoots. Effective harvest of a bamboo clump or entire forest, would therefore require input from both men and women.

Gendered mapping is usually conducted among separate groups of men and women.

The following are additional steps to be considered by the facilitator:

1. Ask the participants to identify symbols to represent men and women. For example, "x" for men, and "o" for women.
2. For each of the resources or features in the sketch map, ask the group to determine whether it is predominantly associated with men, women, or both, and apply symbols accordingly. If time permits, further clarify who has access and who has control over the resources.

Gendered maps may be used for:

- Raising and discussing issues and concerns;
- Identifying existing and potential resource use conflicts so appropriate action can be determined; and
- Identifying bamboo related livelihood opportunities for men and women.

2.7.1.5
APPROACH D: TWO-STAGE RESOURCE MAPPING

This variation involves transposing the information from the sketch map to a conventional topographic map. Two-stage resource mapping may be used by the community in dealing with formal institutions on particular issues related to tenure, usage rights, harvest regulations, etc.

The outputs obtained from this variation can be transferred with minimal distortion to more sophisticated information storage systems (i.e. Geographical

Information System or GIS) and be used for planning and monitoring purposes on broader geographical areas. To maintain momentum among participants, the process of data transfer occurs before the completion of the sketch map.

The following are some additional steps to be considered by the facilitator:

1. Expose the topographic map (in a suitable scale) close to the developing sketch map, aligning the two maps according to the compass points. Allow time for the participants to familiarize themselves with the topographical map, eventually assist them in interpreting contour lines and other features, on the map.
2. Ask some participants to start transposing the information spotted on the sketch map onto the topographical map. Use symbols and colors uniformly in representing individual sets of information. Should one topographic map become crowded, a second one can be used. Name landmarks, rivers, hills, mountains, settlements, forest areas, agriculture areas, etc.
3. Make sure that a legend appears on each map. Make sure that both maps are being completed, then ask participants to list their names at the bottom of the maps.
4. Allow for validation of the generated information sets/indicators by a wider forum.
5. Draw copies of the maps. Leave originals with the community.

OUTPUTS

Two-stage resource mapping generates two outputs: the resource sketch map (stage 1) and the elaborated topographic map (stage 2).

The first is richer in people's perceptions. The second adds precision in the location of the information, allowing for a larger number of information sets to be mapped more precisely.

Facilitates the communication between insiders and outsiders, because the media is understood and valued by both sides.

STRENGTHS

Translating information from resource sketch map onto a topo-map allows:

+ Information to be defined in terms of occurrence and most significant in terms of extent;
+ Generates easily verifiable information on the locations of the resource, and more importantly - it quantifies how much resource exists in each location
+ The generation of an output readily linkable to secondary information;
+ The use of the map within an evaluation process, because the topographic

base map remains the same over time;

+ The transfer of mapped information into a computerized format, providing a valuable contribution to both scientific research and comprehensive bamboo resource management planning.

LIMITATIONS

- Limitations apply to the second stage of the process in cases where topographical maps are not available or inaccurate.

General Considerations and Recommendations When Mapping

The conduct of mapping may take one day. An additional half day may be necessary to produce copies of the outputs and to consolidate the notes taken by the person documenting. The validation may occur on the same day, and generally takes about one hour.

Take every opportunity to add or crosscheck data with same party or a third party to clarify the maps. It is also useful to compare community generated maps with government maps of the same area if available, to find overlap and generate very specific new angles of questioning for next meeting.

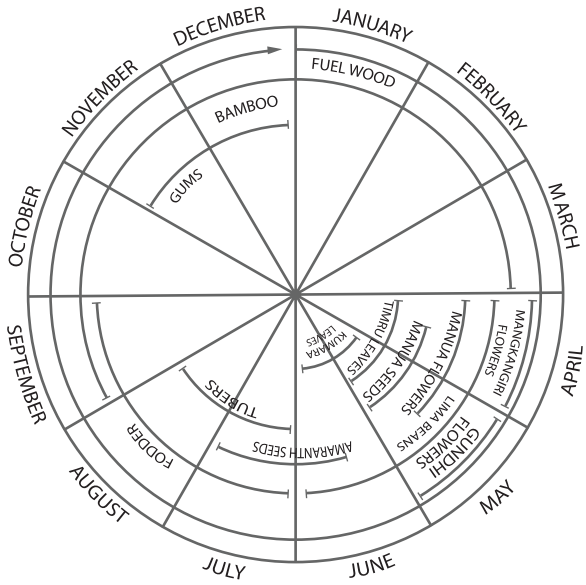
2.8
SEASONAL CALENDAR

Definition:
A seasonal calendar is a tool for documenting the significant events and management needs that occur over a single year in the bamboo growth and harvest cycle.

The seasonal calendar provides a general picture of important environmental, cultural and socio-economic periods throughout the year. They are a commonly overlooked source of traditional knowledge.

It is a good idea to document the community's seasonal calendar activity at the early stages of a Resilient Bamboo Forestry program. It should take place after the preparation of a bamboo resource assessment, as the features on the map may serve as a guide for the calender.

The calendar emphasizes qualitative Information. It focuses more on periods (usually lasting a few days to a month) than events (that usually last a day or less) and these periods are based on experiences from previous years. How does this calendar cooperate with other agricultural/forestry species?



Traditional Javanese Calender

Purpose:

- To allow bamboo growers to distinguish important periods during the course of a year that influence their activities and socio-economic condition.

- To identify appropriate periods for conducting various bamboo management activities (eg. culling of reject culms, understory management, soil treatment, harvest).

- To generate information that highlights potential biases in information collected only during certain periods of the year.

Seasonal calendars can also be generated by gender to establish exactly who will be busy – doing what – when (which can be very useful for resource management and maintenance planning).

Requirements:

Human Resources

- facilitator (preferably experienced in agriculture extension and with knowledge of bamboo)
- co-facilitator (if the group is large)
- participants

> Participants involved in preparing the seasonal calendar must come from the local community of that area. Working only with a farmer group may not provide the widest range of information. Encourage other sectors of villagers to participate as these are often overlooked sources of traditional knowledge.

Materials:

- large sheets of paper
- tape or push pins
- large markers
- oil pastels
- notebook

Possible *Approach:*

1. Prepare for the activity by having participants draw an outline of the local annual calendar on large mural paper.

SEASONAL CALENDAR

Activity	MONTHS											
	J	F	M	S	M	J	J	S	S	O	N	D

2. Ask the participants to identify important environmental, cultural or socio-economic periods in a year that are related to bamboo. Give examples such as rainy season, a cultural festival requiring bamboo, periods of higher need of money, etc. (Refer to following list for other suggestions)

   Activities/events which could be used are:
   - Environmental conditions (temperature, wind, rains)
   - Farming (other major cropping seasons which compete for time of farmers)
   - Economic aspects (household expenditure, market values)
   - Social aspects (health, education)
   - Other livelihood activities (tourism, handicrafts etc)
   - Socio-cultural activities (religious events, holidays)

3. Use symbols or drawings to add interest to the activity. Let the group decide what symbols they want to use. For example: XXX can be used as a symbol for the rainy season. It should be placed in the matrix at the appropriate periods (e.g. months) in which rains occur.

4. Repeat the process for other periods.

5. After the activity, transfer the output from the large mural paper to smaller handouts that can be kept by each individual.

Tip: If there are data gaps, then a strategy to fill these should be put in place. A great way of doing this, is to keep a log-book to record significant events throughout the year as they take place. Some activities/ events may need further discussion, this is best facilitated by inviting key community members to participate in a focus group discussion (for example: who / where and when is harvesting edible shoots).

ANALYSIS:
When analyzing the calendar, make links within the calendar and with the overall problems and issues of the community.

For example; is expenditure high at the same time as the growth/resting period for bamboo? When is expenditure high and why? Are school fees due? When are the busiest seasons for buying bamboo? For instance, bamboo sales are highest in the dry season when most construction takes place and the need for scaffolding is high?

Encourage the participants to probe into issues and make the links. Note down what trends need more study and data gathering.

OUTPUTS:
- Seasonal Calendar for Bamboo
- Analysis of Trends

2.8.1
EXAMPLE 1 - CENTRAL JAVA HIGHLANDS, INDONESIA

This calender was written as part of the first Bamboo Field School - A Training of Trainers, for 28 bamboo growers from 7 villages in the Progo Watershed, Central Java. This calender was compiled at the onset of Bamboo Field School. Revised calenders were made by trainers and participants after 12 weeks of improved bamboo clump management following the steps in this manual. The revised calender serves to remind bamboo growers of important management actions.

Activity/Event	MONTH											
	J	F	M	A	M	J	J	A	S	O	N	D
Weather	☂	☂	☂	☂	☁	○	○	☁	☁	☂	☂	☂
Expenditure	L	L	M	M	H	M	M	L	L	M	H	H
Bamboo Crop Shoots/Poles	▲	▲	▲		II II	II II	II	II				
Pests	porcu-pines	porcu-pines	porcu-pines									
Current Mgmt	✂	✂	✂	✂	✂	✂	✂	✂	✂	✂	✂	✂
Future Manage-ment	chemi-cal fertil-izer around shoots	com-panion plant-ing		weed-ing	begin har-vest ✂ fertil-izer in stumps	best har-vest ✂ fertil-izer in stumps	best har-vest ✂ fertil-izer in stumps	har-vest ✂ fertil-izer in stumps	mulch heavy with bam-boo leaves and soil	weed-ing organic fertil-izer	mulch-ing & soil mound-ing	har-vest 1st shoots and eat
Income	L	L	H	L	L	M	M	L	L	H	M	L
Handicraft Making	L	L	L	L	L	L	L	L	L	L	L	L

Key

L - Low
M - Medium
H - High

▲ - shoots
II poles

- powder post beetles & termites
✂ - cut bamboo

2.8.2
EXAMPLE 2 - SOUTHERN CHINA

This seasonal calender was complied after an interview with Dr. Fu Maoyi, the principle scientist of the Research Institute for Subtropical Forestry of Chinese Academy of Forestry. This calender is based primarily on management of sub-tropical sympodial bamboos for shoot production, but applies also to culm production for timber. The 'Six Pillars of Managing Bamboo Clumps' covered in Chapter 3 of this manual are significantly influenced on the management steps within this calendar.

Activity/Event	MONTH											
	J	F	M	A	M	J	J	A	S	O	N	D
Weather Percipitation												
Soil Temperature	too cold poor for shooting					HOT			if this season is too dry leads to poor shooting in spring			
Shooting Season (*D. latiflorus*)												
Fertilization	Solid fer-mented manure	Fertilize ditches (below) with low amount of NPK before shooting		NPK 4:3:1 - shoots 4:3:1:0.5 - culms (+SiO_2)		Fresh Grass	NPK or Urea or Fermented green organic fertilizer					Solid fer-mented manure
Soil Preparation		Dig ditches to open up soil to sun for warming (3-5 days)		Mounding of soil shallow for culms deeper for shoots						Loosening of soil Lowering of soil level so clump doesn't grow too high		
Propagation	Sub-branch nursery propagation										Sub-branch nursery propagation	
Mulching											Adding mulch for monopodial shoots	
Watering		If 5-10 days of drought in a row										
Harvesting Culms (*B. textilis*)												
Aging New Culms											Marking year with paint, '08,'09...	
Second Shooting							If you don't cut shoots all the way down at the bottom, you can get a 2nd shooting.					
Topping of new culms (1.5m)*												
Pest Control (Preventative)			Understory clearing (turn to green manure before weeds go to seed)								Soil loosening Pruning/clearing of understory	
Pest Control (Curative)				Incidental use of sprayed pesticides, baited insect traps and hand removal during outbreaks.								

REFERENCES CHAPTER 2

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3

6 MEASURES OF MANAGING BAMBOO CLUMPS

1. Initial Adjustment of Clump Structure
2. Understory Plant Management
3. Soil Systems & Bamboo
4. Soil Nutrient Management
5. Sustainable Harvest
6. Ecological Pests & Disease Management

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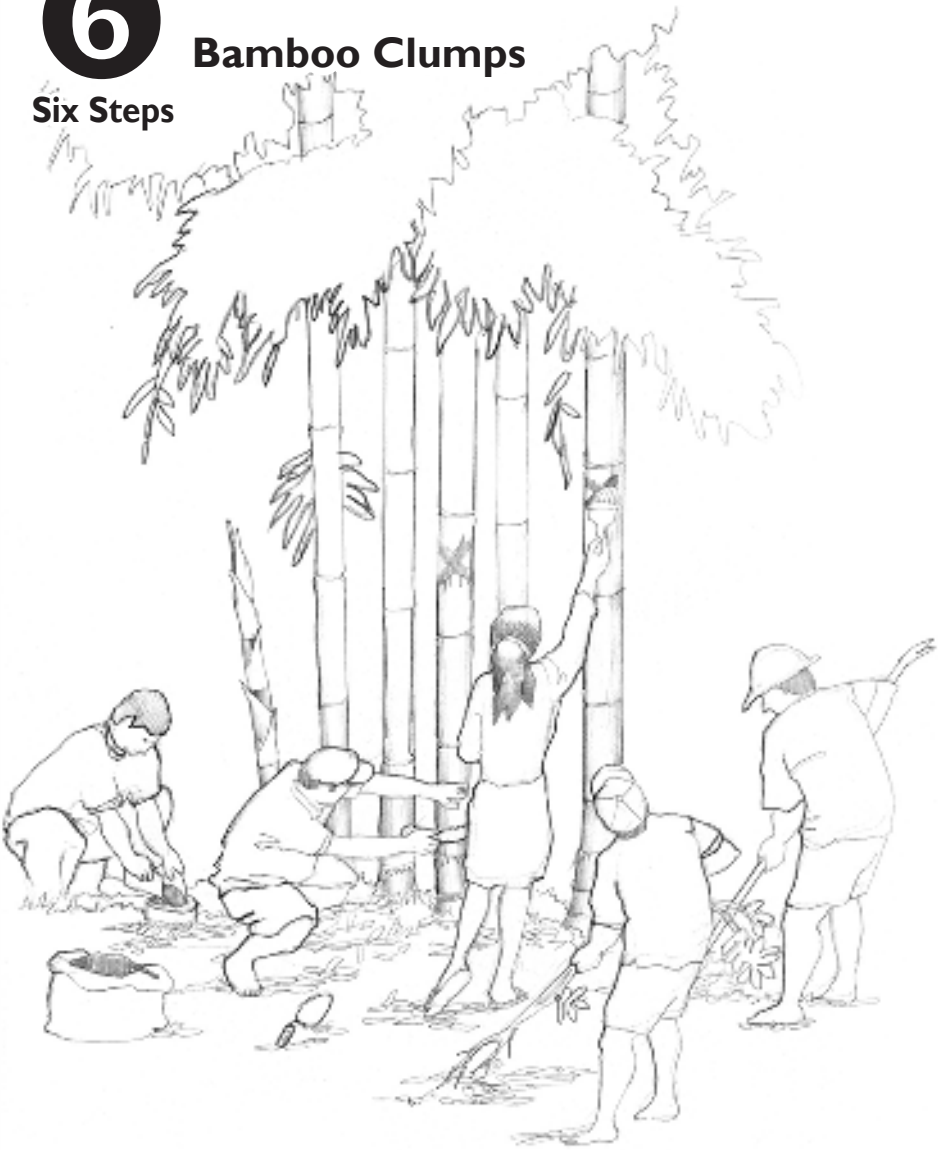
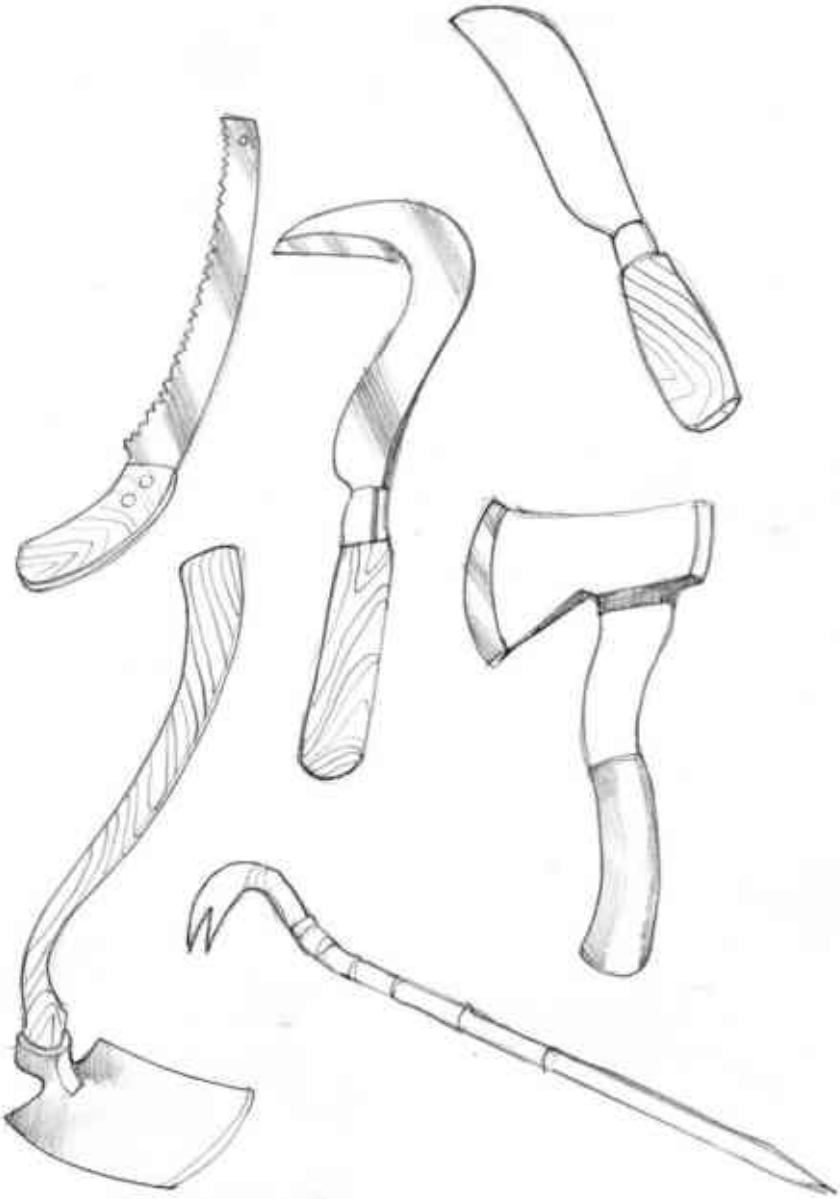
6 Six Measures of Managing Bamboo Clumps

Six Steps



Routine annual maintenance and management of community bamboo resources rewards the manager with a lucrative and consistent source of income. Bamboo management cooperatives have been formed in Bali and Java, as a testament to the axiom, many hands make light work.

Some tools you will need for bamboo clump management are:

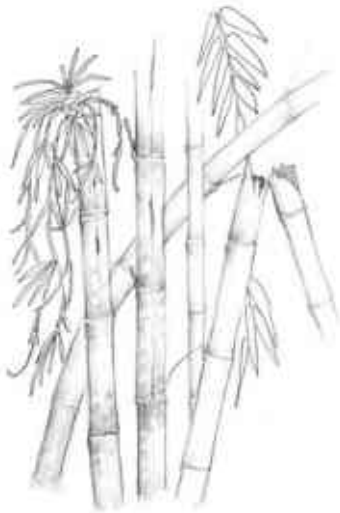


3.1
INITIAL ADJUSTMENT OF CLUMP STRUCTURE

Intent: To undertake preliminary management of a previously unmanaged bamboo clump by adjusting the structure and distribution of culms to increase the health of the plant and productivity.

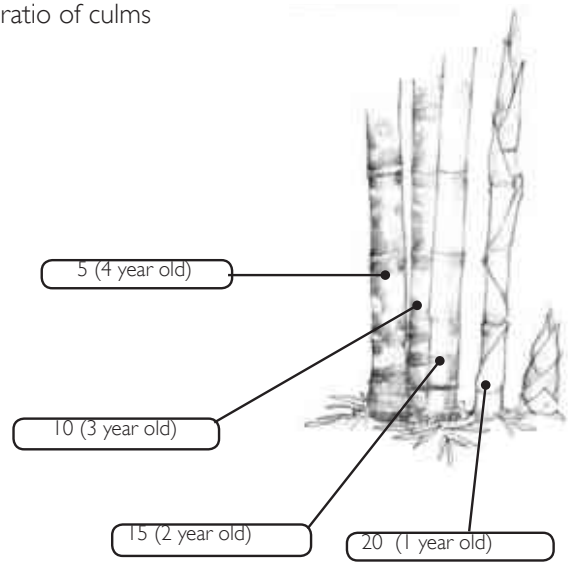
Approach: The following three steps should be followed in order to achieve appropriate clump structure;

1. Remove culms which interfere with clump health(diseased, too old, too bent, too small, broken)



2. Adjust culm spacing within the clump

3. Adjust age ratio of culms



Considerations:
A bamboo clump with appropriate structure has many benefits:

- Easy to access and manage
- Young culms are protected by older culms which provide structural support during times of wind and storm
- Mature culms are able to produce a maximum number of offspring

****
It is very important to restore nutrients to the soil. For all culms that are taken from a clump nutrients are lost. Restore nutrients to the clump by adding compost and mulch. Remember to compost the leaves and culms removed (see Chapter 3.3-3.4) during the clump adjustment to add back to the clump later !
****

Definitions

Structure will be used to describe the physical integrity of the bamboo clump. A clump with good structure has members (bamboo culms) which are able to support one another, appropriate space for the emergence of new shoots, and a rhizomic network able to effectively anchor the plant.

INITIAL ADJUSTMENT OF CLUMP STRUCTURE

Selection - Prioritise cleaning the base of the clump in order to clearly see the situation of not only the outer culms, but also the inner culms within the clump. The principle of no BSB should be put in to practice when selecting which culms can be appropriately removed from the clump. Appropriate spacing and adjustment of age ratio must not be forgotten.

Cleaning - Start with establishment of a key hole then focus on easily removed small, broken old and diseased bamboo. With more space, working on bent bamboo which are usually pinched (between two other culms) is much easier.

All small branches growing from the base of the bamboo should be removed. Keep the workers spread out so as to avoid unecessary danger.

Final - Once all BSB Od's have been removed the need for appropriate spacing is the next important management activity. This should be done starting from the inner part of the clump accessable from the key hole and then working towards the outer perimeter of the clump. All remaining culms should then be tagged with an approximate age in years. The quantity of each age of clump should be tallied which will faciltate an adjustment of culm age ratio. The ideal age ratio (which is usually achieved after 3-4 years of clump management) is 4:3:2:1 for 1, 2, 3 and 4 year old culms. Be careful not to weaken the clump structural integrity when adjusting age ratio. Juvenile bamboo should have a mother near by to support them

INITIAL ADJUSTMENT OF CLUMP STRUCTURE

PROBLEMATIC CULMS	TIME (hours			
	8am	9am	10am	11am
1 - Primary Cleaning	*Travel time*			
2 - Selection & Tagging				
3 - Making a Key hole				
4 - Too Bent				
5- Too Small				
6 - Broken				
7- Too Old				
8- Diseased				
Assumption: There are 5 people (1 Harvester/site manager and 4 Clearers)				

Check list for Management Activity - for Harvester	Tick
At morning briefing	
1 - All tools needed are available on belts	
2 - All tools are sharp and in good condition	
3 - Harvester checks that Clearer's backpack is complete	
4 - Clearer checks that Harvester's backpack is complete	
5 - Harvester checks lunchboxes and water supplies	
6 - Harvester does PPE inspection of all team members	
7 - Coordinate with bamboo haulers & pickup truck	
ON SITE	
1 - Team receives daily targets	
2 - Make a daily schedule in log book	

in a work day)					
12pm	1pm	2pm	3pm	4pm	5pm
	Lunch break				*Clean up*

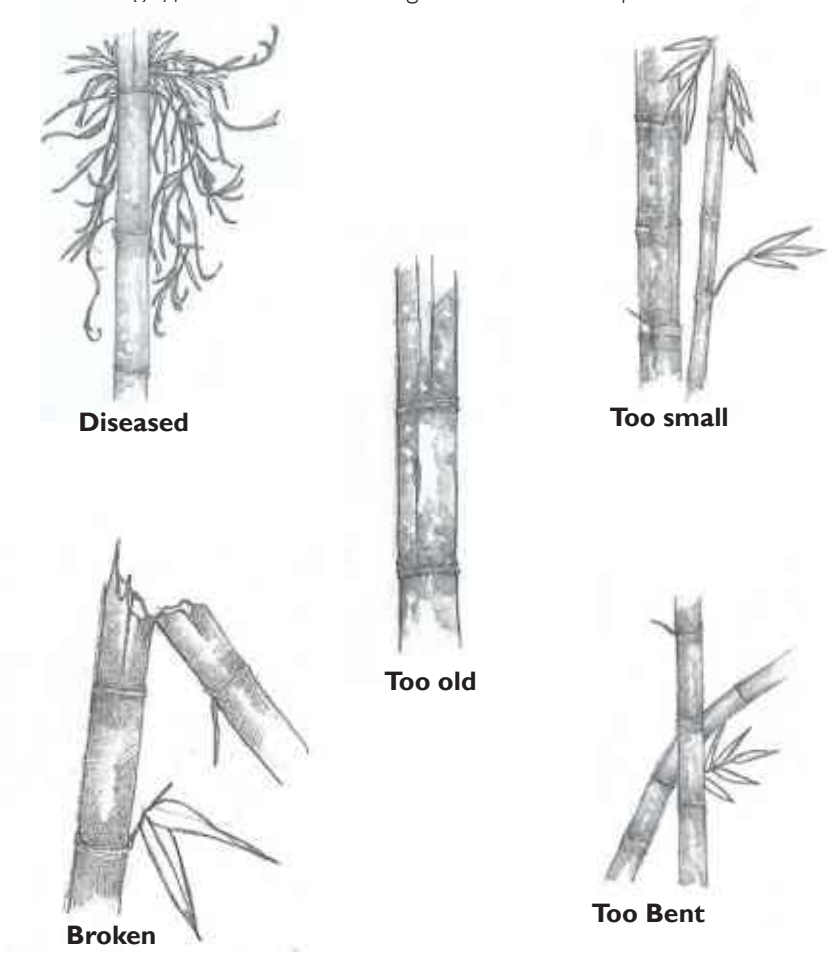
Check list - site	Tick
Adjustment of bamboo clump structure	
1 - Assessment of which culms to harvest	
2 - Tagging culms to be harvested & other activities (log)	
3 - Work instructions for harvester to clearers:	
a) Identify bamboo collection point	
b) Confirm lengths of cuts	
c) Confirm instruction for leaves & branches	
d) set up winch	
BEFORE LEAVING SITE	
1 - Confirm all bamboo has been hauled away	
2 - All bamboo leaves & branches (which stay) in neat pile	
3 - Log quantity of harvested poles	
4 - Sharpen tools & repack backpacks appropriately	

3.1.1
PROBLEMATIC CULMS

Intent: Removal of problematic culms which interfere with clump health and production of shoots. We will call these rejects.

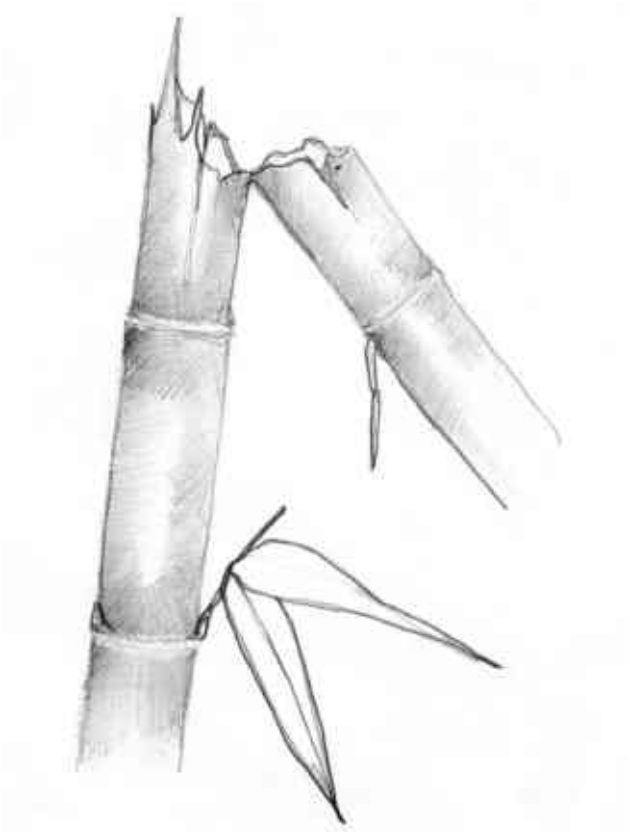
Approach:

1. The first step in managing a previously unmanaged clump is to mark the following types of culms for felling with an oil-based paint.



2. After marking, these culms should be removed from the clump. For instructions on the appropriate way to fell bamboo culms, see section 3.5

3.1.1.1
BROKEN CULMS



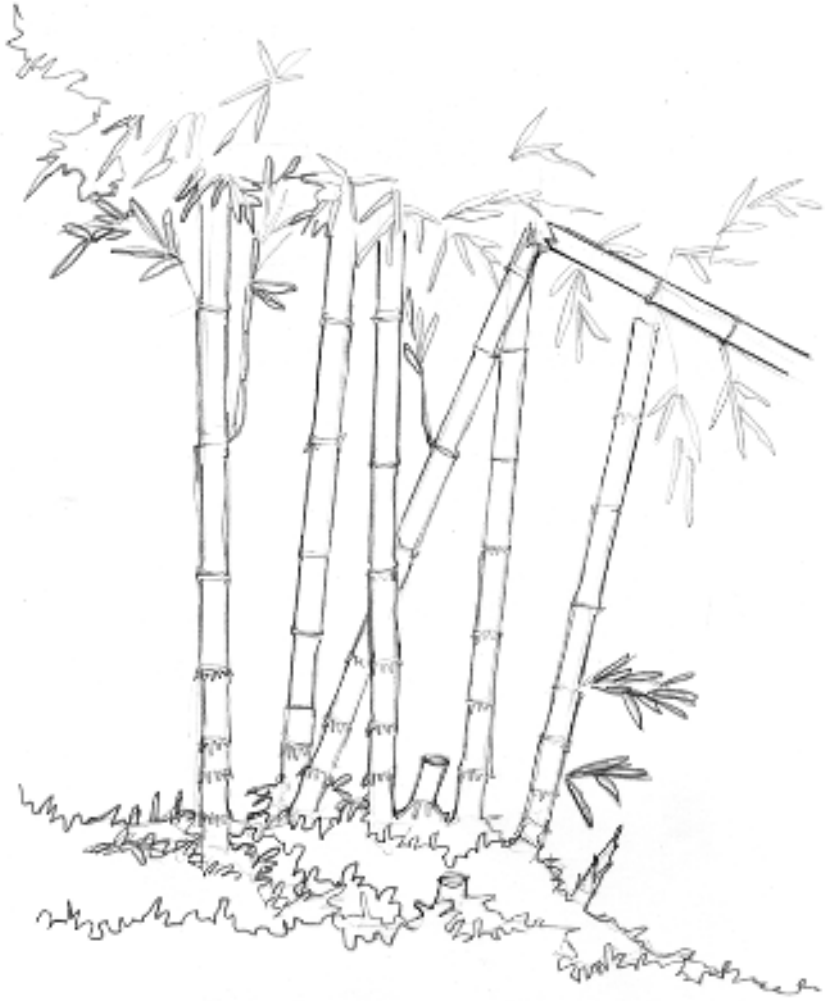
Broken culms

- cause competition for space within the clump;
- reduce light availability for shoot production;
- may host diseases which can spread to other culms;
- provide pathways for fungus colonization.

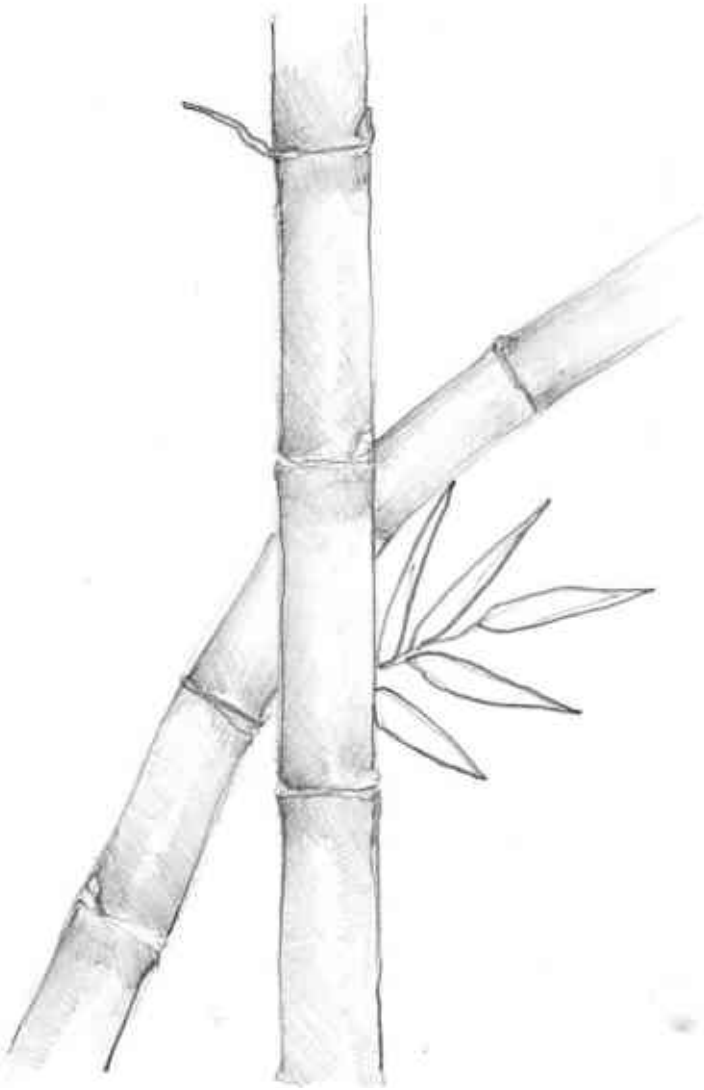
Broken culms should be cut properly and removed from the clump.

Exception

Broken culms may be left standing when there are too few culms within a certain section of the clump. In this case, as long as the break occurs toward the upper part of the culm, a broken culm may be left in place until the next season of shoots has grown and reached full height before being removed.



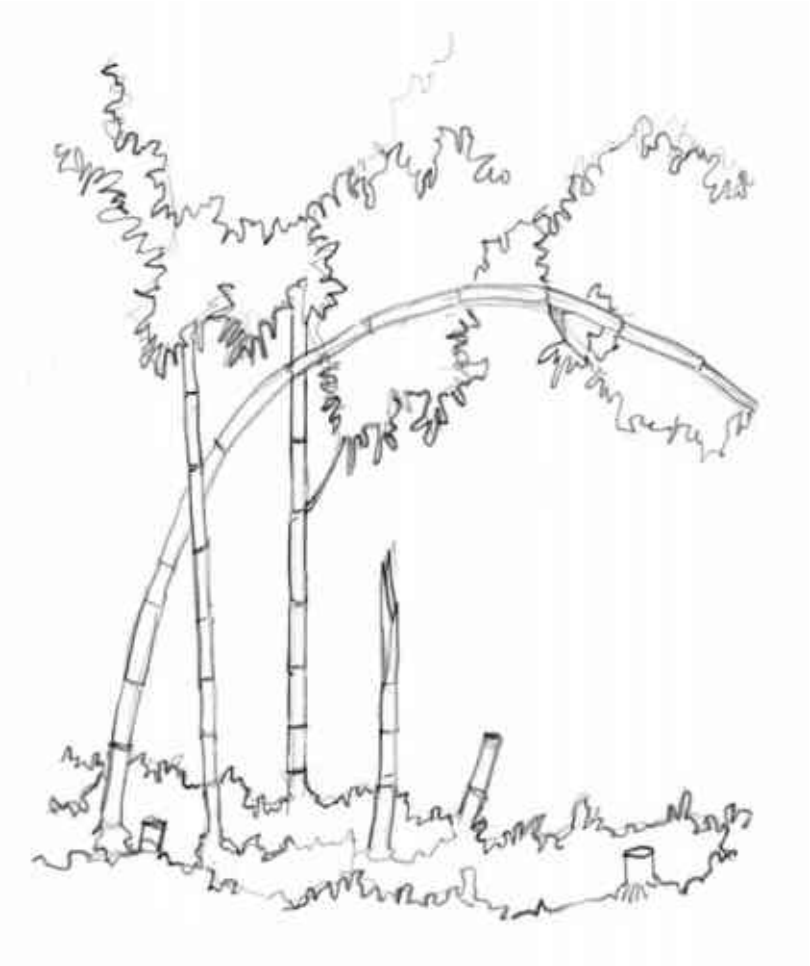
3.1.1.2
BENT



- Culms which are too bent, disturb the normal, straight growth of new shoots and culms.
- Remove culms which are bent so that they don't interfere with other fully grown culms, or block the path of growth of new shoots.

Exception:

Overly bent culms should always be removed from the clump, unless there are too few culms on the side of the clump from where the bent culm originates (see illustration).

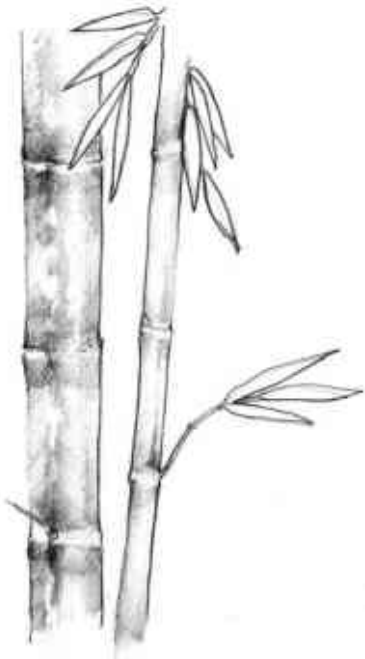


In this case, a bent culm may be kept for a season, to assist in supporting young shoots. The bent culm is then cut the following dry season when the young shoots have reached full height.

3.1.1.3
TOO OLD

- All culms which are too old should be removed from the clump. (For tips on determining the age of a bamboo culm refer to section 3.5.3)
- For most *Dendrocalamus* species, culms are considered too old when they reach seven (7) years of age or older.
- For most Gigantochloa bamboos, five (5) year old and older bamboos are considered too old.
- When a culm is too old, it has already lost most of its strength and is worth less for construction and handicrafts. Old bamboos are unlikely to produce new shoots, and take up valuable space in the clump.

3.1.1.4
TOO SMALL

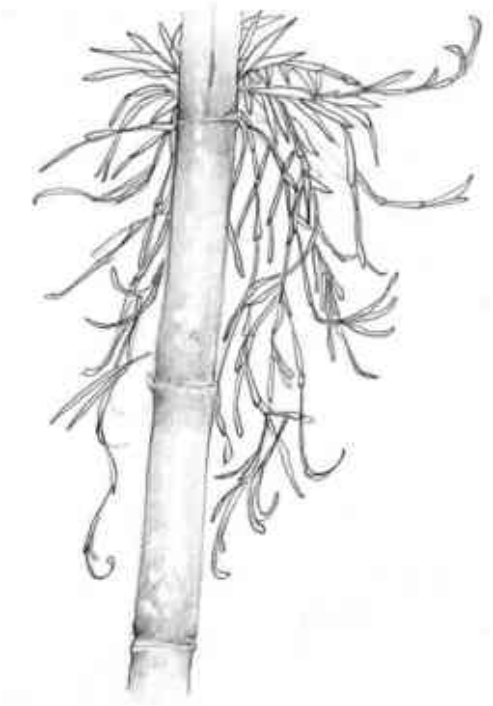


- Culms that shoot too small are a direct result of some type of stress on its mother culm. Lack of nutrients, water, space, or even a nurturing mother can cause offspring that are small and usually weak. It is important to clear bamboo that is too small because they tend to behave differently to other bamboo culms and one quickly loses the homogenous process of managing a bamboo clump.
- Culms which are significantly smaller than the normal diameter for a certain species should always be removed. These overly small culms will cause crowding. When shooting, small culms usually give rise to small shoots resulting in a new generation of small culms.
- The exception, is for newly planted bamboo clumps, which have not yet reached maturity. The table below depicts when bamboo culms of common types can be considered too small.

Table 3a

Type	Too Small	Normal Diameter
Gigantochloa apus	<5 cm	6-10 cm
G. atroviolacea	<6 cm	8-12 cm
Dendrocalamus asper	<10 cm	12-20 cm

3.1.1.5
DISEASED BAMBOO (TOO SICK)



It is natural for bamboos to play host to fungi, micro-organisms and insects, but many of these can be detrimental to both bamboo clump and forest. It is best to immediately remove any diseased bamboo culms including those:

- Colonized by fungus
- Infested by insects
- Attacked by parasites (eg. Witches Broom, pictured above)

These bamboos should be felled without exception and infected areas should be burned to avoid spread to other culms/clumps.

3.1.2
PROBLEMS WITH OVERCROWDING

APPROPRIATE SPACING

Intent: To achieve appropriate spacing between culms within a clump to improve bamboo health, structure, and allow for optimal growth of new shoots.

Approach:

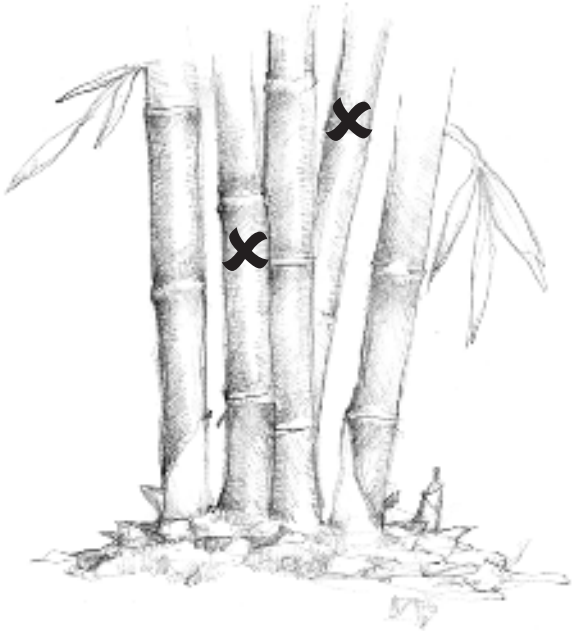
1. After removal of problematic culms, the next step in the preliminary management of the bamboo clump is to adjust spacing and density to maximise the options for appropriate asexual reproduction of a rhizome bud from its mother.

2. Appropriate spacing of bamboo culms depends much on the size and way of growth of the bamboo species you are managing. The table below provides spacing guidelines for high productivity of new shoots which grow into culms.

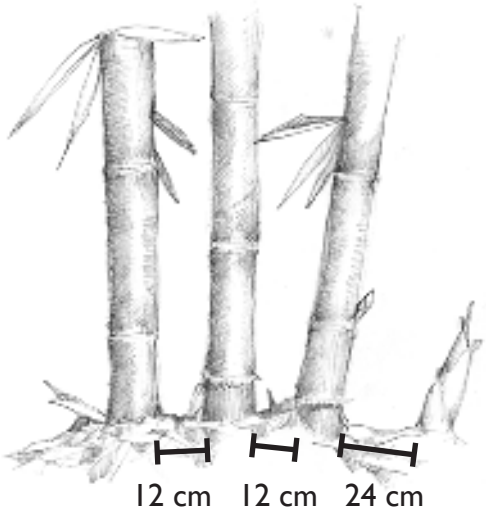
Guidelines for Appropriate Spacing Between Bamboo Culms

Bamboo Species	Minimum Spacing (cm)	Maximum Spacing (cm)
Schizostachyum spp.	3	5
Gigantochloa apus	7	14
Gigantochloa atroviolacea	12	24
Dendrocalamus asper	20	35

3. After determining spacing goals, harvest 3 and 4 year old culms to achieve your appropriate spacing.

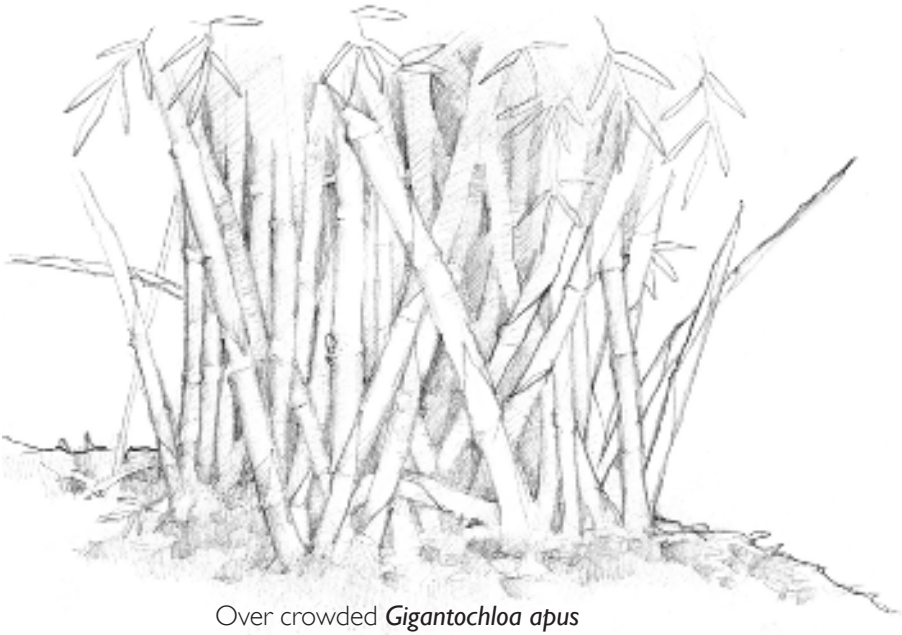


Before spacing adjustment for
G. atroviolacea



After spacing adjustment for *G. atroviolacea*

Considerations:
Unharvested bamboo clumps tend to become congested, resulting in deterioration both in terms of quality of culms and quantity of shoots produced.



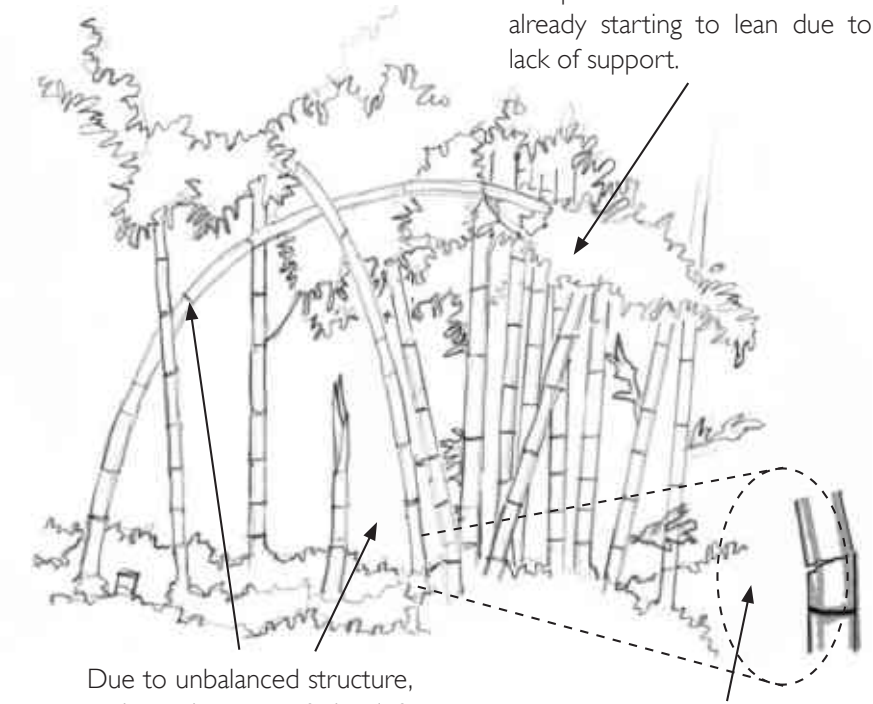
Over crowded ***Gigantochloa apus***

PROBLEMS WITH OVERCROWDING

- Culms become bent in their search for light.
- Rhizomes emerge from the soil seeking a space in which to grow and are less likely to produce healthy shoots than rhizomes which remain underground.
- Crowding creates overly humid conditions within a clump which increases the risk of fungal infection.
- It is difficult to manage and harvest crowded clumps.

Bamboos growing on slopes have specific management considerations. In terms of spacing, bamboo culms which occur too far apart (due to overharvest) can lead to collapse of the entire structure of the clump.

This extremely bent culm will inhibit the normal, straight growth of culms on the right side of the clump. Note: bamboo culms already starting to lean due to lack of support.



Due to unbalanced structure, and overharvest of the left side of the clump, bamboo culms on the left side will grow bent, collapsed, cracked etc.

Cracking formed at the base of this culm nearest to the side of the clump that was over-harvested. This occured due to lack of structural support

3.1.3
ADJUSTMENT OF AGE RATIO

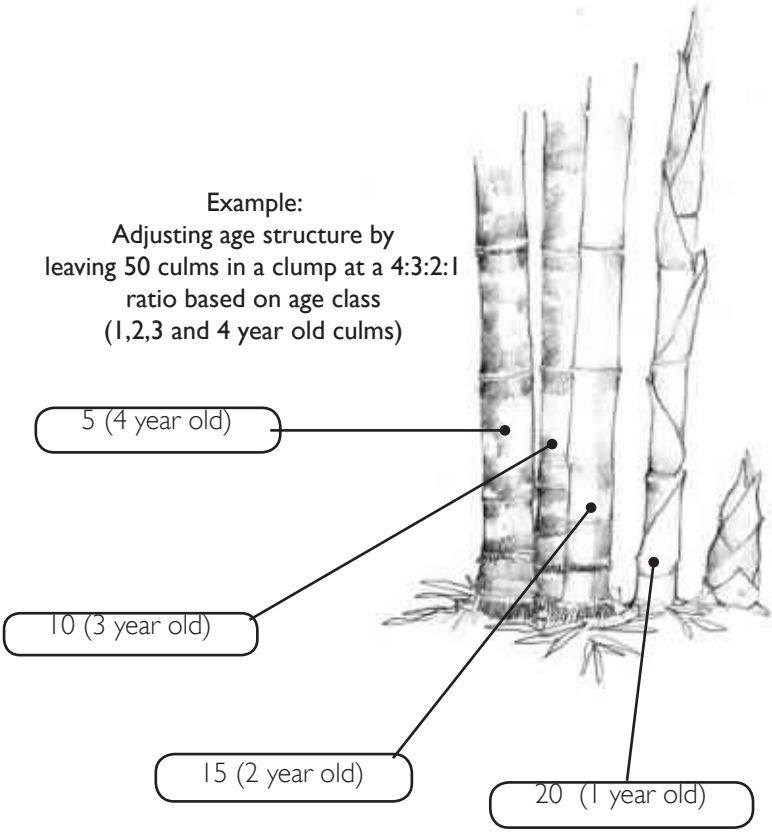
Adjustment of Age Ratio

Intent: Maintain an appropriate ratio of young to old culms in order to maximize productivity of new shoots and quality of culms.

Approach:

1. Identify and mark the ages of all culms within your clump.
2. Calculate the proportion of 1, 2 3 and 4 year old
3. An appropriate age ratio is 4:3:2:1
4. Adjust the age ratio of your clump by harvesting the culms to achieve a 4:3:2:1 distribution.

Considerations:



2 Year Old

The proportion of two year old culms in a clump should be high, as these are the culms which are most likely to produce new shoots.

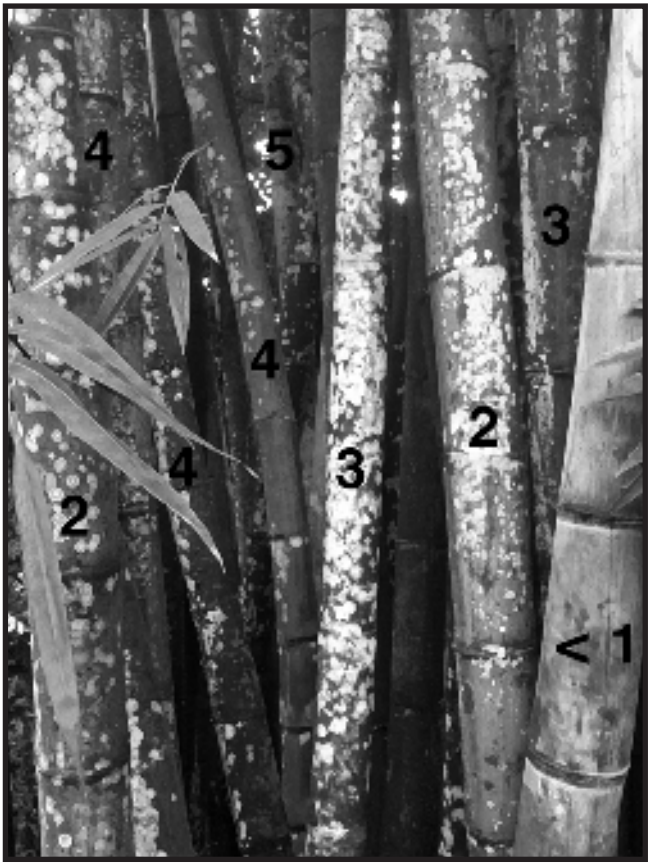
3 Year Old

Three year old culms are mostly harvested, as these culms are at the peak of their strength. Nonetheless several three year old culms are left standing in a clump for both structural and reproductive purposes.

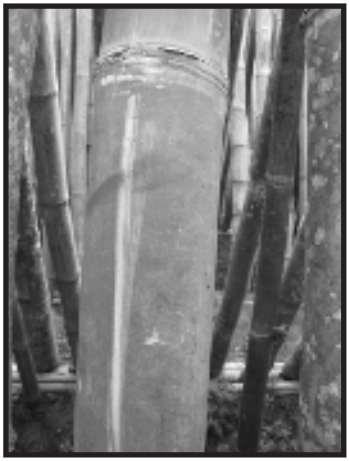
4 Year Old

It is rare to keep four year old bamboos in a clump, although some are maintained for structural purposes.

When harvesting to achieve appropriate age ratio, it is important not to compromise balanced distribution of culms, which is discussed in section 3.1.2



AGE 1



AGE 2

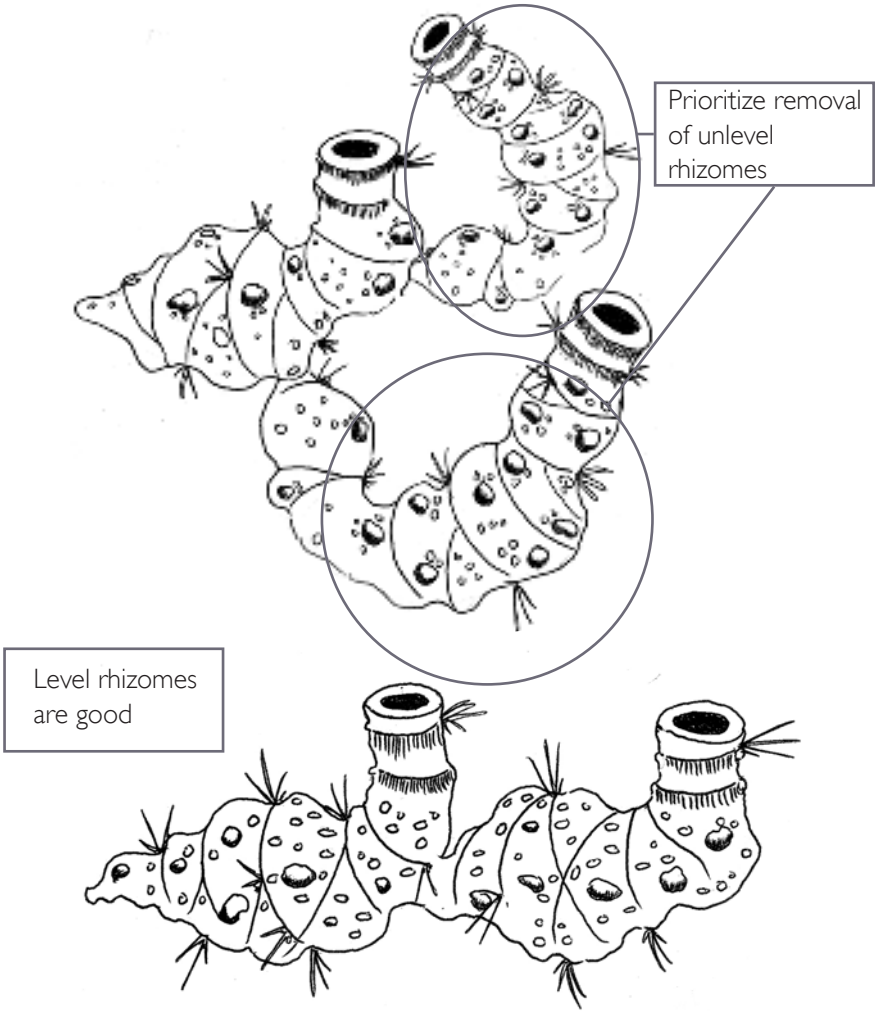
AGE 3

3.1.4
FLATTENING THE CLUMP

Flattening the Clump

The key to success of adjusting clump structure is to flatten the clump. This means that new shoot should be level with its mother as well as each subsequent generation. When harvesting young culms to improve clump age structure, those culms which do not grow at the same level of the mother should be preferentially harvested.

OFFSPRING FROM THE MOTHER RHIZOME SHOULD BE LEVEL



3.2
UNDERSTORY PLANT MANAGEMENT

Understory Plant Management

Intent: Encouragement of beneficial/companion plants, and removal of weeds growing within and around the clump to reduce the competition for water and nutrients and ease general management

Approach:

1. Plants growing amongst bamboo clumps can be considered either companions (plants wanted by humans or beneficial to the bamboo) or weeds (plants unwanted by humans). First, determined weeds from companion plants.

2. Remove all weeds growing within the clump and within a radius of 50 cm from the outer perimeter of the clump.

3. Weeding should take place twice a year. First at the end of the dry season before shooting, and second toward the end of the rainy season. Mulch and incorporate these weeds into the soil around the clump.

4. Weeding can be accomplished by hand-weeding down to the roots or by slashing the above ground biomass with a machete or large knife.

Considerations:

Companion Plants

- Many plants grow well under the canopy of bamboo, and can be of economic benefit to local communities during the growing season for bamboo when culms are not harvested. Suggested species for inter-cropping with bamboo are provided in chapter 4.4.
- Diversified cropping provides assured, regular income and reduced risk from price and climatic fluctuation.
- The use of space, light and land space is maximized.
- Erosion and weeding costs are minimized due to the growth of crops between the bamboo plants.
- Increased leaf litter, leaf mulch and leaf trimmings from plants including nitrogen fixers can be applied to bamboo as well as the "agroforestry" crops.
- Family labour is maximized throughout the year.
- Micro-climate is improved.
- Biological activity is improved.

3.2.1
COMPANION PLANTING

The density of the understory can be increased by planting the suggested understory plants around bamboo and throughout mixed bamboo agroforestry patches. The symbiosis between bamboo and the companion plants will instill additional ecosystem services.

REJUVINATE THE MOUND

Before planting reapply a compost earth and mulch mix or at least apply some fresh soil from surrounding the clump. Use this opportunity to bring the mound level back to 1cm below NODE ONE (if it has sagged over time).

Roots like this need to be covered by soil

MAINTAINING COMPANION PLANTS

Three or four months after planting companion plants it is important to check on companion plants and add plants if the spacing is too far apart. Vanilla bean will grow up the culm and provide good protection against lichens as well.

APPROPRIATE PLANTING

Planting of shade loving species like vanilla bean (shown above) and zingeberacea species (shown below) can help with soil health in the mound and will keep the soil loose for ease of clump expansion (growing outwards). Good spacing is critical and understanding how to plant local zingerberacea species is very important. Planting should be done at the end of the rainy season to minimize losses (usually from fungal infestation).

COMPANION PLANTING WORK PLAN

	PROBLEMATIC CULMS			
	8am	9am	10am	11am
1 - Rejuv Mound	*Travel time*			
2 - Mound Height				
3 - Mound Health				
4 - Planting Creepers				
5 - Planting Zingebers				
6 - Check Spacing				

TIME (hours in a work day)					
12pm	1pm	2pm	3pm	4pm	5pm
	Lunch break				*Clean up*

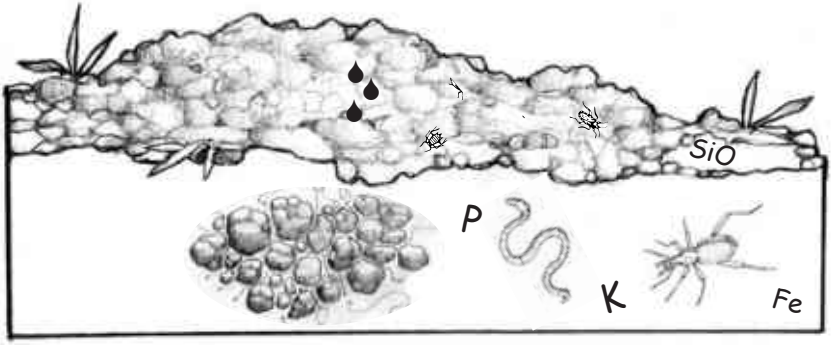
3.2.2
WEEDS

- If weeding is done too early in the rainy season, the weeds will not have fully grown and may resprout in greater numbers. Also, young weeds do not contain enough nutrients to re-mix into soil. Weeding too late after the rainy season runs the risk of too many mature seeds causing increased weed problems the following year.
- Old weeds take a long time to decompose. To accelerate decomposition, weeds can be composted.
- Weed residues used as a mulch or used to establish contour mulch lines for erosion control can be important soil conservation measures.
- Clearing all weeds, deep tillage of soil, and use of herbicide should be avoided as these practices damage soils.
- Hand-weeding down to the roots is very effective, and very selective. However, hand weeding is labor intensive and can loosen the soil leading to erosion.
- Slashing is less labour intensive than hand-weeding, and does not loosen soil. However, slashing does not kill weeds, it only slows their growth.

Definitions:

Companion Plant: A plant which grows in conjunction with a host plant, which does no harm to the host plant. Companion plants may be of ecological benefit to the host plant and/or agroecosystem, and may also provide economic and social benefits.

Weed: A weed is any plant growing in a place where it is not wanted by humans.



3.3
SOIL SYSTEMS & BAMBOO

Soil Systems & Bamboo

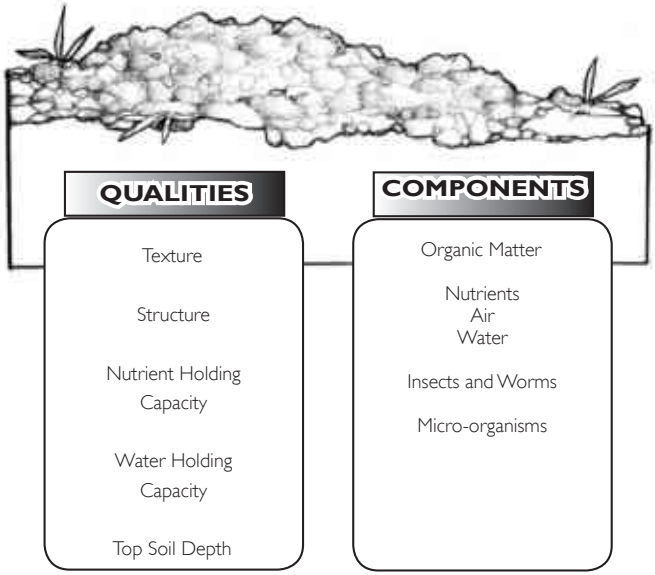
The major structural bamboos discussed in this book (*Dendrocalamus asper*, *Gigantochloa apus* and other Gigantochloa bamboos) thrive on heavier soils with high organic content and good drainage.

Nonetheless, many soils in SE Asia do not meet such criteria, especially due to the insidious loss of top soil which has been occurring over the years due to deforestation and poor farming practices. Before going into detail about soil management (toward the end of this section and into the next section), it is necessary to understand more about soil systems and how they related to specific requirements of individual bamboo plants and bamboo forests.

We suggest adhering to management actions with the following format; intent, approach and considerations. Resources and definitions are placed at the end of this section.

3.3.1
SOIL SYSTEM

The principal elements associated with a soil system include "characteristics" (e.g., water-holding capacity, structure) and "components" (e.g., sand, worms, air).



3.3.2
SOIL TEXTURE

Soil texture is described by the size distribution of the particles:

Soil particle:	Particle size diameter:
Sand	0.05 to 2.0 mm
Silt	0.002 to 0.05 mm
Clay	< 0.002 mm

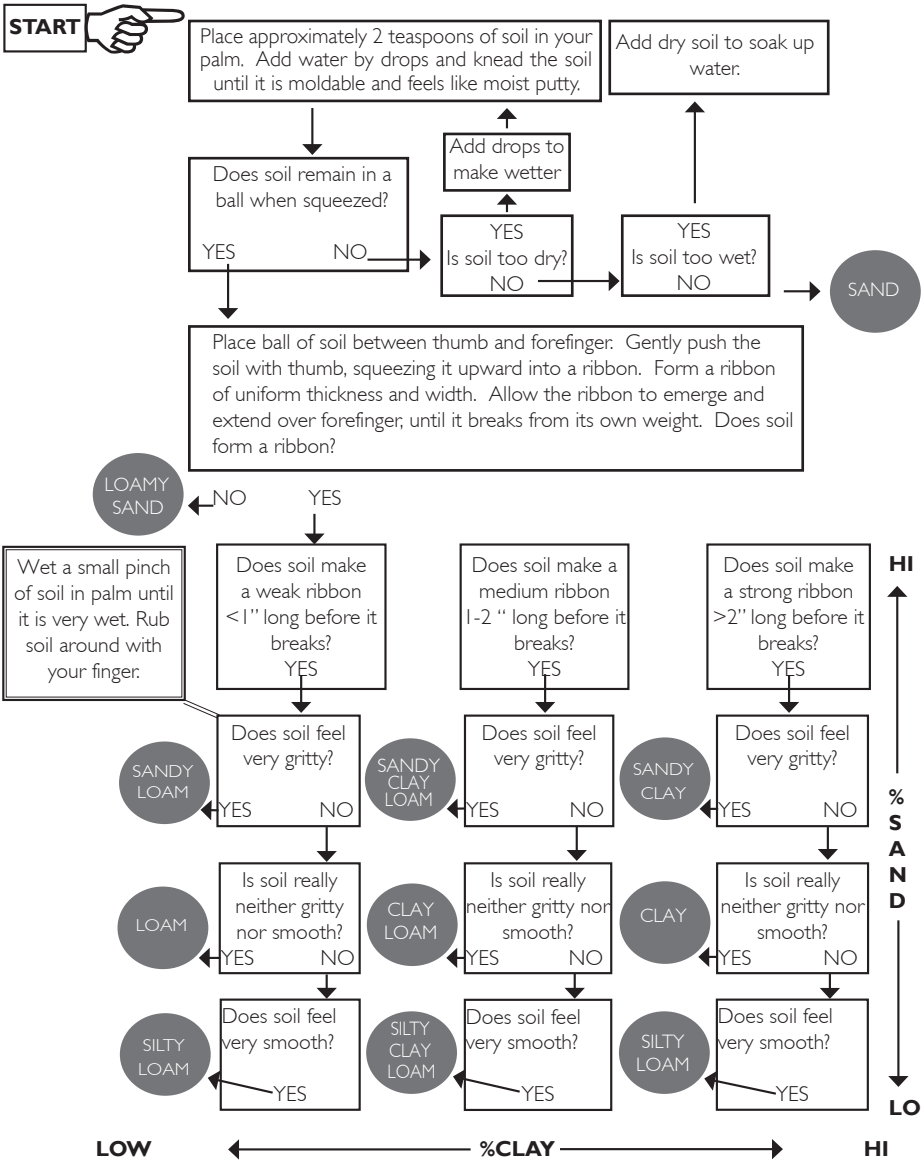
Coarse-textured soils have more sand while fine-textured soils have more clay. Loam or loamy soil are soils equally influenced by sand, silt, and clay.

Soil texture is important for soil fertilty and the ability of the soil to:
- absorb water
- retain water
- hold plant nutrients
- affect roots development

Clay soils, or "heavy" soils, retain more nutrients, hold more water and drain slowly, while nutrients are easily leached through sandy soils, or "light" soils, which hold little water unless they contain lots of organic matter. Bamboo growth is often unfavorable in soils with an extreme textural composition (very sandy, silty or clayey).

KEY TO SOIL TEXTURE BY FEEL

Approach: Begin at the place marked "Start" and follow the flow chart by answering the questions, until you identify the texture of your soil sample.



Modified from S.J. Then. 1979. A flow diagram for teaching texture by feel analysis. Journal of Agronomic Education. 8:54-55.

Many of the sympodial (clumping) bamboos that are favorable for timber (such as *D. asper and G. apus*) prefer to grow in heavier, clayey soils.

It is not as practical to change a soil type as it is important that a farmer knows the most appropriate bamboo to select for the soil type. *

There is a Chinese saying about this:

"Appropriate place,
Appropriate time,
Appropriate bamboo."

*For additional ways to test your soil texture, refer to the "Living Soils Curriculum," Exercise 1-5 (available online: http://betuco.be/CA/Training%20Exercises%20for%20Integrated%20Soils%20management.pdf)

3.3.3
SOIL STRUCTURE

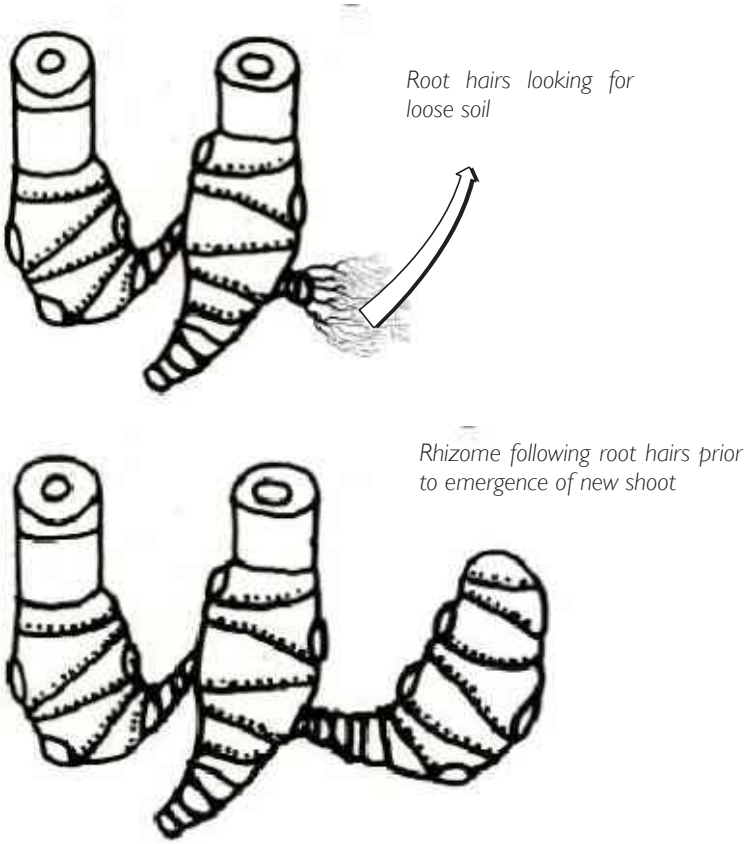
There is a complex system of empty spaces in a good structured soil, where the geometrical arrangements of the soil composition made from sand, silt and clay soil particles provide a wide range of pore spaces. These different sized gaps give a variety of shelter to root systems and microorganisms and allow different rates of diffussion of gases and water.

3.3.4
SOIL POROSITY

Porosity is one aspect of soil structure, and a porous soil has good air circulation, light and water availability. Healthy soils are loose and porous. Pore space in a "good" dryland soil composes between 40% to 60% of the total soil volume. Bamboo plants root hairs scouts for loose and porous soil and once the root hairs establish themselves the rhizome develops and the bamboo proceed to shoot.

Soil Porosity

Bamboo plants send out their root hairs, which act as scouts to find loosen and porous soil.



Once the roots hairs establish themselves in loose/porous soil, the rhizome follows, and then the bamboo shoot. Establishing roots in loose porous soils encourages bamboo shooting.

3.3.5
IMPROVING SOIL STRUCTURE

Soil structure can be improved. Microbes and worms benefit soil structure through the production of gummy substances called "aggregates" that glue the soil together. Worms and insects moving through the soil also create channels or tunnels, similar to the improved soil structure generated from plant root penetration. Manual addition of organic matter in the form of compost, organic fertilizer or mulch can improve soil structure in several ways. Large spaces left behind in the soil after the dacay of organic matter can improve porosity while the organic matter also provides food for microbes to produce agregates and food for worms and insects to leave more porous spaces in the soil and bind the loose particles into humus aggregates.

Improving Soil Porosity

Intent:

To improve air circulation, light and water availability in the soil and promote the spread of roots and rhizomes to increase both clump diameter and overall productivity of the bamboo clump.

Approach:

1. Adding Compost/Organic Matter

   Compost/Organic Fertilizer should be added around the bamboo clump several weeks before the start of the shooting season. Make sure to fertilize around, but not directly on top of bamboo shoots.

2. Mulching

   Mulching around the bamboo can also take place around the end of the rainy season.

3. Soil Loosening

If the soil is very hard, and not yet full of organic matter, you can loosen the soil with a pry bar. Hard soils around the bamboo should be loosened with a pry-bar during the dry season. Physical soil loosening can take place every 3-5 years, to a depth of 15-20 cm near the clump and 20-30 cm away from the clump.

3.3.6
SOIL MOUNDING

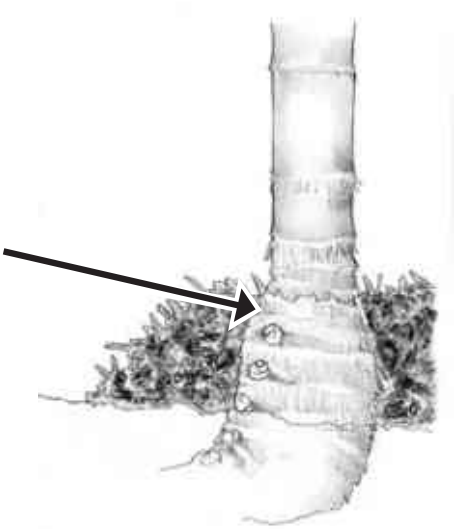
Intent:
To achieve a top soil depth that promotes the maximum number of bamboo shoots, which will grow into bamboo culms.

Approach

1. Soil should be heaped around the developing clump one to two months before the start of the rainy season

2. This soil should be mounded up to cover the uppermost rhizome bud.

3. Soil may be gathered from nearby and should be mixed thoroughly with fallen leaves (usually plentiful during the dry season)



Considerations:
The ideal situation is for the rhizome buds of the mother bamboo to be covered with rich, porous soil by the time of the shooting season.

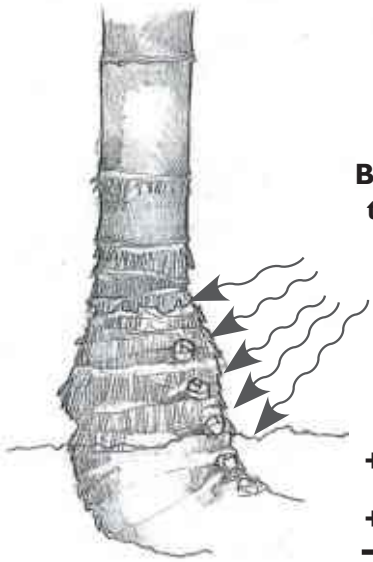
If too much soil has been lost around the bamboo, it will be necessary to devise a strategy to both REBUILD your soil and RETAIN your soil.

Read "Options for Soil and Farmer Friendly Agriculture in the Highlands of Northern Thailand" for more information on soil management (available online: http://www.mekonginfo.org/assets/midocs/0001937-society-options-for-soil-and-farmer-friendly-agriculture-in-the-highlands-of-northern-thailand.pdf)

RHIZOME BUDS

Each bamboo culm has anywhere from 2-14 bud eyes in pairs running down the culm base. In the rainy season, some of these buds swell and eventually form new shoots. Bud eyes (apical buds) on the middle and lower part of the culm base usually give rise to more robust shoots than those higher up (especially buds above ground).

The main MANAGEMENT GOAL is to increase the number of shoots that turn into bamboo culms from each mother bamboo. Management steps 1-4 discuss making room for shoots to grow, and covering the apical buds with rich soil so that they can produce a maximum number of offspring.



Be Careful Never to Disturb your Rhizome Buds

HEALTHY BUDS
+ CARBOHYDRATES
+ PHOSPHATE
= SHOOTS

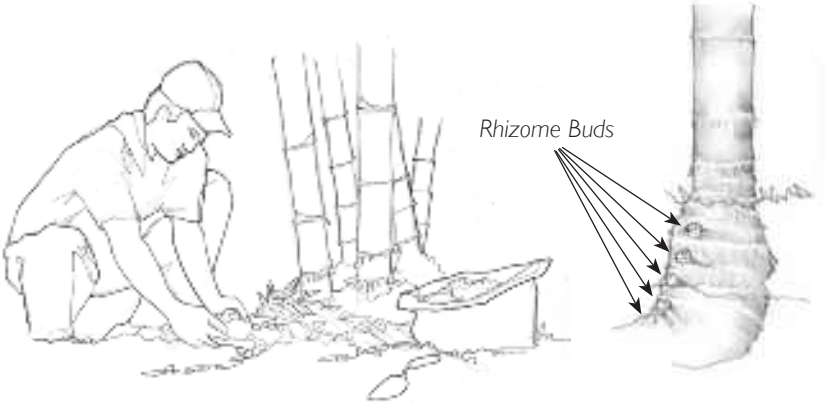
A healthy bamboo culm with healthy apical buds can produce between 6--8 culms in one lifetime. An un-managed culm will usually produce only 1-3 culms in a lifetime.

3.3.6.1
EXPERIMENT #1 SOIL MOUNDING

1. Choose a number of bamboo clumps (example = 5) as control clumps, and the same number (5) as treatment clumps.

2. One to two months before the onset of the rainy season, mound soil up to the lower part of each mother bamboo culm, in each of the 5 "treatment" bamboo clumps. The mounded soil should cover all rhizome buds, but not go higher than the lowest internode.

Soil from nearby is mixed with bamboo leaves and piled both around and within the bamboo clump. Mounded soil should cover all rhizome buds of potential mother bamboos.



3. You may choose to add mulched bamboo leaves into the mounded soil, and/or add mulched bamboo leaves on top of the soil. If you add mulch you should be aware that it will be more difficult to draw conclusions about the pure effect of mounding versus not mounding.

4. Do not mound soil or mulch around any of the "CONTROL" clumps.

Considerations

If possible, once loose and porous soils are established it is good to avoid physically loosening your soil. Maintaining loose soils by adding organic matter is a preferred practice. Practices such as tilling, or turning over the soil disturbs the small community of organisms living in the soil (worms, bacteria, insects, etc). These organisms should not be disturbed if possible.

3.3.6.2
SOIL MOUNDING BEFORE SHOOTING SEASON

SAMPLE DATA SHEET FOR EXPERIMENTAL SOIL MOUNDING BEFORE SHOOTING SEASON

Bamboo Species: Observer:
Location: Notes:
Year:

TREATMENT CLUMPS - WITH MOUNDING

Clump	Soil Mounding Date	Earliest Shooting	Latest Shooting	Total Shoots	Total Shoots grown to new culms
1-T	9/21	12/4	3/10	26	10
2-T	9/21	12/14	3/31	24	8
3-T	9/21	1/1	2/25	14	6
4-T	9/27	12/25	3/15	28	11
5-T	9/27	1/7	4/04	19	8

CONTROL CLUMPS - NO MOUNDING

Clump	Soil Mounding Date	Earliest Shooting	Latest Shooting	Total Shoots	Total Shoots grown to new culms
6-C	NA	1/4	2/28	12	5
7-C	NA	12/23	3/11	15	5
8-C	NA	1/15	2/21	9	3
9-C	NA	12/25	2/28	11	4
10-C	NA	1/15	2/21	7	3

Intent:
To increase the water holding capacity of the soil around managed bamboo clumps.

Approach:
A clearly important characteristic of a soil is its ability to hold water. One problem with a coarse sandy soil is that water (and nutrients) are rapidly lost from the soil. One of the important qualities of Soil Organic Matter is that it helps to retain water.

1. Mix compost and mulch (bamboo leaves) into the soil around you bamboo when mounding (see 3.3.6 - Soil Mounding)

2. Place a mulch layer, 10-20 cm thick on top of your soil at the end of the rainy season. This will help directly retain water by reducing evaporation from the soil surface. Mulching will also act to slowly increase soil organic matter as the leaves break down and become mixed with the soil.

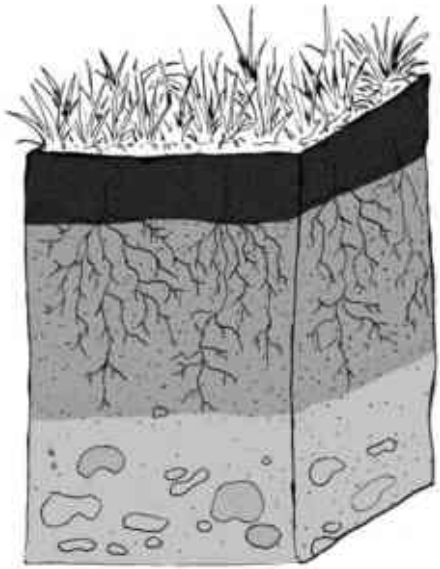
Considerations: Advantages of Mulching

- Excellent erosion control technique
- Suppresses broad leaf weed growth (if applied in a thick layer)
- Recycles organic matter and plant nutrients
- Keeps the soil moist and cool
- Encourages the presence of beneficial organisms, i.e. serves as a habitat for beneficial soil organisms and natural enemies of pests.

3.3.7
HUMUS & NUTRIENT HOLDING CAPACITY

Nutrient Holding Capacity

In the bio-geologic cycle, humic acid occurs naturally in soil from the decomposition process but is also produced in cured compost. Humic acid and carbonic acid around the roots of plants increase soil microbial activity, interact with larger minerals, and possibly alter soil pH so that previously unavailable nutrients are made available.



Humus exists as a dark (brown or black) uniform, spongy substance in the biologically active upper layers of soil and is used as food by micro-organisms that are responsible for creating good soil structure and fertility.

Chemically, humus has many active sites which bind to ions of plant nutrients, making them more available. Thus, the amount of humus in soil also reflects the soil's nutrient holding capacity.

If there is not enough humus (about 3% organic matter in the tropics, and up to twice that in temperate areas) in the soil then nutrients returned to the soil may leach out.

In this book, we use the term soil organic matter more frequently than the term

humus, which has a stricter scientific definition (see definitions at the end of this section).

3.3.8
PRINCIPLE NUTRIENTS

Nutrients are the elementary building blocks that plants need for their growth. The three main plant nutrients are NPK, as most farmers know. There are also many micro-nutrients which are important for different aspects of plant growth.

Nitrogen (N): An essential plant nutrient that is required in great amounts by bamboo. Nitrogen is derived from the organic part of the soil and not from rock or rock residues. This is one reason why it is important to conserve and increase soil organic matter. Even under good management, it is recommended to supplement nitrogen to your bamboos periodically.

Phosphorous (P): An essential plant nutrient derived from both rock and plant residues. P is strongly attached to soil particles, and while a soil may have a high concentration of P, most of it may be unavailable to plants - a problem that is typical for almost any highly weathered tropical soils. It is very difficult to maintain P reserves through the application of plant residues (mulch, compost, green manure).

Potassium (K): An essential plant nutrient derived from rock and plant residues. Bamboos uptake a large amount of potassium, and over time potassium needs to be replaced through supplementation.

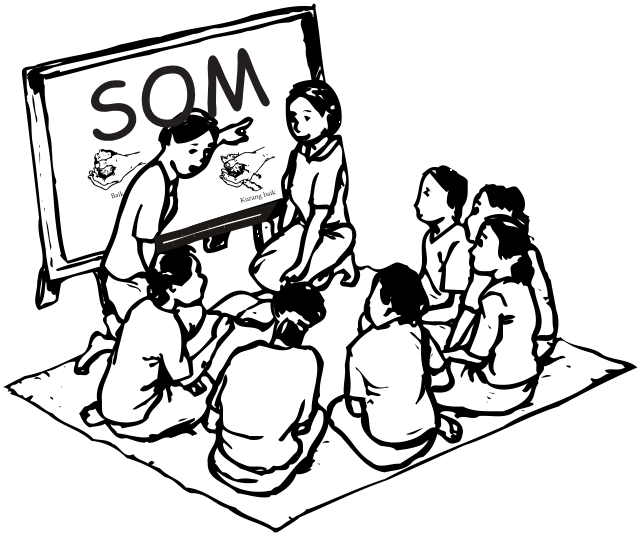
Nutrients need to be present AND made available to your bamboo. The next section of the book discusses soil nutrient management, focusing on nutrient cycling and appropriate fertilization.

3.3.9
SOIL ORGANIC MATTER (SOM)

Soil Organic Matter (SOM):

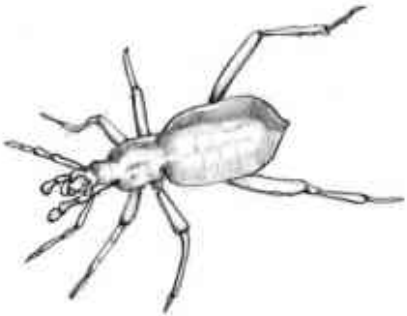
- is a source of plant nutrients (after decomposition)
- helps soil to retain nutrients by preventing nutrients from draining away with water to deeper soil layers (a process which is called leaching)
- increases the capacity of soil to store water (called water holding capacity)

- makes soil softer, easier to cultivate and more resistant to erosion
- encourages the presence and stimulates the activity of soil organisms (insects, worms and micro-organisms)



3.3.10
BIOLOGICAL SOIL PROPERTIES

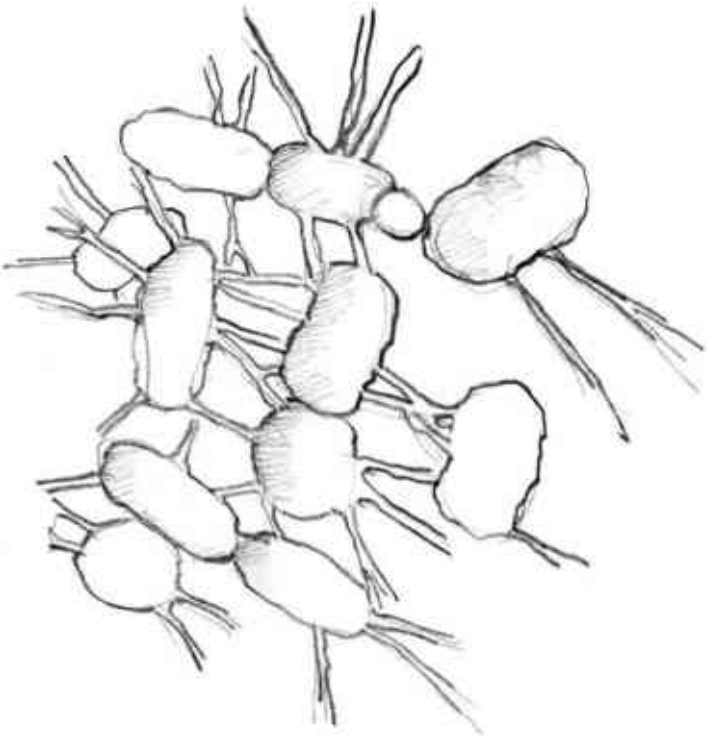
Biological properties of soils are related to the kind and number of organisms living below the soil surface. These organisms can be several centimeters long or microscopic. Some belong to the animal kingdom, while others belong to the kingdom of plants, fungi or monera. In general, soil organisms are very useful to bamboos (and to the ecosystem), but some do act as parasites or decaying agents.



A major role of the beneficial soil organisms is to break down soil organic matter into smaller particles through a range of processes called soil organic matter decomposition and mineralization. Some of the particles resulting from these processes can be taken up by plants as plant nutrients. Another major role of certain micro-organisms is the natural fixation of nitrogen, a process that is very beneficial to the soil.

Like for all living creatures, the well-being of soil organisms is influenced by their environment. The way the soil is managed has important effects on their numbers and activity. To keep a soil fertile a farmer or forester must nurture the beneficial soil organisms while avoiding the build up of large populations of harmful soil organisms.

Micro-Organisms
Experiment #2- Studying Effective Microorganisms in Soils Under Bamboo



EXPERIMENT #2 - STUDYING EFFECTIVE MICRO-ORGANISMS IN SOILS UNDER BAMBOO

Goal:

To demonstrate the existence of microorganisms in soil under bamboo clumps.

Materials:

- Poly-propylene bags large enough to hold 1-2 kg of material (one bag for each soil type)
- Soil from under a bamboo clump, fruit tree, rice field, dry land crop, rainforest etc.
- Sawdust - Rice bran
- Sugar - Bucket for mixing

1. Take two clear plastic bags and fill with a mix of sawdust, rice bran and sugar in a ratio of 75:20:5

2. Collect a handful of topsoil from 15 cm below a bamboo clump, as well as a handful of topsoil from other agroecosystems and forest types (rice field, rainforest, fruit orchard etc)

3. Mix each soil sample into a cup of sugar water (about 5% sugar)

4. Add the soil/sugar water mixture into the plastic bag filled with sawdust/rice bran/ sugar to inoculate the media.

5. Leave the bags in a dark place over several days until you see obvious microbial growth

Note: A slimy or soupy layer of many colors indicates bacterial growth, whereas a fungus appears to produce "dry" "mycelia" which looks like a layer of fine cotton fibers.

Sample Questions

1. What type of microbes develop on the medium in the bag?
2. Are there differences in the speed of development or the type of microbes you can observe among the different types of soil?
3. What relationship do microbes have to organic matter?
4. What other types of tests can you think of using this method?

3.3.11
DEFINITIONS

Definitions:

Aggregate - A conglomeration of soil particles

Apical Bud - This is the spot on the base of the culm from which the new shoots sprout. Apical buds are paired on opposite sides of the culm base, numbering from around 5-7 pairs.

Green Manure - Fertilizer made with primarily plant material

Humus - is similar to soil organic matter, but more specifically in soil science, humus refers to any organic matter which has reached a point of stability, where it will break down no further and might, if conditions do not change, remain essentially as it is for centuries, if not millennia

Loam - A soil whose properties are equally influenced by sand, silt, and clay is called a loam or loamy soil.

Mulch - In this book, mulch refers only to plant material that is used for the purposes of enhancing soil texture and nutrient content. Mulches do no contain animal manures, except when bedding from stables is used.

Porosity - The space between soil particles which allow for water and air circulation, as well as the penetration of some sunlight in the form of heat energy.

Soil Organic Matter - is decomposed plant and animal matter in the soil which is the main source of plant nutrients in a natural forest.

Soil Structure - is the arrangement or the geometry of these soil particles. A good structure provides a wide range of pore spaces, defined to be the empty spaces between particles.

Soil Texture - is based only on particle size distribution, namely percentage of sand, silt and clay. It is difficult for a farmer to change soil texture.

3.4
SOIL NUTRIENT MANAGEMENT

Nutrients are elementary chemical building blocks, which the bamboo needs for its growth. Bamboos (as well as all plants) require 13 nutrients from the soil, but it is difficult to specify the role and status of each nutrient in simple terms.

Certain nutrients (N, P and K) affect the growth of every part of the bamboo plant, and are therefore required in large amounts. Special efforts are needed to conserve and even increase the soil's contents of these nutrients for continuous production of large, healthy bamboo culms.

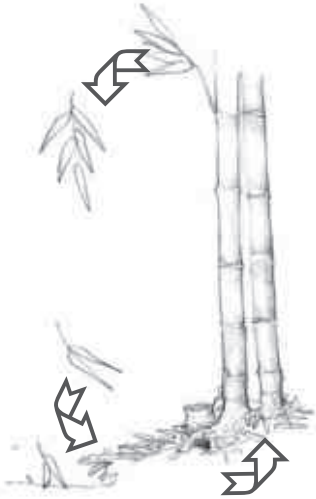
The sub-sections in this section which suggest management actions adhere to the following format; intent, approach, consideration, while other sections are meant to provide information only. Resources and definitions can be found in the final sub-section of this section on soil nutrient management.

3.4.1
KEY COMPONENTS SOIL NUTRIENT MANAGEMENT

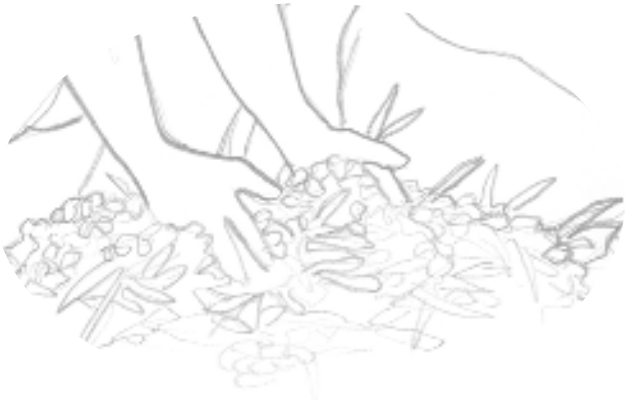
Key Components of Soil Nutrient Management

In order for the nutrients mentioned above to be of use to your bamboo, they need to be managed. The two most important ways to manage nutrients are:

1. Nutrient Cycling



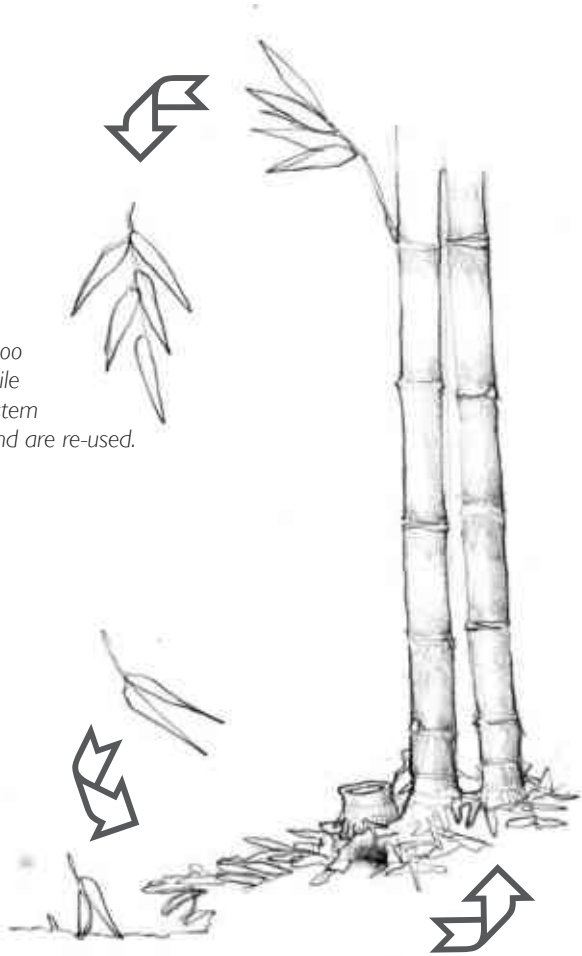
2. Appropriate Fertilization



3.4.2
NUTRIENT CYCLING

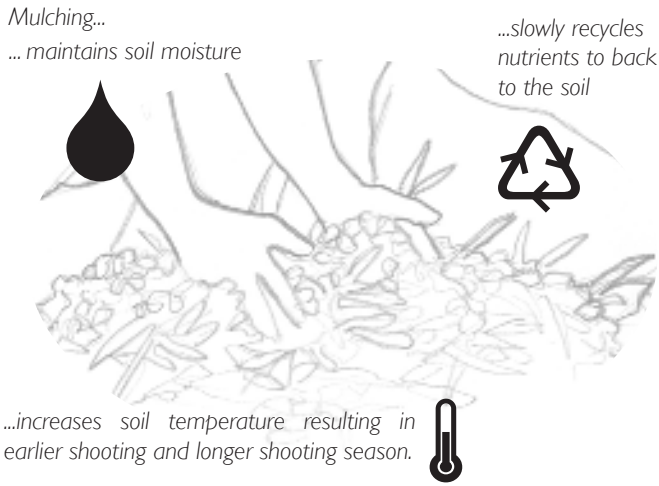
In a natural bamboo forest, without harvest, nutrients gains and losses are balanced. When bamboo is grown as part of an agricultural ecosystem this balance is disturbed. Taking bamboo culms and leaf litter out of the system requires the bamboo grower to compensate for these losses by adding nutrients.

Nutrient cycling (or recycling) is a way of managing the bamboo stand so that a majority of mobile nutrients are kept within the system (the bamboo agroecosystem) and are re-used.



3.4.3
MULCHING TO RECYCLE NUTRIENTS

Mulches are plant or non-living materials, used to cover the soil surface to control moisture loss , protect the soil from rainfall impact, and to fertilize the soil.



3.4.4
TYPES OF MULCH

Mulches are made of semi-decomposed plant materials. Some appropriate mulches for mulching bamboo include:

- Bamboo leaves
- Rice husk
- Cow manure/straws
- Sugarcane
- Leaves from Nitrogen-fixing trees
- Rice Straw
- Cut grass
- Sawdust

3.4.5
TO BURN OR NOT TO BURN

Burning of plant residues, including bamboo twigs and leaves, is a common practice amongst rural farmers in the tropics. This practice is wide-spread,and evokes both controversy and misconceptions. In the days of global warming, a re-examination of this practice is necessary. In order to avoid misunderstanding, the following discussion does not take into consideration uncontrolled burning (either intentional or accidental), which is destroying forests and releasing CO2 into the atmosphere at an alarming rate. This discussion revolves solely around the issue of whether or not to burn plant residues (fallen biomass), in a bamboo agroecosystem setting.

Controlled burning in a ecosystem is typically only undertaken by rural farmers as a means of "cleaning up" undesired biomass. The effects of burning on soil organic matter and soil organisms are controversial. It is clear in this day and age that unnecessary burning of biomass has negative impacts at the global climatic level.

Advantages of controlled burning of plant residues in bamboo agroecosystems.

+ Cheap and easy way to get rid of excess vegetation
+ Short-term improvement of soil chemistry through ash and heat effects: increased pH, temporary increase of mineral N, important and long-lasting increase of P.
+ Reduction of initial infestation levels of a wide range of crop pests (weed plants and seeds, insects, nematodes, fungi and especially rodents which may plague a bamboo forest after mass seeding).

Disadvantages of controlled burning of plant residues in bamboo agroecosystems.

- Loss of a protective cover of plant organic matter.
- Potential loss of soil organic matter (in the long term).
- Release of particles and gasses (CO2, CH4, NOX, N2O, SO2) into the atmosphere, which implies nutrient losses from the system and air pollution.
- Loss of fertile ashes through wind and erosion.
- The short-term increase in nutrient availability can lead to increased leaching losses.
- Killing of above and below ground, beneficial organisms (especially soil micro-organisms).

Soil organic matter is important. If plant residues, including bamboo leaf and twig litter, are burned every year, soil organic matter may fall below a critical level needed to support bamboo growth. In a natural forest setting this is never an issue. In a bamboo agroecosystem, biomass in the form of culms, leaves, and twigs, is extracted every year. It is important to cycle some of the harvested material, especially leaves and twigs, back into the soil. Active mulching or even fermentation of plant residues from a bamboo agroecosystem, and replacement back into the system is a recommended management step.

Based on the information presented above, it follows that burning of plant residues can create problems at two levels:

1. Problems at the local level: These relate to the negative effects in the bamboo agroecosystem where residues are burned (loss of plant nutrients and organic matter from the system, possible increase of erosion and destruction of beneficial organisms), and to effects burning may have on the entire village area (damage of property, watershed degradation, air pollution).

2. Problems at the global level: Of greatest concern are the emissions of climatically important trace gasses, i.e. gases which contribute to the greenhouse effect, depletion of the ozone layer and global warming.

In current times the rate of deforestation is said to contribute to 25% of global green house gases. Proper management of plant residues, the upkeeping of forest ecosystems and production capacity can be combined with REDD finance and its supporting mechanisms. The link inbetween creating an interaction of high quality bamboo yields and preserving the forests ecosystem is the essence of future resilient bamboo forestry.

Several non-burning alternatives are proposed in the following sections, such as mulching and producing liquid and solid fertilizers which can be used in and adjacent to the bamboo agroecosystem.

3.4.6
BAMBOO LEAF MULCH

Intent: To return nutrients from fallen bamboo leaves back into the bamboo stand.

Approach:
One of the easiest ways to mulch in a bamboo forest is to use bamboo leaves which are rich in nitrogen, potassium, as well as important micro-nutrients for bamboo growth such as silica. In fact, bamboo leaves have the same chemical composition as the bamboo plant itself and may give a better growth response than animal fertilizers such as cow dung.

Bamboo leaves can be recycled back into the bamboo forest in two ways; Incorporation and Mulching.

1. Incorporation
   Bamboo leaves are mixed with soil during the mounding process. The more thoroughly the leaves are mixed into the soil, the quicker the nutrients will be returned to the plant.

2. Mulching
   Bamboo leaves can be used as a mulch on top of the soil. This can take place twice a year; at the start of the dry season to maintain soil moisture, and before the rainy season when mounding.

Considerations
Expect that bamboo leaves will decompose within 2-4 months in tropical soils. Experiment with other ways of breaking down the leaf material more quickly, such as fermentation.

Using Bamboo Leaves
Intent: One of the problems associated with the dependence of farmers on synthetic fertilizers results from the thinking that "N,P,K" is all that a plant needs for food. In fact there are some 20 different nutrients that are necessary for plant growth. Nitrogen, phosphorus and potassium are needed in relatively large quantity by the plant, and are therefore called macronutrients. Others, such as zinc and magnesium, are only needed in minute amounts, and are called micronutrients. The farmer is most often unaware of this, thinking that adding N,P,K will make up for lost nutri- ents. While nutrient mining may not cause nutrient deficiency problems this season, or next season, eventually the soil will become deficient in one or more critical nutrient.

There is no easy way to know which nutrient might first be depleted, as nutrient composition of soils vary from location to location, and are available or not depending on fairly complex soil chemistry. We can, however, identify that removal of bamboo culms or leaves is the equivalent of removing the nutrients in those culms and leaves.

The very best way to ensure that a proper balance of nutrients is fed to the soil is to return as much of the original plant material as possible to the soil after harvest. For vegetable crops, it is best to apply compost. For bamboo plants this would involve putting the bamboo leaves back into the soil before the next shooting season. However, in many locations farmers burn their bamboo leaves (to "clean" the area up), or feed the leaves to livestock. In essence this puts the farmer in the position of continually extracting, or "mining" his soil for nutrients.

Now that participants have an idea of the value of organic matter in general, and bamboo leaves specifically, we can proceed with an analysis of how farmers use their leaves. This varies widely in Indonesia from village to village. Even within the single watershed where Farmer Field School for Bamboo was first tested, there was a great variety in how bamboo farmers used their leaves.
Some farmers chop the bamboo leaves up, place them in mulching piles and sell them as bamboo mulch. Others feed them to their live- stock. Some burn the leaves, while others leave them on the forest floor where they fall. Several villages already used the leaves in mulching their bamboo clumps, and some even turned

the leaves under in mounded piles of soil (an action also recommended in this manual).

In cases where the bamboo leaves are taken out of the forest, a nutrient cycling issue surely exists. In order to overcome this situation, a bamboo farmer would need to clearly understand the benefit of re-cycling bamboo leaves back into the forest soil.

Helping participants examine their constraints (and perceived constraints) of managing bamboo leaves in a nutrient cycling system.

Requirements:
- Human Resources
- Facilitator (preferably experienced in agriculture extension and with knowledge of bamboo)
- Co-facilitator (if the group is large)
- Farmer participants

Materials
- Marking pens
- Mural Paper
- Tape
- Bamboo leaves
- Tools for chopping bamboo leaves
- Means of carbonizing bamboo leaves
- Shovel/hoe

Approach (Classroom):
1. The facilitator can put up on the board a drawing of a bamboo plant with arrows leading away, indicating the possible uses of bamboo leaves in the community.
2. In small-group sessions, participants draw a two column matrix, indicating the "positives" (benefits) and "negatives" (constraints) associated with returning bamboo leaves to the soil under a bamboo clump. (this can, of course, also be done as a facilitated large-group discussion, depending on the judgment of the facilitator) .
3. Participants report back to the large group and discuss their findings. The facilitator should be knowledgeable enough on the subject to be able to distinguish "real" constraints from "perceived" constraints (some of which will have no real basis in fact). During the discussion try to bring out the

difference between the two (see examples below).

4. Discuss the possible solutions to the constraints and see if this can lead into plans for farmers to do experiments on the topic in their bamboo stands.

Some real constraints to returning bamboo leaves to the bamboo stand:

1. Bamboo leaves decompose too slowly, and pile up inhibiting bamboo shooting.
2. Bamboo leaves are needed for animal feed, or some other external need.
3. Long dry season (three months or more) means that bamboo leaves must be stored. If turned under too soon it decomposes long before the next shootng season. Likewise, if turned under too late, decomposition will require nutrients (decomposing bacteria require nutrients) which will also be needed by the bamboo plant.
4. Snakes are good predators of mice and other pests and should be respected. Take precautions before working amongst bamboo leaf piles. REFER TO PAGE 207.

Some perceived problems that have little or no basis in fact:

1. *Bamboo leaves are a reservoir for disease?*
   The Principle Scientist of the Chinese Academy of Forestry - Research Institute of Subtropical Forestry (Dr. Fu Maoyi) suggests that turning the bamboo leaves back into the soil as the best way to dispose of bamboo leaves from diseased plants. The disease spores are destroyed and the subsequent soils richer in organic matter are better able to suppress subsequent attacks by pathogens.
2. *Synthetic fertilizers are better for bamboo yields?*
   In fact, trials at the Chinese Academy of Forestry and elsewhere have shown that the most productive choice of fertilizers will be a combination of organic matter and synthetics (most especially a synthetic nitrogen source). Among the organic inputs, bamboo leaves has been proven to give a positive response - sometimes even better than equivalent amounts of cow dung. Bamboo leaves, after all, have almost the same chemical make up as a growing bamboo.

Farmer-run Experiments

In this section, farmers will be asked to devise simple experiments to test different ways to recycle the nutrients found in bamboo leaves.

Points to Emphasize:

1. Keep it simple! The tendency is always to try and test too many factors at one time. The more factors varied in an experiment, the more difficult it is to interpret the results.
2. Remember to include an equal number of CONTROL bamboo clumps for every TREATMENT bamboo clump. In other words, if you add bamboo leaves as mulch to 10 *D. asper* clumps, also leave 10 *D. asper* clumps untreated.
3. Since the experiment involves putting organic matter (in the form of bamboo leaves) back into the soil and evaluating the outcome, realize that effects may not be easy to see after the first season. For bamboo clumps to show a strong response to recycling bamboo leaves, you might need to wait until the second year.

   A typical increase in bamboo shooting after managing bamboo leaves as organic residue is often around a 20% increase in yield beginning the second year. It is not unusual, though, that overall better bamboo management leads to doubling or even tripling of bamboo shooting within two years.
4. Look to evaluate a wide range of effects. If farmers wish to test a new method that has effect on their soil system, look at a full range of effects—not just on the yield, but the general appearance of the bamboo plant; the incidence of diseases , pests and natural enemies; the effects on the physical factors related to the soils.
5. Plan times to get together to undertake the experiments as well as to monitor the effects of the experiments.

Possible Field Experiments in the Bamboo Stand:

1. Adding bamboo leaves directly to soil during mounding (see page 78-80)
2. Composting bamboo leaves in a pile before adding to soil around bamboo.
3. Piling bamboo leaves to certain measured depths in and around bamboo clumps.
4. Shredding bamboo leaves before use in soil augmentation or mounding.
5. Try carbonization (making bamboo leaf charcoal) of bamboo leaves before soil augmentation. (Note: this may be a good way to make Phosphorous in bamboo leaves more readily available to the bamboo plant). You can bury the leaves in a hole, covering with just a couple centimeters of dirt or sand, and build a fire on top of the covered leaves. Recover what you can when it is safe.
6. Determining the decomposition rate of bamboo leaves
   a. Bury leaves in 12 mounds of soil and dig up one mound each week for 12 weeks. During which week do the bamboo leaves begin to show signs of decomposition? When do you feel the leaves are fully

decomposed and would make good fertilizer? Does this give you any insight as to when it is best to add bamboo leaves to the soil below a bamboo clump? How does this relate to the shooting season for bamboo?

b. Mound the leaves in a pile above ground without adding soil. Perform weekly checks for decomposition. Have the bamboo leaves decomposed? If so, when? Does this give you any insight as to about managing bamboo leaves for use as mulch/soil amendment? How might this relate to the shooting season for bamboo?

Resources:
http://www.fao.org/docrep/005/ac834e/ac834e00.htm

3.4.7
MULCH THICKNESS

Considerations
It is important to calculate the time it takes for the leaf mulch to break down in order to deliver nutrients to the bamboo plant when the plant needs it most, during shooting.

Shooting usually occurs in the tropics one month after the onset of the rainy season (depending on factors such as species, altitude, water holding capacity of soil, etc.) It is important that leaf mulch is entirely broken down when shooting occurs.

Expect that bamboo leaves will decompose in soil in 2-4 months in the tropics. Experiment with other ways of breaking down the leaf material more quickly, such as fermentation, or by feeding the leaves to goats. Make sure to calculate the time it takes for leaves to decompose.

Appropriate Mulch Thickness

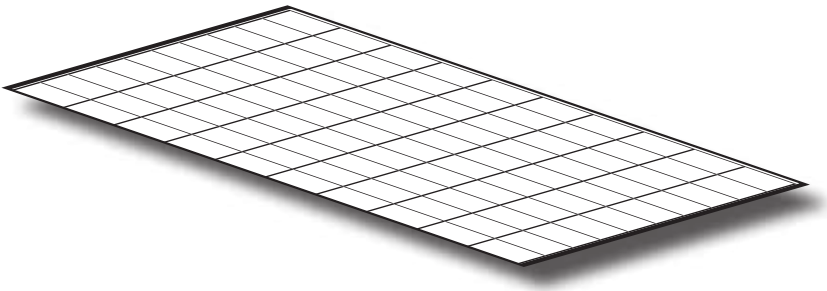
Be careful not to add TOO THICK of a layer of bamboo leaves or other mulch over your soil. 15 cm is an appropriate thickness for leaf mulch.

Too thick of a mulch layer will inhibit shooting.

3.4.8
MULCHING EXPERIMENT

3.4.8.1
EXPERIMENT #1 - BREAKDOWN OF MULCH

1. Select a 10 meter by 10 meter plot on an open grass field (away from trees



and falling leaves) and create a grid with lines spaced one meter apart.

2. Bury 100 plastic bags (one each square meter) distributed evenly along the

grid.
3. Fill each bag with an equal amount of bamboo leaf litter.
4. Each week for a 2 year time period, pull one bag at random (use a random number generator), and analyze the decomposition of the leaf litter over time.

Note: This study was performed in Chiang Mai, Thailand in 1995 support by the IDRC. They found that 90% of the nutrients were decomposed by microbial bacteria while 10% were decomposed by insects, worms and other animal detritivores.

3.4.9
INCREASING THE WOODY CONTENTS IN LEAF LITTER

In the tropics, in the natural forest, most available nutrients are stored in plant materials and most rain that falls is absorbed directly by tree roots straight back into the water cycle, or it is held by the organic matter and leaf litter and allowed to infiltrate the soil slowly. But in cultivated areas without 100% ground cover, the rainfall hits the ground hard, and in quantities that often exceed the amount the more shallow-rooted crop plants can absorb, and there is little organic matter to hold it. This excess water will often not infiltrate the soil until the soil is wet - as cultivated soil is often harder and more compact, but it will run over the surface as 'run-off'. Because run-off is often a large volume of water – it has high energy and flows fast and is able to move, or erode, soil particles as well organic matter, nutrients and stones. In fact large quantities of unprotected and un-vegetated top soil can easily be lost via run-off erosion if left unchecked.

The solution is to keep the nutrients in the plants and attach to it a vigorous nutrient recycling process. One often overlooked aspect in soil and water conservation is the role of lignin (a substance found in the woody part of plants) in organic matter, and this is really a key issue to look at.

Tilling, or turning over the soil underneath and surrounding a bamboo clump can be detrimental and result in erosion if it is not mulched (depending on how and when it is done), so it is best to leave the soil as is to minimize the disruption the soil ecosystem of bacteria and other micro-organisms, and results in erosion. Instead of tilling the soil – a better practice is to add lignin, in the form of twigs and stems, which would be naturally present in a forest, and will directly improve the soil structure. The twigs decompose slowly, gradually releasing the elements they are made of. Leaching is reduced while soil structure is improved.

The main source of lignin in the bamboo forest is the original organic matter, that is, the cell walls of woody tissues, plentiful in mature plants and the fallen decaying twigs, branches, culms and clumps from the bamboo itself, but also from other plants and trees that grow in the bamboo forest.

The lignin from various species of bamboo, trees and other plants, will be made available at different times, depending on how rapidly the plant material breaks down. Bamboo material, due to its high mineral content including silica, breaks down slowly. Their inclusion in the soil guarantees a long, slow, stable decomposition process. When managing a stand of bamboo, it will also be desirable to include woody plant material from species which break down rapidly, such as *Gliricidia sepium, Flemengia congesta, Desmodium gyroides, Cajanus cajan, Desmantus spp*., etc. These species are commonly used by rural farmers for animal fodder and green manure, and are frequently nitrogen-fixing pioneer species. They also provide abundant twigs and stems. As these species do not grow well in and amongst bamboo (shaded canopy), it will be necessary to bring them in from adjacent areas. It is also recommended to experiment with twigs and stems of plants and trees growing within the bamboo forest itself.

3.4.10
ORGANIC VS INORGANIC FERTILIZER

Allowing twigs to remain on the forest floor, or even breaking them up and incorporating them into mulch to be piled in and around the bamboo are recommended practices, which reduce the need for tillage, and lessens the likelihood of soil erosion. Reducing erosion and loss of soil is especially important in hilly bamboo forests/plantations as the slope will increase the erosivity of the run-off. This practice also enables the soil to hold more water, for a longer period of time.

If soils in your bamboo forest are nutrient poor, or if you are pushing for very high yields of bamboo each year, you will likely need to add fertilizer to your bamboo clumps.

Rural farmers, however, seldom fertilize bamboo, so gaining social acceptance for bamboo fertilization will be a major consideration.

There are two types of fertilizer:

1. Organic Fertilizer
   Organic soil amendments of plant, animal or human origin.
2. Inorganic Fertilizer
   Inorganic soil amendments that were industrially prepared.

The table below compares the advantages and disadvantages of both types of fertilizer with regards to bamboo farming.

	ORGANIC FERTILIZER	INORGANIC FERTILIZER
ADVANTAGES	Long-term fertilizing effects (slow-release), Contain organic matter, which can protect or improve the soil, Contain both NPK and plant micro-nutrients Stimulate the activity of soil organisms, Many organic fertilizers are free and locally available.	Give fast and spectacular effects (because they contain high concentrations of readily available plant nutrients), Are easy to store, transport and apply because of their low weight and volume Facilitate precise timing and dosage of nutrient supply
LIMITATIONS	Fertilizing effects can be rather slow Nutrient concentrations are in general low compared to chemical fertilizers. Are heavy and bulky and therefore difficult to store and transport to the bamboo stand. Application, especially on sloping land, requires much labor input If the residues are not composted or fermented, they may be a vector for pests and disease.	Have, in most cases, only short term effects. Over-use can have negative effects on soil (soil organic matter decline, structure degradation, micro-nutrient depletion, acidification) Always imply a financial risk. Can be difficult to obtain in remote areas.

3.4.11
RECOMMENDED FERTILIZER USE

Some General Recommendations for Appropriate Fertilizer Use

Use inorganic/commercial/chemical fertilizers sparingly, in the appropriate season and appropriate way. This is an economic consideration.

If you are not burning bamboo leaves, using ash in your fertilizer, or charcoal, you will need to occasionally add a natural source of phosphate. This should be added within the bamboo clump, within a bamboo stump, or on the edge of the clump, as Phosphorous is not very mobile in the soil.

Types of organic fertilizer potentially available in Indonesia:

Table 4d

Low Quality	Rice straw and husks, bamboo leaves, corn residues, grass residues	To maintain soil organic matter levels and improve soil structure.
Medium Quality	Residues of legume plants, broad leaf weeds, cow, buffalo, horse and duck manure	Immediate improvement of the soil nutrient content. Whenever available, and if their application is practical, they should be preferred over use of commercial inorganic fertilizers.
High Quality	Residues of algae and water plants, pig, chicken, goat, swallow and bat manure	

3.4.11.1
RECIPES FOR ORGANIC FERTILIZERS

Intent:
Step by step instructions are provided for bamboo growers to begin producing their own solid fertilizer (compost) and fermented liquid fertilizer. These organic fertilizers are made entirely out of materials commonly found in most rural, agricultural areas of S.E. Asia. Application of these fertilizers to your bamboo clumps in the right amounts, during the right time, will improve your bamboo's yield.

About Compost
Good compost is very important for optimal bamboo growth. It aerates soil, breaks up clay, binds together sand, improves drainage, prevents erosion, neutralizes toxins, holds moisture, releases essential nutrients, and feeds the microbiotic life of the soil, creating healthy conditions for natural antibiotics, worms and beneficial fungi.

There are many ways that people have found to build compost piles. The reader is encouraged to ask around to find other "recipes" and, of course, to experiment. The basic requirement of all (hot) compost piles is that:

1. The compost pile be large enough so that the heat generated is greater than the heat lost to the outs
2. The pile needs to be "turned" or mixed up in order to bring the less processed materials from the outside, to the inside, and to add oxygen to the pile. This should be done about once per month.
3. The pile needs to kept moist, in order to promote microbial growth, but not too wet (causing anaerobic conditions)

To build a compost bin out of locally-available materials
Required Materials:

Succulent Fresh Weeds

Manure

Farm Tools

Leaves (Bamboo, Banana, etc.)

Banana Tree Trunks

Plastic Twine

Ashes

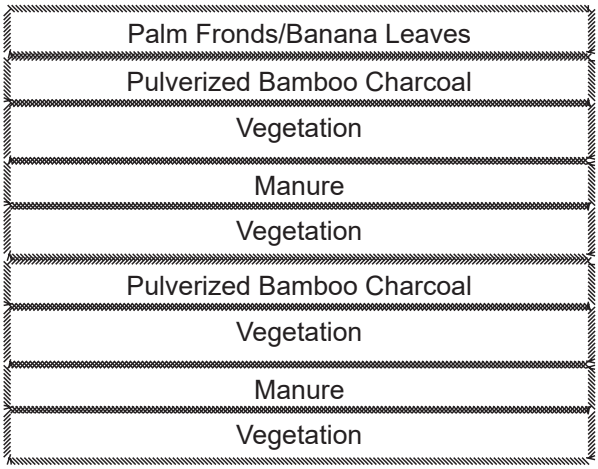
Bamboo Stakes (1.5 m x 4 cm)

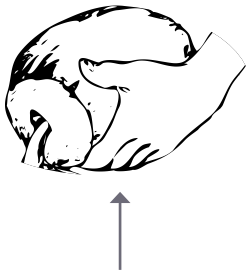
Young Coconut Water

Optional Materials:
- Pulverized Bamboo Charcoal
- Plastic tarp covering

Approach:

1. Layout an area about 1.5 x 1.5 m, either in the village or in the bamboo forest.
2. Cut between 30 – 40 straight bamboo branches from harvested culms; each should be about 1.5 m tall. The four corner posts should be the biggest and somewhat taller
3. Insert and/or pound into the ground with a hammer in order to make a bamboo cage. Spaces between branches should be 2-3 cm. Tie horizontal branches from each of the four corner posts, to stabilize the structure. Tie the plastic twine along the horizontal branch, from branch-to-branch in order to further stabilize the structure.
4. Cut succulent weeds from roadside areas, and/or collect banana leaves and trunks from harvested banana trees or just about any other leafy materials. Chop these up with a large knife to accelerate the breakdown process.
5. Collect cow dung (chicken and pig dung can also be used; these are higher in N, but also have more odor).
6. Begin with a layer of vegetation about 20 cm in the bottom of the bin; add then a layer of manure, then a second layer of vegetation; then a sprinkling of pulverized charcoal (if available) vegetation; manure; vegetation; charcoal; etc., until you have reached the top (about 1 m).
7. After every layer of vegetation, tamp down the vegetation in order to compress the pile (not too much)
8. After every few layers, sprinkle a few liters of water and/ or young coconut water on the pile to make the material damp, but not soaking wet young coconut water provides sugars to assist fermentation.





Douse entire pile with young coconut water.

9. After the layers are completed, thrust a pole down to the bottom of the pile in 4 to 6 locations in order to create an air channel to the center of the pile
10. Cover the top with a layer of coconut fronds to keep rain from soaking the pile (or perhaps build the pile under the bamboo canopy).
11. Monitor the pile weekly and add water as needed (if the center of the pile becomes dried out, white and "chalky" it means you need more water)
12. Turn the pile on a monthly basis, bringing the outside materials in to the center, and the center materials to the outside.
13. Once decomposed use within 1 month
14. If dung is not available, you will need to layer the pile with urea instead. The pile will be completed when the compost is a dark brown, crumbly consistency, with the odor of fresh earth. This may take three months, depending on the climate. Once you have successfully created a compost pile, and carried it through to completion, you may want to build a series of compost structures and stock them on a monthly basis in order to create a consistent source of compost.

3.4.11.2
USING CHARCOAL IN YOUR COMPOST

Using Charcoal in Your Compost

(From: Integrated Charcoal Technology - 2nd Edition, Yayasan Dian Tama - Indonesia, 2004)

The opportunity to produce charcoal, and charcoal vinegar (the distillate from vapours created when making charcoal) have a high market value and are an excellent way to utilize parts of the bamboo plant not meant for construction purposes.

These products can be used directly for agricultural purposes. Here we discuss the benefits of adding pulverized bamboo charcoal to your compost.

Charcoal does not provide nutrients (N, P, K, Ca, Mg, etc.) from plant matter back to the soil, but compost made with charcoal is more effective at providing these nutrients. Improper composting of fresh vegetation can give rise to the development of harmful fungi, depleted oxygen and root rot when applied to crops. Use of charcoal in compost has numerous benefits including;

- Increased activity of bacteria needed for decomposition of vegetable matter
- Increase in temperature of fermenting compost
- Increase the speed of decomposition
- Decrease the need to turn or mix the compost pile (that is usually needed to increase oxygen for aerobic bacteria)
- Improve the smell of your compost

For information on production of charcoal from bamboo and other materials, visit the Asian Regional Cookstove Program website at **www.arecop.com**

Dolomite Lime

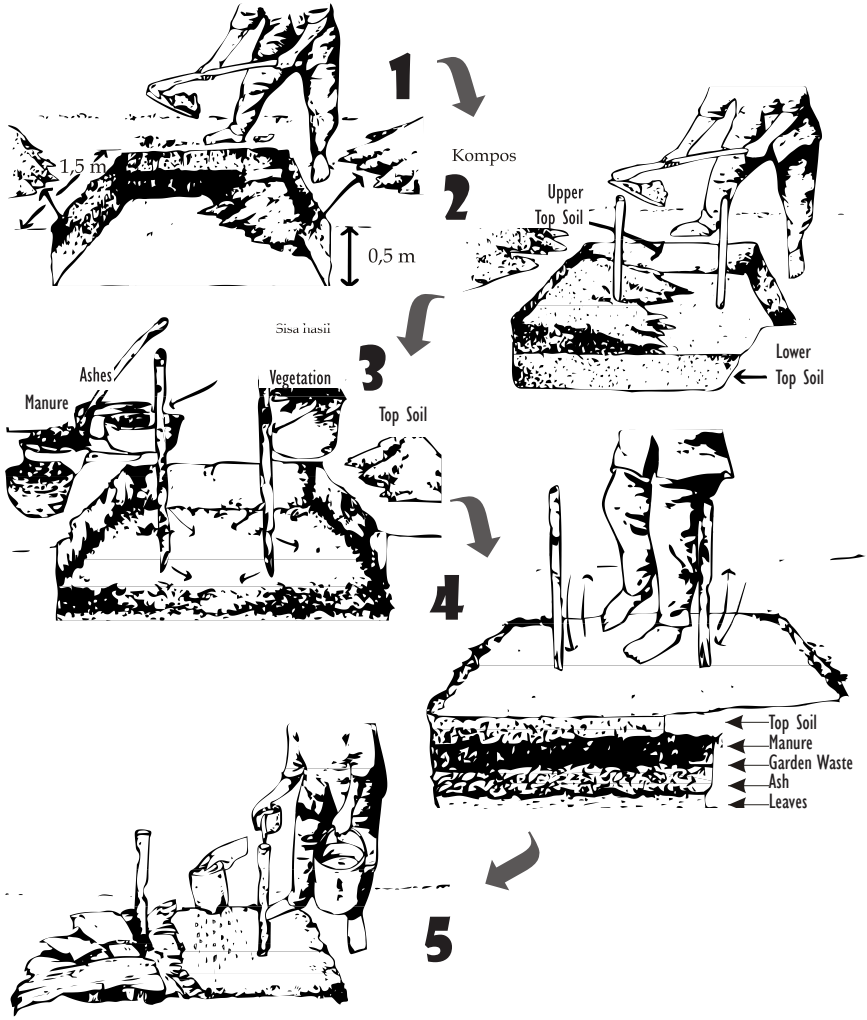
Dolomite lime is a good source of both calcium and magnesium, to be used as a soil amendment when both are needed.

Many people add dolomite lime to layers of their compost. This practice is not recommended. **Do not use lime to "sweeten" the compost pile**, as doing so will result in a serious loss of nitrogen. A layer of soil will discourage flies and reduce odors, or better yet, use pulverized charcoal.

3.4.11.3
VARIATION - UNDERGROUND COMPOST PILE.

Strengths: Underground compost piles are easier to construct, and do not require above ground structure (bamboo poles etc.). Easy to locate in the forest itself.

Limitations: An above ground compost pile is preferable because it allows for maximum breakdown of organic matter by aerobic microbes. Underground piles, by nature, are not as well aerated as above ground compost piles, and thus favour anaerobic decomposition which slowly produces methane and generates hydrogen sulphide and more acidic compost.

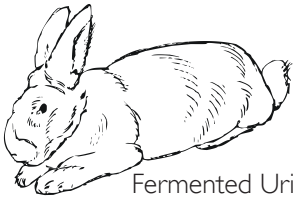


3.4.11.4
MAKING FERMENTED LIQUID FERTILIZER

Buckets and Trash Cans with Lids

Unrefined Molasses

Surplus Fruits & Roots from Ginger Family

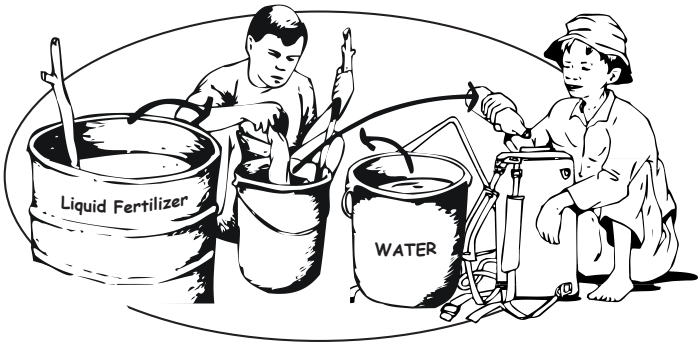


Fermented Urine

Optional Materials
- Beneficial fungus spores (Trichoderma spp.)

1. Ferment one liter of urine (rabbit or cow preferred) in one 5 liter bucket of water for a period of three days. Keep the bucket lightly covered.
2. Mash and boil a handfull of various roots from the ginger family, such as ginger, turmeric, lesser and greater galangal, etc. Let this water cool to room temperature. Gingers make an excellent natural fungicide, especially turmeric.
3. Crush 0.5-1 Kg of surplus farm fruits such as papaya (without seeds), tomato, starfruit, and banana into a pulp. Do not use citrus fruits.

4. Mix the ingredients from steps 1-3 into a lidded bucket or trash can. And top up with water.
5. Add 1 tablespoon of molasses per ten liters of solution. As a replacement for molasses, you can mix in sugar, sap from the inflouresence of the coconut, sugar, lontar or nypa palm, or young coconut water. These sugars, as well as the sugars in the crushed fruit will help the solution ferment.
6. Cover lightly and allow to ferment for 3 days. Dilute the finished solution 1 part solution, to 10 parts water and spray the base of your bamboo or other plants immediately in the growing season.



3.4.12
BALANCED FERTILIZER APPLICATION

Intent:
Maximum use of organic fertilizers, with timely, complementary short-term application of inorganic fertilizers for maximum benefits to culm production, soil health and environmental well being.

Approach:
Well managed bamboo clumps should be fertilized.
There are two appropriate ways to use fertilizer to support excellent bamboo growth.

1. Fertilizing In and Around the Clump

2. Fertilizing Dead Stumps

3.4.12.1
IMPROVING SOIL HEALTH

1 - Mulch can easily be created by chipping bamboo or plant leaves and branches. The appropriate dimensions for bamboo mulch is 1cm wide and greater than 1cm long and about 0.2-0.5 mm thick.

2 - Making compost (Refer to page151). A compost pile will make compost in 5-6 months if done appropriately. Key concepts to monitor include 1. Carbon content. 2. Microbial activity to catalize break down or bio-degradation. 3. heat build up to further catalize the biodegration of the bamboo carbon

3 - Soil collection: soil surrounding clump should be collected no deeper the 20cm deep but can go out as much as possible. Many bamboo roots will show in the soil don't worry they will come back better after mounding.

4 - Correct ratios: The ratio for the mounding mix is 5:3:1 of soil, mulch and compost. The compost is a fertilizer and depending how rich the compost is more compost may need to be added if seen as appropriate. The mulch is mainly for airation and will provide soil fauna with food. Soil is a binding agent with many minerals. It should be taken from around the clump. Keep all these piles in as much shade a possible.

5 - Appropriate mixing: mixing should be carried out until there are no masses of compost or soil in the mix. The mix should seperate evenly when thrown in the air. Try to do this in as much shade as possible. approx time: 10 minutes/5 bamboo clumps.

6 - Appropriate mounding: the mix should then be mounded against the outer perimeter of the clump before below NODE ONE. This will minimize fungal attach on bamboo culms. Mound should be at least 50cm wide.

IMPROVING SOIL HEALTH

PROBLEMATIC CULMS	TIME (hours in a work day)									
	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm
1 -Collecting mulch	*Travel time*					*Lunch break*				*Clean up*
2 -Collecting compost										
4 -Collecting soil										
5 -Mixing										
6 -Mounding										

3.4.13
FERTILIZING IN & AROUND THE CLUMP

Fertilizing In and Around the Clump

A mixture of organic fertilizer and commercial fertilizer will provide the highest yield for your bamboo.

1. Add organic fertilizer to the soil, both around the perimeter of the bamboo clump and within the bamboo clump one month before the rainy season/shooting season. This can be done together with mounding of the soil (from section 3.3.6).

2. Mix 250g of NPK in a ratio of 5:1:1 into the ground within the clump during the growing season when the majority of healthy shoots have already emerged and are growing into full culms. (Note: This is a recommended ratio for bamboo culms as timber. Ratios differ greatly for edible shoot production).

3. Liquid organic fertilizer can also be applied at this time. Apply liquid fertilizer directly within the clump but not directly on shoots.

3.4.13.1
FERTILIZING BAMBOO STUMPS

Fertilizing A Bamboo Stump

Fertilizing directly within a freshly cut bamboo stump is a relatively unknown but highly effective fertilization method, with multiple purposes:

1. Assists mother bamboo in providing nutrients to new bamboo shoots.

2. Speeds up the decay of the bamboo stump, which will provide room for future bamboo shoots to emerge.

3. The decay of the bamboo stump takes place without giving rise to destructive fungus and bacteria, as the fertilizer/compost provides a medium for the growth of beneficial bacteria.

After appropriate harvest of a bamboo culm (either during initial maintenance or harvest season), clean the cut with a saw just above the first internode.

1. Create a hole in the diaphragm of the lowest internode with a crowbar or similar tool. If the cut has taken place at the second internode, you will need to punch through several inter-nodes.

2. Fill the bamboo stump with organic fertilizer or compost.

3. Top the cut stump off with dirt.

Considerations: On slopes greater than 20 degrees, in-stump fertilization is increased while fertilization around the bamboo clump is decreased. This is done in order to minimize loss of valuable fertilizer through run-off.

3.4.13.2
FERTILIZATION EXPERIMENT

3.4.13.3
EXPERIMENT #1 - FERTILIZER

1. Choose three types of fertilizer
   examples : - goat manure
   - homemade organic liquid fertilizer
   - store-bought urea

2. Select 5 bamboo clumps (all of the same species) from your forest for each type of fertilizer, plus 5 clumps that will serve as your control (i.e. no fertilizer).

Ex. If you have three types of fertilizer, then you will need to select a total of 20 bamboo clumps; 5 (goat manure) + 5 (liquid fertilizer) + 5 (urea) + 5 (control) = 20.

3. Spread your fertilizer around each bamboo clump, outward to the area where you predict new shoots will emerge. Do not spread fertilizer directly onto new shoots. You should also fertilize the empty interior of the clump. Make signs for each treatment i.e. "Goat Manure - 10 November 2008 - 2 kg"

4. Do not add fertilizer to the 5 control clumps. You will still need to mark each control clump with a sign (i.e. "Control - 10 November 2008 - No Fertilizer")

5. Use the data sheet on the next page to keep track of your results.

3.4.13.4
SAMPLE DATA SHEET FOR FERTILIZATION EXPERIMENT

SAMPLE DATA SHEET FOR EXPERIMENT #1

Fertilizer Type: *Goat Manure*
Application Date: *10/11/08*
Bamboo Species: *D. asper*
Location: *Seloprojo - North Slope*

Observer: *Ihksan*
Notes: Fertilizer from 1 month old goat manure; 2kg per clump

Clump	Earliest Shoot	Latest Shoot	Total Shoots	Total Shoots becoming Culms
1	11/11	04/21	14	9
2	11/21	03/30	17	11
3	10/31	03/15	12	7
4	11/07	04/15	21	12
5	11/10	03/28	18	12

Fertilizer Type: *CONTROL*
Application Date: *NONE*
Bamboo Species: *D. asper*
Location: *Seloprojo - North Slope*

Observer: *Ihksan*
Notes:

Clump	Earliest Shoot	Latest Shoot	Total Shoots	Total Shoots becoming Culms
6	12/15	02/21	9	4
7	11/29	02/30	10	3
8	11/31	03/15	8	2
9	12/07	03/14	14	6
10	12/10	02/28	8	3

3.4.14
DEFINITIONS

Agroecosystem: An ecological system (ecosystem) modified by people to produce food, fibre, timber, meat, and various other agricultural and/or natural products for human use.

Biomass: The organic material produced by living organisms.

Compost: Fertilizer derived from organic matter subjected to an accelerated process of organic matter decomposition. This aims to optimize moisture content, temperature, nutrient composition of the final product, and species composition of the populations of biodegrading organisms.

Fertilizer: Any organic or inorganic material which is added to the soil to supply one or more plant nutrients.

Green Manure: Fresh or dry plant biomass that is applied to the soil as fertilizer.

Leaching: The transport (by water) of nutrients or other soil compounds to deeper layers of the soil.

Mineralization: The conversion of an element from an organic to an inorganic form as a result of microbial decomposition.

Mulch: Plant or non-living materials, used to cover the soil surface with the object of protecting the soil from the impact of rainfall, controlling moisture loss, and in some cases fertilizing the soil.

Nitrogen Fixation: The biological conversion of elemental atmospheric nitrogen (N2) into organic compounds. This happens by specialized micro-organisms that can "catch" nitrogen from the air (where it is present abundantly as a gas) and turn it into plant available nitrogen forms. Some micro-organisms can do this on their own, but the most important ones require a close association with the roots of plants (legumes).

3.5
SUSTAINABLE HARVEST

In earlier sections, when discussing cutting bamboo, we focused on culling out weaker culms from previously un-managed clumps. The key being to cut out culms which are harming productivity of the clump as a whole.

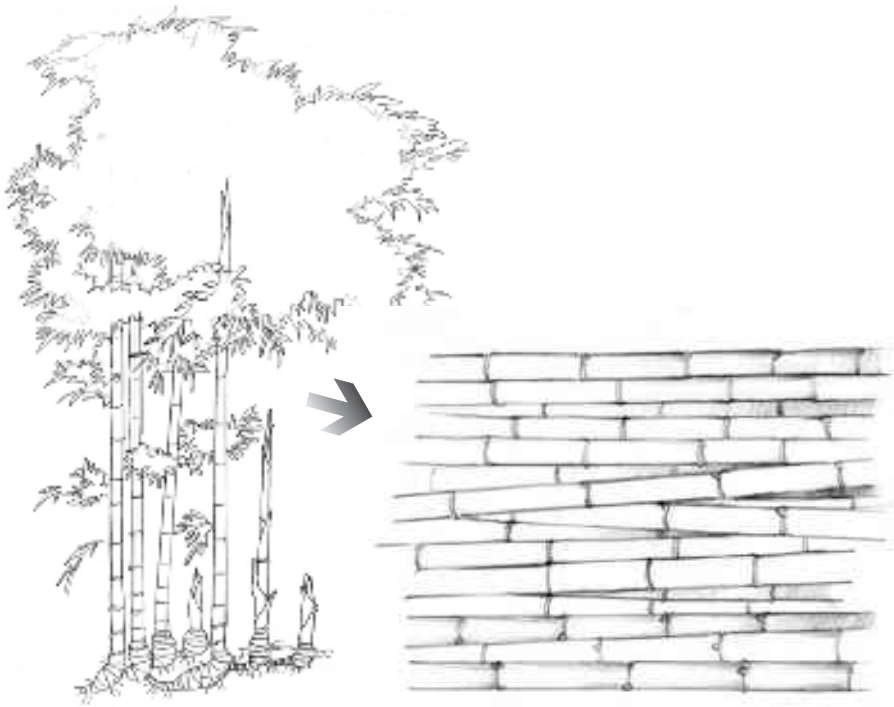
In this section, we change our focus to discuss steps toward maintaining a sustainable harvest. The harvest steps in this section are steps that will be performed year after year. These harvest steps will get easier as time goes on, as managing a well managed clump, with appropriate structure and spacing is relatively simple. Keep in mind, you will still need to maintain appropriate spacing, and structure of your bamboo, but you will find that a well managed bamboo clump will not require the culling of bamboo which is too old, broken, bent, diseased or small after an initial 2-3 years of management.

At the end of this section, are considerations of how to integrate sustainable harvest areas and practices into your business.

3.5.1
GOALS OF SUSTAINABLE BAMBOO HARVEST

The Goals of Sustainable Harvest are:

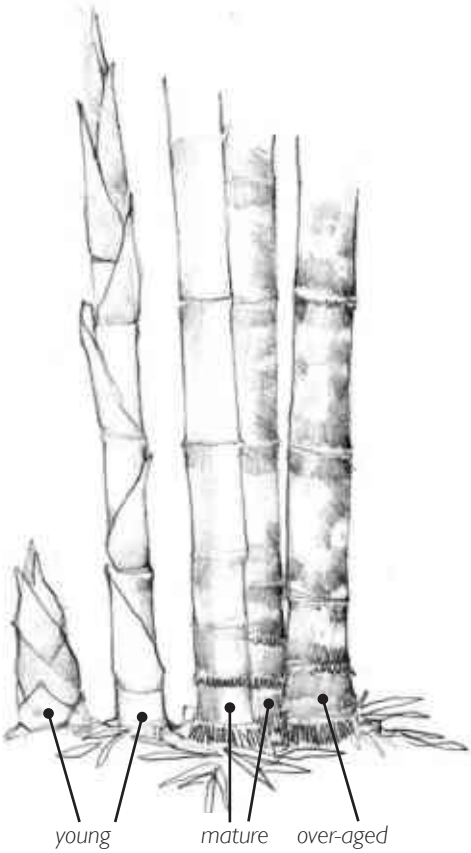
- Maintaining your social economic and social ecologic balance.
- Improving productivity of your bamboo
- Increasing shooting
- Maximizing the number of shoots that turn into culms,
- Improving the quality of your bamboo culms
- Maintaining the long-term health of your bamboo clump



3.5.2
AGE STRUCTURE OF A BAMBOO CLUMP

Tropical bamboos grow in clumps.

After shooting, bamboos can be split into three age classes;



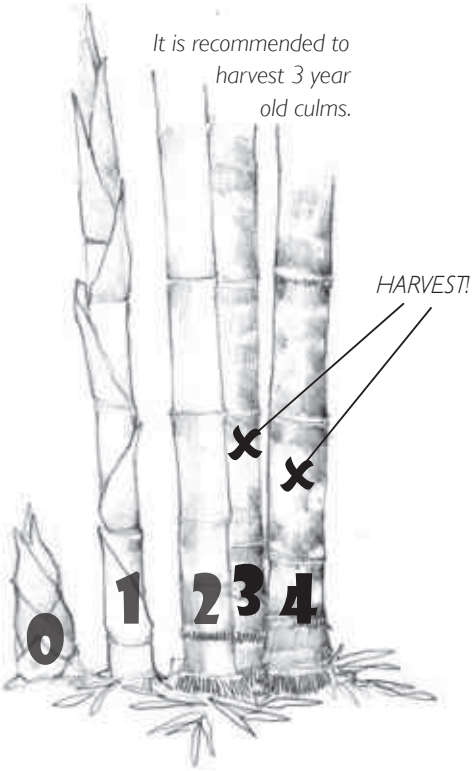
Each age class has a distinct pattern of growth;

1. **Young bamboo** – (1-2 year old bamboos). The tissues are tender, the rhizome buds on the culm base are well-developed and vigorous enough for excellent shoot production, culm walls are thick and water content is high. Branches, leaves and root systems have yet not fully developed. Two-year old bamboos are able to sprout new bamboo shoots.

2. **Mature** – When bamboos are 3-4 years old, they hold less water and culms

achieve peak strength. The remaining rhizome buds that have not produced shoots have less vigor and lower shooting capacity.

3. **Over-aged bamboo** – Around the 5th year, the bamboo leaves begin to fall away and the bamboo culm loses both its strength and ability to produce new shoots. However some *Dendrocalamus* bamboos maintain their strength up until the 7th year.

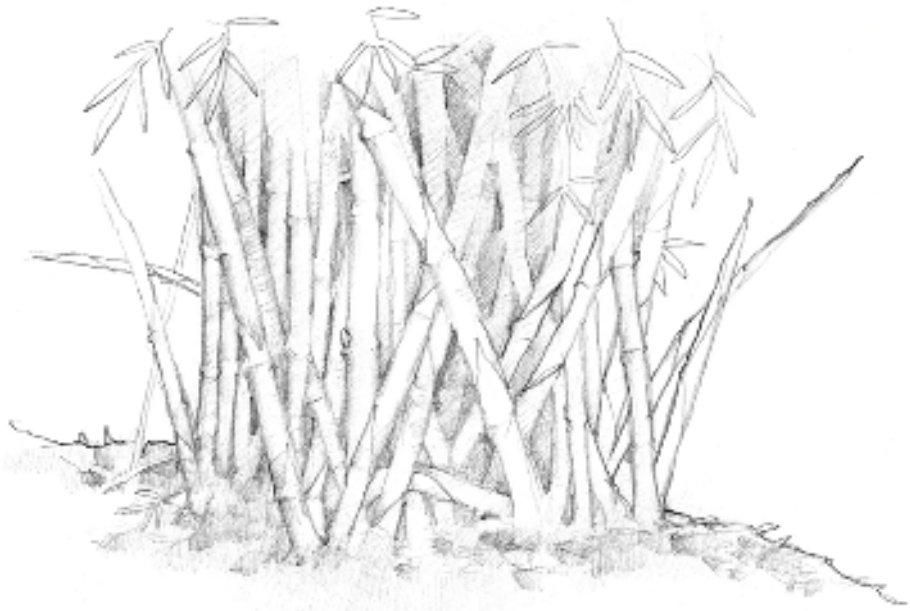


Three (3) year old bamboo culms from most species have already produced shoots, and are at peak strength. Most three (3) year old bamboos should be harvested, as well as nearly all four (4) year old bamboos.

There is evidence that *Dendrocalamus asper* can be harvested when culms are older, 4-5 years being recommended. Harvesting of young bamboo for woven products is a common practice, but does not result in maximum productivity of the bamboo clump.

3.5.2.1
CROWDING & AGE STRUCTURE

Bamboo clumps should be cut in order to grow well. Cutting, in this context, means selective harvest. Selective harvest of bamboo timber means cutting only 3-4 year old bamboos, once a year, every year.



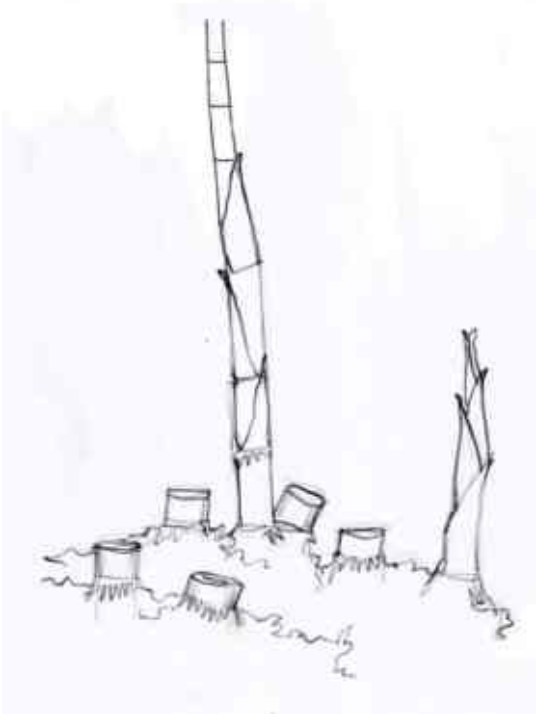
Over-congested G. apus which has seldom been harvested

If you neglect to cut your bamboo clumps, they tend to become congested, resulting in deterioration both in terms of quality and in quantity.

It is also difficult to extract bamboo from congested clumps.
If left untended, clumps of some species (such as *Gigantochloa apus*) become extremely congested.

3.5.2.2
CRY FOR MOTHER BAMBOO

It is important to be careful, when harvesting older bamboos that they are not currently providing nutrients to a young shoot growing into a culm. This is one reason why it is suggested practice to harvest in the dry season, when no new shoots are growing.



Young bamboo, whose mother is harvested while it is still growing ends up drastically tapered in diameter. In China this is termed "Cry For Mother Bamboo."

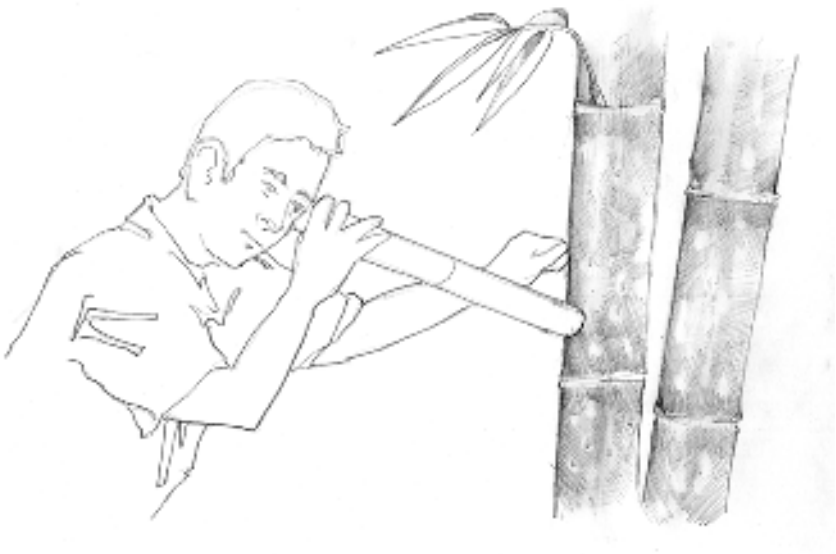
3.5.3
AGING CULMS

3.5.3.1
AGING CULMS

Intent:
To distinguish between various age classes of bamboo culms, when first approaching a bamboo clump, in order to facilitate appropriate harvest.

Approach:
There is a simple field tests that can help you determine the age of a bamboo culm when first approaching a new clump.

1. Resonance Test



- Take a section of 6-8 cm diameter bamboo, 50-75 cm in length.
- Hold one end of the bamboo to your ear and place the other end on the bamboo culm to be tested.
- Knock on the bamboo to be tested.
- Older bamboos produce a sound that lasts a longer time in the ear, this is known as resonance.
- Test this on bamboos of known age (new bamboos and obviously old bamboos) in order to train your ear to listen for resonance.

Considerations:

- Most bamboo growers are able to distinguish between young and old bamboo. Some clear signs are amount of lichen and moss on the culm, lack of culm sheath, amount of aerial roots on nodes, and coloration.
- Pays to be careful. In very wet forests, even one year old bamboo can be covered with lichen and moss. Coloration also differs depending on environmental conditions, particularly soil.
- Investing in a resonance meter may be useful for plantations, to ensure bamboo age.
- Once a bamboo stand is under management, it is useful to mark young bamboos with the year in which they emerged. Markings can be made with an oil based paint.

Definitions:

Resonance - The length of time that sounds are sustained in different materials

3.5.3.2
SELECTING BAMBOO FOR HARVEST USING RATIOS

Intent: To adhere to a simple ratio to assist in annual sustainable bamboo harvest.

Approach: No matter what size your bamboo clump, a simple ratio of leaving 4 - one year old bamboos, 3 - two year old bamboos and 2 - three year old bamboos in the clump each year leads to optimum productivity.

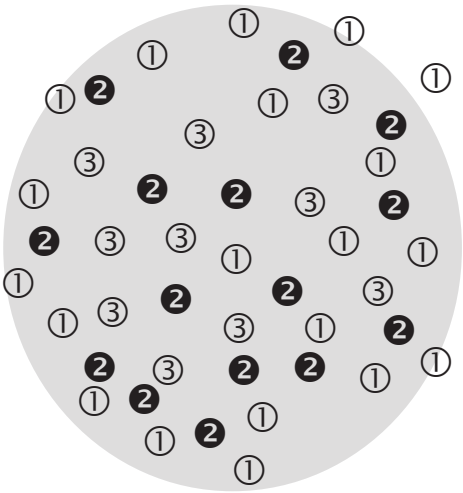
LEAVE
4-3-2 CULMS OF
1-2-3 YEARS OF AGE

The graphics below depict a clump with 45 culms being split into year classes based on the 4-3-2 ratio.

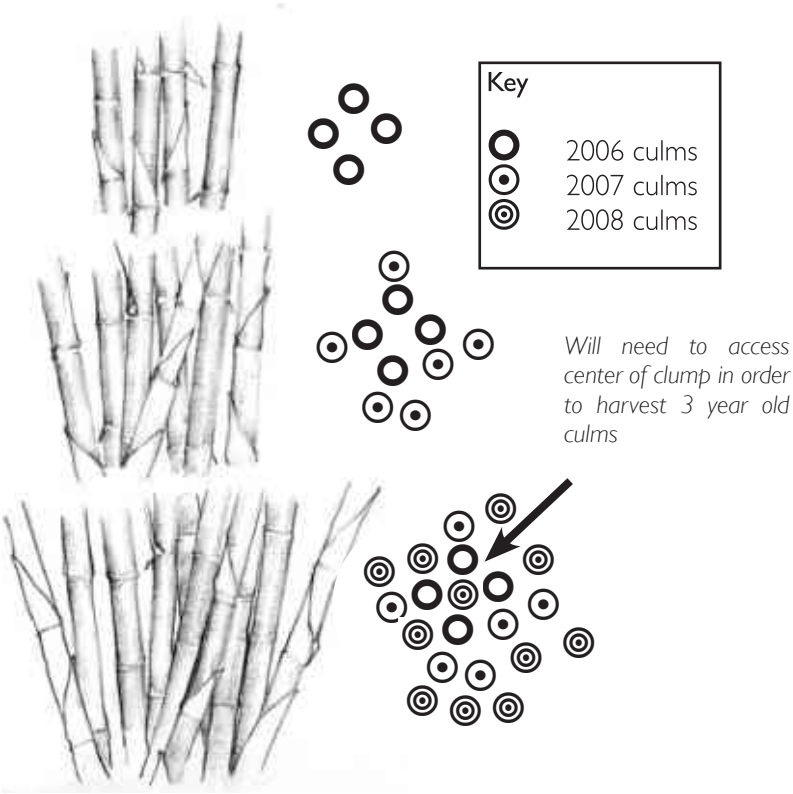
45 — 20 (1 year old)

15 (2 year old)

10 (3 year old)



Considerations:
Natural Growth and Development of a Clump
Over A Three Year Period (2006-2008)



In a bamboo clump, new shoots normally appear on the outwards edge of the clump (although shoots can grow on the inside of the clump if there is adequate room and soil).

Older culms are usually found in the center of the clump.

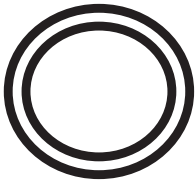
Harvesting of bamboo therefore take place predominantly in the center of the clump. This means you will need access to the clump center.

Considerations (continued)
Relationship of Culm Density Within the Clump to Yield:

When determining the appropriate ratio and spacing for your bamboo, refer to the following:

Lower standing-culm densities promote increased diameter of each culm but reduce total yield.

Diameter =



Yield =

Higher standing-culm densities increase total yield but reduce diameter of shoots and culms.

Diameter =

Yield =

3.5.4
HORSESHOE HARVESTING METHOD

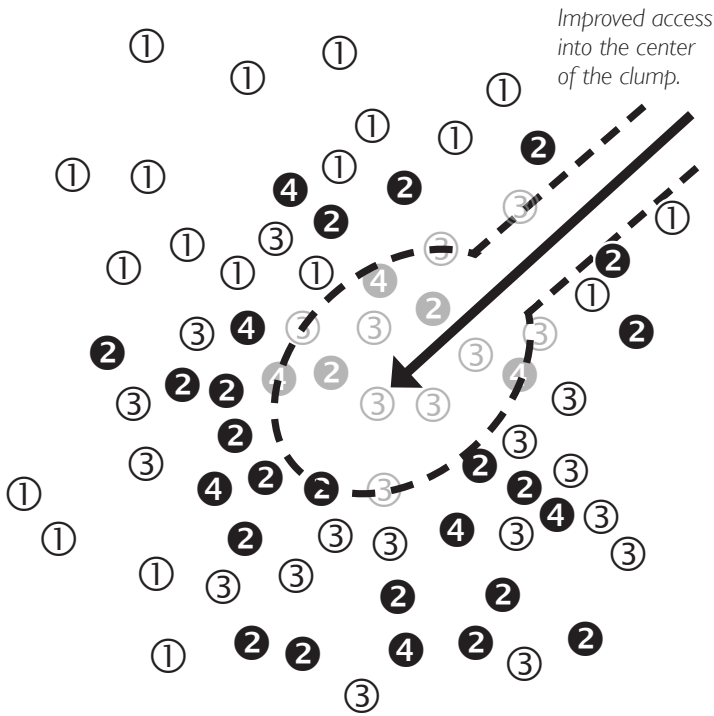
Horseshoe Harvesting Method

Intent: To open up the center of the clump for improved access to bamboo culms, and to make space for growth of future shoots.

Approach
One way to maintain access to the clump center is to harvest in the shape of a horse-shoe (below)

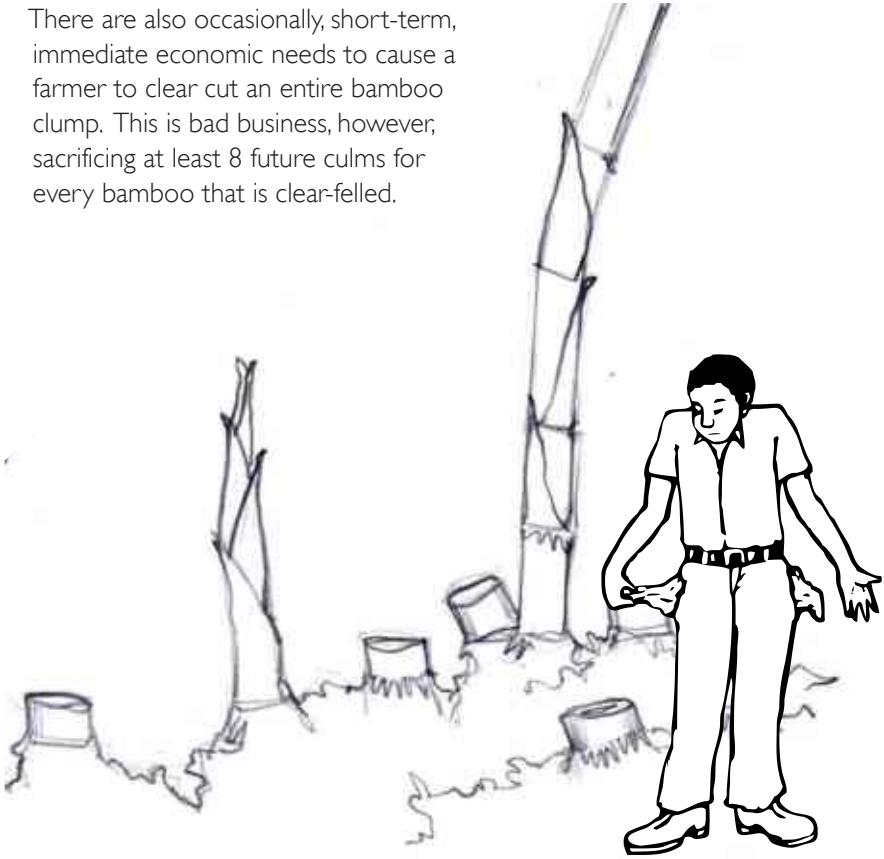
The open end of the horse-shoe facilitates entry inside the clump for cutting of mature stems.

In creating the opening initially, it may be necessary to cut some younger bamboos (1-2 years old). In the clump below, cut bamboos are indicated by fading. No one year old bamboos were harvested below, but a pair of 2 year old bamboos were cut from the clump center to facilitate ease of future harvesting.



Considerations:

- Occasionally, when a clump is overgrown, there is temptation to clear cut the entire clump. For most species, clear cutting will seriously reduce the future productivity of the clump, and if done repeatedly can even kill the clump.
- For over-crowded clumps it is recommended to clear a harvesting pathway through the clump, and then engage in regular harvesting.
- There are also occasionally, short-term, immediate economic needs to cause a farmer to clear cut an entire bamboo clump. This is bad business, however, sacrificing at least 8 future culms for every bamboo that is clear-felled.



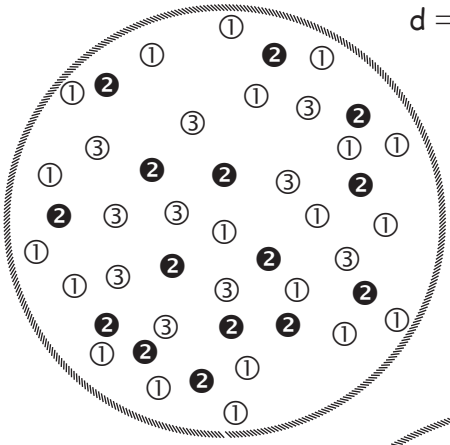
Case Study:

A natural forest of about 30,000 hectares existed in the 1960s in West Banyuwangi Forest District, East Java, Indonesia. This very healthy bamboo forest consisted purely of the sympodial species *Gigantochloa apus* (Bl. ex Schult. f.) Back. ex Heyne. Lack of knowledge of appropriate harvesting led to poor extraction practices (mechanized harvesting using tractors and featuring clear cutting of clumps), lead to the drastically reduced culm productivity, ceasing of natural regeneration, and eventual destruction of the forest (Sulthoni, 1995).

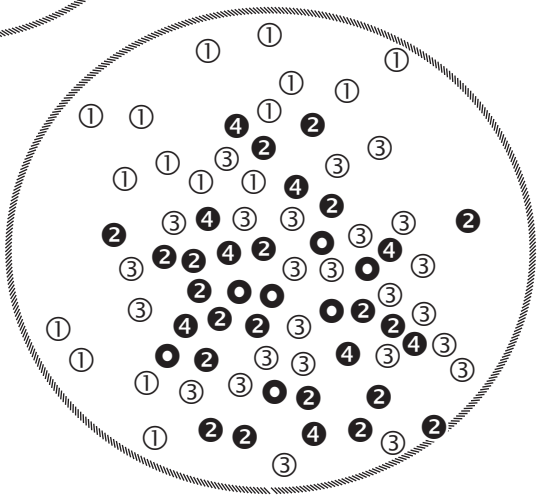
Practice Cutting

Below are two clumps of bamboo. Practice cutting the clumps based on the harvest guidelines from this section by marking bamboos with different letters

x = cut the culm
d = dig the young shoot



Clump A



Clump B

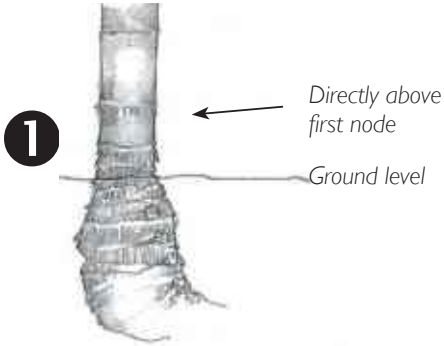
Explain your choices to the group.
How many bamboos did you cut
from Clump A? Clump B?
Next year, how many culms do you
expect to cut from Clump A? Clump B?

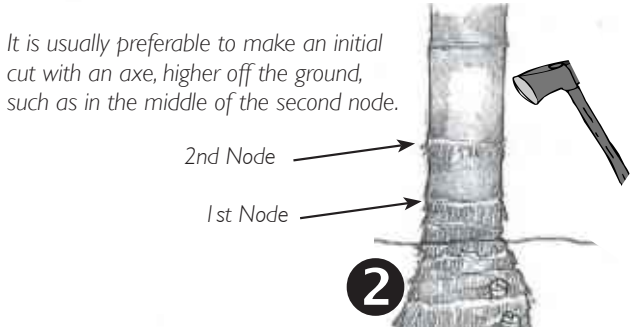
3.5.5
FELLING BAMBOO

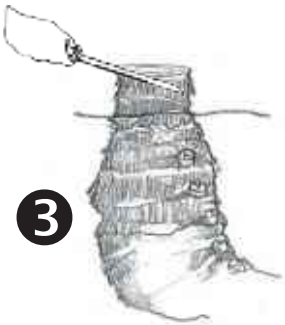
Intent: Appropriate felling of a bamboo culm for long term health of the clump, and maximum value of the culm.

Approach

A. Culms should be cut between 15 - 45 cm from the ground, directly on top of the first node above ground. Cutting too high above the ground is a waste of raw material



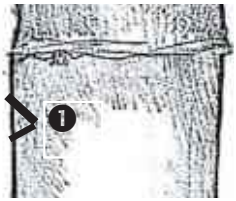




FELLING BAMBOO
(continued)

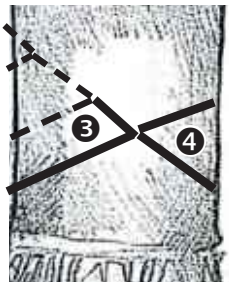
Approach (continued)

B. Follow these steps when cutting bamboo with a saw.



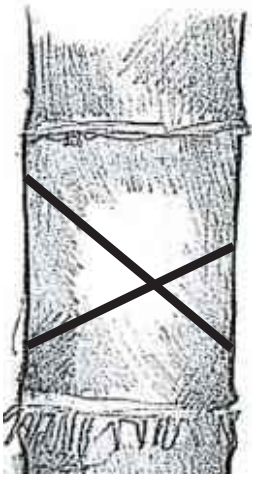
❶ Cut a small wedge on the felling side.

❷ Cut a larger wedge.



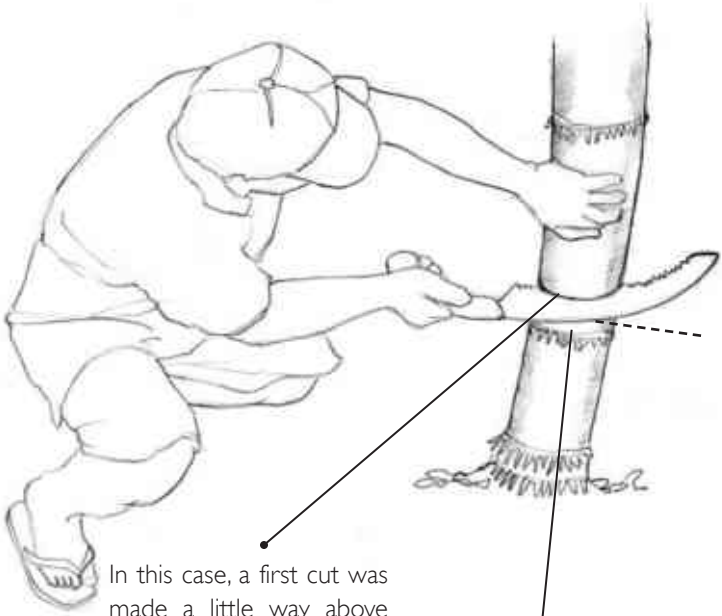
❸ Still larger.

❹ Make a back cut.



At this point your bamboo will be ready for removal from the clump, but BE CAREFUL, bamboo can snap quickly and move dangerously when felled.

Sometimes it is possible to cut a bamboo culm directly above the first or second internode on the first try. In other cases, you will need to cut the bamboo as low as possible on the first try (in order not to waste bamboo material), and to clean up the cut a second time, right above the internode.



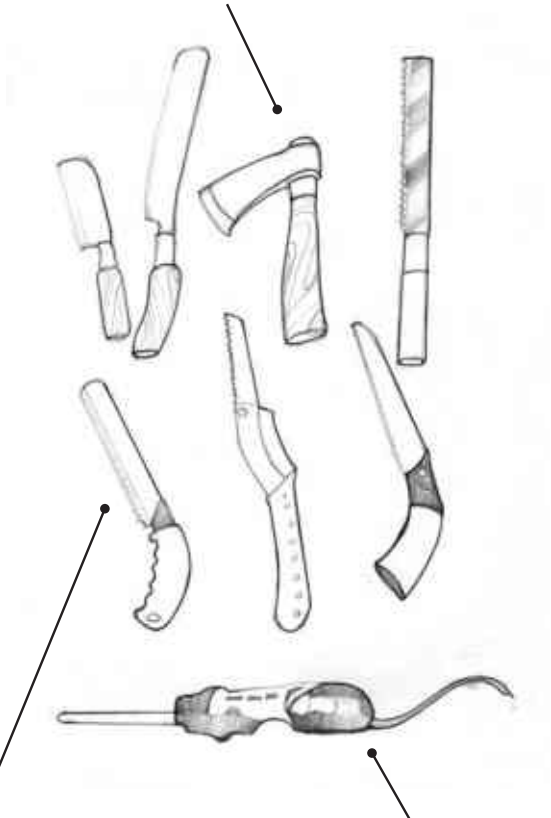
In this case, a first cut was made a little way above the internode (perhaps to avoid splitting the bamboo, or because other culms were in the way).

A second cut will be made directly above the internode, so that no water can collect in the remaining bamboo stump.

FELLING BAMBOO (CONTINUED) TOOLS YOU WILL NEED

Considerations:

HATCHETS/AXES are perhaps the preferred tool for making the initial cut on a bamboo culm. This cut should ideally take place directly above the first node, but may be made above the 2nd or 3rd node if cutting is difficult (in a crowded clump).



Sharp, thin-bladed SAWS are always used for cleaning up cut, after the initial felling. One should always saw directly above a node.

A POWER RECIPRO SAW is a time-saving tool, enabling bamboo foresters to make quick, clean cuts. Use of a power recipro saw requires a portable generator.

FELLING BAMBOO
(continued)
CLEANING STUMPS

Considerations (continued):
Stumps are cleaned up so that water will not collect in the bamboo stump.

Water collecting in the stump infects the bamboo (through bacteria, fungi and parasites) and also provides a breeding area for mosquitoes.

After cleaning the stump, it is best to create a hole, and fill the hole with fertilizer (see Section 3.4.11). The stump is then topped off with soil. This allows the stump to deteriorate in a disease-free way, making room for future bamboo shoots. It also provides nutrients for any shoots that the bamboo stump will continue to produce.

3.5.6
BIODYNAMIC BAMBOO STUMP PASTE

Intent:
After cutting bamboo, the following paste can be applied to the freshly cut bamboo stump, that both nourishes the bamboo plant, and also protects the bamboo tissue by sealing it against pests.

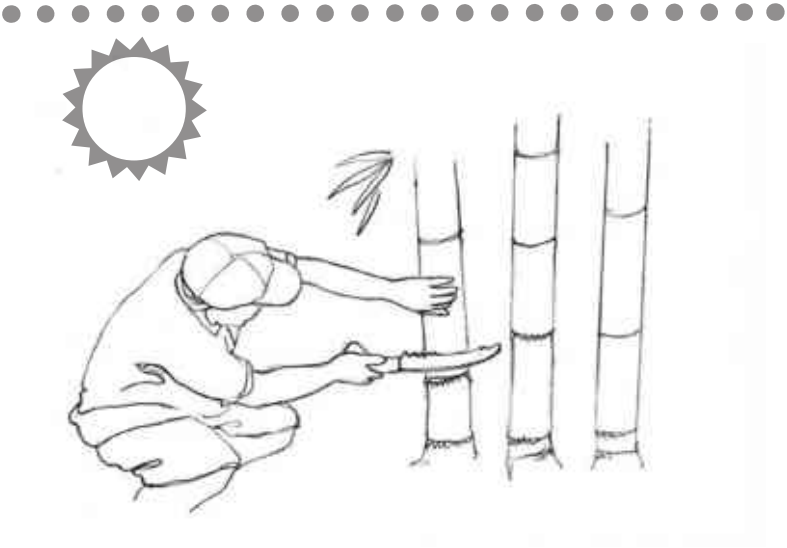
Approach
Mix the following ingredients:
4 parts cow manure
2 parts silica sand or diatomaceous earth
3 parts clay or bentonite
1 part dried blood

The proportions do not need to be exact, and you can leave the blood out of the recipe. The cow manure should not be fresh.

The ingredients are stirred into a sloppy paste with rainwater.
Remove all debris from the bamboo stump, and paint the paste on the stump after harvest.

3.5.7
ADDITIONAL HARVESTING TIPS

Consideration:



The dry season is the best time to cut bamboo in the tropics.

ADDITIONAL HARVESTING TIPS
(continued)
Consideration:

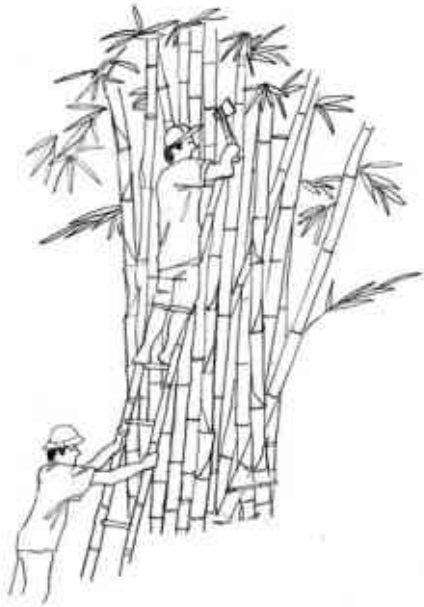
- In a sustainable harvest system, one and two year old culms should never be cut. One and two year old culms are needed to make new shoots.
- Occasionally you will need two year old bamboos for making woven bamboo pieces (as they are more pliant than mature bamboo culms). These

should be harvested with care, following the same instructions as harvesting mature culms.

- If you require young culms for woven bamboo products, it is wise practice to set aside an area where young culms may be harvested. This area should not overlap with a bamboo stand that is dedicated to sustainable harvest of mature culms for superior bamboo timber.

ADDITIONAL HARVESTING TIPS
(continued)

Cutting Debris
All cutting debris should be collected and removed away from the clump. Leaves should be used for mulch or animal fodder, branches can be used for handicrafts, building material, or carbonized for high quality charcoal.



No Lopping
Lopping means cutting bamboo near the top of the plant.

Never lop bamboo
Only cut bamboo near the top of the culm if you are trying to induce sub-branching for propagation. This is done by cutting the culm 1.5 meters from the tip in the end of the growing season. Sub-branches will form with aerial roots, ready to separate and plant directly.

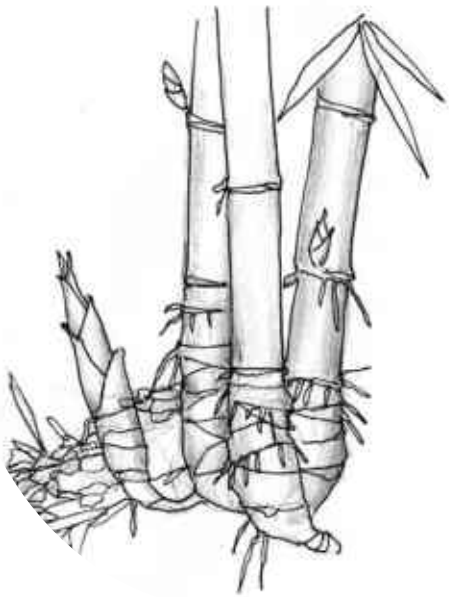
ADDITIONAL HARVESTING TIPS (continued)
Bamboo Shoots

Intent:
Harvest bamboo shoots which will disturb the overall health of the clump and distribution of nutrients to timber culms.

Approach:
This manual has not concentrated on bamboo management for shoot harvest. Nonetheless, when managing bamboo for maximal production of culms for timber, it is also common practice to harvest some shoots.

- Harvest all shoots which emerge very early or very late in the shooting season.
- Harvest all shoots which emerge very bent or crooked.
- Harvest shoots which will cause crowding in the clump.

Considerations:
Studies in China on the changes in nutrient content of bamboo shoots of different ages show there is a definite advantage to harvesting the shoots while they are still underground with sheaths just appearing above ground. Tests were done, using Phyllostachys pubescens (a monopodial bamboo), by harvesting at three different stages: underground, 5 days above ground, and 10 days above ground. It was found that protein and amino acid content are highest when shoots are still underground. In fact the author stated that protein content of a bamboo shoot (P. pubescens) underground is higher than any other vegetable.



3.5.8
BAMBOO EXTRACTION

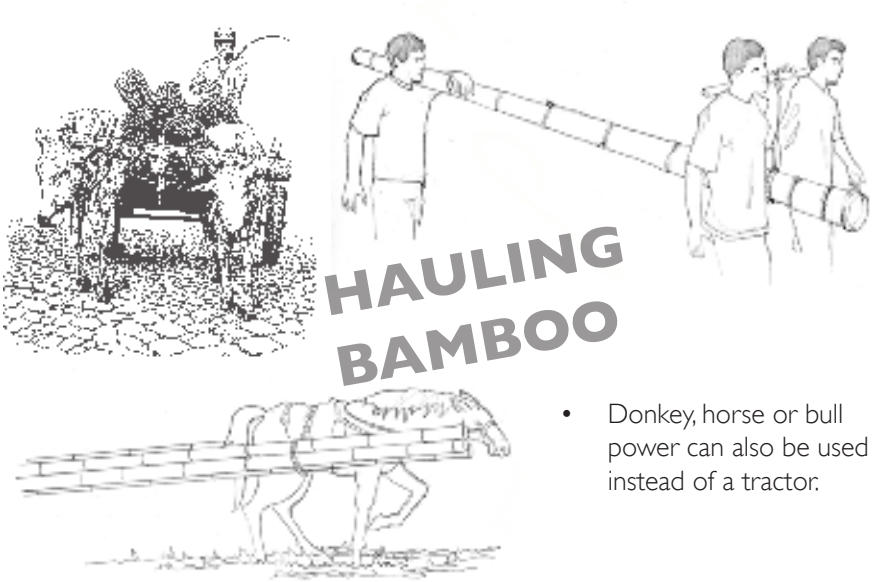
Bamboo Extraction

Intent:

Creating a clear plan for extraction of bamboo from the forest after harvest, to a centralized site for processing or sale.

Approach

- On less rugged terrain, hauling of cut stems and loading onto carts can be done easily using human labour.



- Donkey, horse or bull power can also be used instead of a tractor.

In areas where terrain is not level and where cutting is done in the bottom of a valley a winch assisted by a pulley fixed to a tree can facilitate the hauling of the harvested culms. The stems are bundled together, so that these can be pulled easily to the roadside or collection area.

Considerations: Hauling of culms should be carefully planned before any harvesting takes place. This is often ignored when planning for the extraction of bamboo. Failure to have a clear plan for the hauling of culms can result in excessive damage of other vegetation and may result in excessive soil compaction.

3.5.9
TEMPORARY BAMBOO STORAGE

Intent: Stock-piling bamboo before it gets to a processor.
Before the bamboo goes to a processor, it may be necessary to stock-pile the bamboo. This is the stage where most high quality bamboo timber losses its value due to improper storage.

Improper Storage has the following risks associated with it

- Time for bamboo to be attacked by termites and powder-post beetles.
- Direct placement in sun causes warping and cracking
- Direct placement in rain causes warping, cracking, and fungal damage
- Placement in a non-ventilated situation leads to fungal infection.

Approach:
Soaking

1. Cut bamboo into desired length. Six meter poles are usually the maximum length for shipping concerns.
2. If soaking whole poles, it may be necessary to puncture a hole through all of the diaphragms of the entire length of bamboo, but check first with your purchaser. If they treat their bamboo with the Vertical Soak & Diffiusion method, you will not be able to puncture the lower one or two diaphragms.
3. If soaking splits, split the bamboo into desired lengths.
4. Be sure to completely submerge the bamboo. Weigh the bamboo down with large rocks, or cleaned, recycled oil drums filled with water or sand.
5. You may submerge the bamboos in running or stagnant water, for the purposes of temporary storage. Salt or brackish water is also ok, but marine borers may begin to infest the bamboo.

Smoke storage

1. Build a platform out of bamboo, much like a table, 75 cm to 1 meter off of the ground.
2. Pile bamboo (splits or whole culms onto the platform).
3. Cover the bamboo with a tarpaulin or sheets of woven bamboo.
4. Start a small fire, low fire under the bamboo, and keep smoking for 2 days. Use of wet firewood assists smoking/smoldering.
5. After smoking for two days, the fire can put out for up to 5 days. Each week that the bamboo is stored, the fire should be lit for approximately two days, until the bamboo is transported for sale.

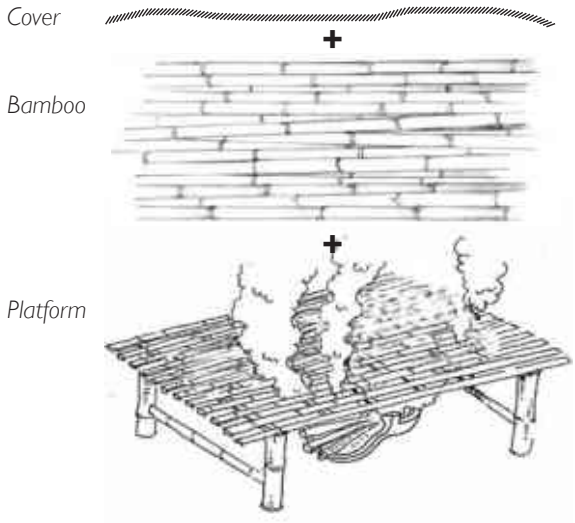
Considerations:

Soaking

- Soaking bamboo in fresh water effectively reduces the starch content of the bamboo.
- There is some debate as to whether soaking in running or stagnant water is better. The debate rests in the action of aerobic versus anaerobic bacteria on the bamboo.
- Soaking bamboo in brackish water (i.e. in a mangrove area) may introduce several marine salts and ions which act to preserve the bamboo. Further research on this needs to be carried out.
- Soaking bamboo directly in salt water usually leads to infestation by marine borrers.

Smoking

- Be careful to keep the fire low, especially during the dry season. Do not leave the fire un-attended.
- Smoking may change the exterior color of the bamboo, and will coat some bamboos with a layer of tar. This may need to be cleaned before sale.
- Improved smoking methods, which may preserve the bamboo for longer periods of time, are being developed, but no methods are yet available for widespread distribution.



3.5.10
OVERVIEW OF HARVEST GUIDELINES

The following bamboo cutting rules are to be followed for a well established bamboo area, taking into consideration what has been stated above:

3.5.10.1
CUTTING CULMS FROM A PREVIOUSLY UN-MANAGED CLUMP

Cutting Culms from a Previously Un-managed Clump

- Cut, remove and burn all diseased culms as well as parasites growing on culms
- Cut culms which BSBOD UNLESS.... they are needed to provide support for younger growing bamboos in a clump with too few culms OR.....they are able to produce healthy shoots which will grow into straight, strong culms.
- In some cases, PARTS of a clump which has never been cut, will need to be clear cut in order to improve spacing.
- All cutting debris should be collected and removed away from the clump.

Annual Cutting Practices

- Get into the practice of cutting 3 and 4 year old bamboo only.
- Get into the practice of harvesting bamboo only in the dry season.
- Culms should be cut above the first node above the ground.
- Cuts should be clean, so that bacteria do not infect the stump.
- After cutting, you should make a hole in the stump, fill with fertilizer and cap with soil. This will feed young bamboo and deteriorate the unwanted stump in a disease-free way.
- All cutting debris should be collected and removed away from the clump
- Lopping of bamboos should be prohibited.
- Make a plan for hauling the cut material from the forest.

3.5.10.2
TREATING BAMBOO

Bamboo culms are a natural material susceptible to insect and fungal attack. Without teatment, products made from bamboo can be expected to last up to 3 years. There are many different techniques for curing and treating bamboo culms in order to prevent splitting, insect infestation and fungal growth. Details can be found in Appendix C and on the following websites:-

1. EBF Vertical Soak Diffusion Method. http://www.bamboocentral.org/index/htm
2. Bamboo Preservation Compendium: http://wwwlnbar.int/publication. Walter Liese and satish kumar.2003.

3.5.10.3
ZONATION FOR LONG-TERM SUSTAINABLE YIELD

Intent: Develop realistic harvesting practices, good for the bamboo and for the farmer.

Approach:

1. Work with bamboo growers to divide the bamboo forest into three zones;
    - Intensive Production for 3-4 year old timber culms.
    - Non-intensive Production for 3-4 year old timber culms.
    - Non-intensive Production for 2 year old culms for woven products.
2. After 10-15 years of management and production, switch the intensive and non-intensive areas.

Considerations: There are always short-term incentives to both over-harvest bamboo and harvest bamboo out of season. Due to need for constant supply during processing, even large-scale bamboo product manufacturers, with a vested interest in long-term sustainable supply and high quality materials, will purchase bamboo out of season (in the rainy season for interest) in order that inputs (bamboo) and outputs (products) flow in accordance to demand.

The previous approach discusses the best way to harvest mature bamboo culms, for superior timber. It is unrealistic to manage all bamboo stands in the same way. As an alternative, it may be best to manage bamboo stands in a patchwork mosaic, with some areas under strict management and sustainable harvest guidelines, and other areas producing younger bamboos (harvested at 2 years for woven bamboo products).

Stand Growth: The growth habit of bamboo groves can be classified into two types: on-and-off year groves and even-year groves. In an off-year, the number of shoots is relatively low compared to the on-year.

Rhizomes are mainly developed in off-years, when leaves are exchanged as well. Shooting and rhizome growth habits are relatively equal in even-years. On-years and off-years alternate regularly. When bamboo stands are managed intensively, in order to maximize production (all on-years, no off-years), the clumps within the stand "age" rapidly. This will push the bamboo clumps into early flowering, and reduce the long-term sustainable production of the entire stand.

3.6
ECOLOGICAL PEST & DISEASE MANAGEMENT

Intent:
To maintain a healthy balance of pests and natural enemies in the bamboo agroecosystem to a point where infestation of pests and disease does not cause substantial economic losses.

Principles:
Although numerous pests and disease act to impede the normal growth of bamboos, and some potentially cause significant devastation to a bamboo crop, pesticide use should not be viewed as a long-term solution or appropriate management tool. An integrated approach to pest management prioritizes raising healthy plants in healthy soils; yet also involves careful observation of pests and disease, mild interventions, acceptance of minimal losses, stimulation of natural enemies and inter cropping.

Healthy bamboo plants, growing in healthy soil in a balanced bamboo forest will by and large, not be attacked by an excessive amount of pests.

Pests and disease can be considered excessive when significant economic losses are being experienced (excessive damage to shoots and culms). Excessive pest and disease infestation indicates an unhealthy imbalanced system. The first step of pest management is therefore to understand the imbalance in the system. The assessment section (Chapter 2) will help you identify imbalances in the bamboo forest.
A healthy bamboo culm with healthy apical buds can produce between 6-8 culms in one lifetime. An un-managed culm will usually produce only 1-3 culms in a lifetime.

3.6.1
SIX PRINCIPLES OF ECOLOGICAL PEST MANAGEMENT

Below is a summary of a presentation by R.F. Smith and H.T. Reynolds to an FAO symposium in 1966 concerning the ecological approach inherent in Integrated Pest Control. These principles still hold true for agroecosystems today.

Principles of Integrated Pest Control

1. Use of Chemical Pesticides:

   The use of chemical pesticides, without regard to the complexities of the agroecosystems in which they are used has been a major cause of disruption and undesirable side effects. Undesirable side effects include: target pest resistance and/or resurgence, secondary pest outbreaks, residue problems, and environmental pollution.

2. Agroecosystem analysis

   The agroecosystem is a unit composed of the total complex of organisms in the crop area together with the overall conditioning environment. There must be an analysis of the agroecosystem to determine population dynamics and mortality factors operating on pest populations.

3. Field Studies

   In more sophisticated programmes, individual fields are surveyed for populations of pests, parasites, predators, and pathogens. On the basis of this information and a consideration of the time of the year, stage of growth of the crop, and weather conditions a prediction can be made of population trends and potential damage. This type of sampling and prediction requires a solid base of fundamental biological and ecological data.

4. Complexity

   The kinds of crops, agronomic practises, patterns of land use, weather, total complexity, and self-sufficiency, of the agroecosystem affect the stability of an agroecosystem. As complexity increases, particularly among trophic interactions, there is usually an increase in the stability of the agroecosystem. Integrated Pest Management should seek to preserve or improve this complexity.

   Tolerable Damage

   Levels or limits of tolerable damage are more important than pest population levels. Tolerable levels of damage vary with market conditions, stage of the crop, local conditions or grower economics, and the personal

values of the people concerned. These levels will vary widely. The presence of pests is not an indication of a threat of economic damage to the crop.

6. Conservation of Natural Enemies and Living Controls
   All but the most sterile of man made environments have some biotic agents influencing pest populations. Appropriate consideration must be given to biotic control agents. In some fortunate situations, the biotic agents are all that is necessary to have satisfactory economic control. The failure of natural enemies to keep a given pest under control should not cause us to invoke control practises that disrupt the controlling action of natural enemies of other species in the same agroecosystem.

3.6.2
ECOLOGICAL PEST & DISEASE MANAGEMENT

This section (3.6) on pest and disease management and control will elaborate on the above six principles, in the specific context of sustainable management of bamboo ecosystems. At the end of the section, some mention is given to common bamboo pests and diseases.

Eradicating Use of Chemical Pesticides:
As in human health, there are two types of actions to combat disease; Preventative Measures and Curative Responses. Approaches suggested in this section focus on preventing disease outbreaks for a variety of reasons:

3.6.3
PREVENTATIVE MEASURES VS. CURATIVE RESPONSES

Positive Impacts of Preventative Measures
+ Maintaining healthy soil and growing a healthy bamboo crop will minimalize the impact of pests and disease in and of itself. Pest and disease attack on well managed bamboo clumps is negligible

Negative Impacts of Curative Responses
- Chemical pesticides and fungicides are costly external inputs and will seldom be used by bamboo farmers
- Chemical pesticides are harmful to the environment, and also harmful to populations of natural enemies which will control pests at a tolerable level.
- Chemical and even natural pesticides, used in the long-run create resistance

in the targeted pest or disease.

- If your approach to pest management is to isolate a single pest or disease for "eradication" you are fighting against the entire bamboo ecosystem.

3.6.4
REVIEW OF CLUMP MANAGEMENT AS PEST PREVENTION

The previous five management steps discussed in this chapter (adjustment of clump structure, weeding, soils and soil nutrient management, and harvesting techniques) are the best preventative measures for maintaining tolerable levels of bamboo pests and disease. Below is a brief review of how these management steps work to prevent pests and disease.

1. **Appropriate Clump Structure:** A bamboo clump which is not overly dense will have good air circulations, lowering fungal attack, and culms will have sufficient light and nutrients in order to grow healthy and resist attack from pests and disease.

   A clump which is too sparse, however, will lack structural support and is at risk of breaking in the wind, giving rise to disease. Also, without enough mother bamboos, nutrient provision to young culms is lower, and young culms may not develop properly, putting them at higher risk of attack as well.

2. **Weeding:** This point is debatable. From an Integrated Pest Management point of view, leaving undergrowth and weeds intact will more closely mirror a natural ecosystem, maintaining balance between natural enemies and pests. In essence, natural controls will be stronger.

   Others maintain that eradication of weeds will keep pest populations low. This really requires some longer term scientific studies to better understand the dynamics of a bamboo forest or agroecosystem. It is likely that leaving weeds and undergrowth intact is actually beneficial to the bamboo forest, even with increased competition for water and nutrients.

3. **Soil Systems:** The best soil type for bamboo would have a roughly equal mixture of sand, silt and clay, and is called a loam, or loamy soil. A loam offers a mixture which includes the benefits of having some sand (water, roots, air, and nutrients can move freely). These benefits counteract the negatives of having too much clay. A loam also has some amount of clay, imparting the

benefits of good nutrient and water-holding capacity, which in turn will provide ideal conditions for bamboo growth and maintenance of health, including resistance to pests and disease.

In addition, soil systems with good texture and structure, give rise to healthy and diverse soil communities. The majority of soil-living organisms are bacteria and fungi and nematodes.

While farmers may know that some of these organisms are the cause of disease for their crops, but actually, the vast majority of them serve a positive role. Many of the fungi serve to breakdown and process dead organic matter into smaller-and-smaller components. These organisms are called "saprophytes". Many of the bacteria serve a useful function in transforming nutrients into forms that are then able to be absorbed by the plant roots. Still others—both fungi and bacteria--may act as predators and parasites to help protect the plant roots from attack by diseases and pests. In other words, just like in the above-ground system, there exist pests and natural enemies in the soil system as well.

4. **Soil Nutrient Management:** The very best way to ensure that a proper balance of nutrients is fed to the soil, is to return as much of the original plant material as possible to the soil after harvest. All nutrients, whether organic or inorganic, tend to be taken up by soil microbes first, before becoming available to the plant.

   In this way SOM, together with the microbes that feed on it, will bind or capture nutrients in a form that allows the stable longer-term storage of nutrients, and their slow release into the soil and eventually into the roots of the plant. This is a much more efficient way to feed the plant because nutrients are released a little at a time over a longer period of time. Too much fertilizer, entering the plant too quickly, can cause problems with disease.

5. **Sustainable Harvest:** In terms of pest and disease control, appropriate harvest is closely related to appropriate structure discussed previously. All of the harvest practices mentioned in the previous section are aimed at maintaining long-term plant health, which in and of itself wards off pest and disease.

   In terms of specific practices, harvesting most 3 year old culms and all culms

by the time they are 4 years old, means that a clump only consists of young and vigorous bamboo culms. Without the presence of older culms which are in the process of physical deterioration, there are less vectors for attack by pests and disease.

Additional practices, such as cleaning off cut stumps, puncturing their nodes and filling them with fertilizer, decomposes the stump in a way that is less prone to fungal and bacterial attack.

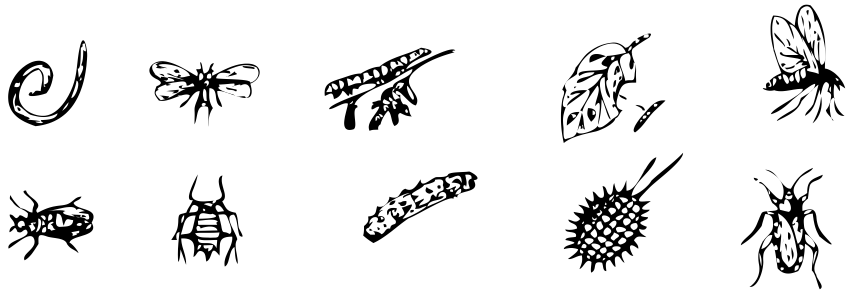
Spend your time and effort taking care of your soil and feeding your plants, rather than worrying about insects. By and large, observation and thoughtful actions are the best tools for pest management.

3.6.5
TOLERABLE DAMAGE

All Six Measures in this chapter, focus more on bamboo clump rather than at larger scales. The following chapter will take a step back from the bamboo clump, and look at the agroecosystem and landscape scales of a bamboo system. Proper management actions at these larger scales, should also be considered preventative measures against pest infestation.

Before jumping to the agroecosystem and landscape levels in Chapter 4, the final sections of this chapter, "Tolerable Damage," and "Conserving Natural Enemies & Living Controls" discuss several curative actions (that do not involve the use of chemical pesticides) that can be undertaken if you are unable to establish a healthy balanced bamboo ecosystem.

Tolerable Damage
Levels or limits of tolerable damage are more important than pest population levels. Tolerable levels of damage vary with market conditions, stage of the crop, local conditions or grower economics, and the personal values of the people concerned. These levels will vary widely. The presence of pests is not an indication of a threat of economic damage to the crop.



Key Principles

- For the most part, insect pests can be tolerated in living bamboo clumps, allowing natural enemy populations an opportunity to suppress pest populations.
- The presence of pests is not an indication of a threat of economic damage to the crop. Only when pests threaten a significant amount of culms.
- In order to have natural enemies in your area, you must have some pests as their prey. Eradication of pests means loss of natural enemies as well, and usually the pest population will bounce back without control.
- The allowance of tolerable thresholds, followed by proper decision making and finally curative pest control are the proper steps toward pest management in bamboo.

3.6.6
CONSERVING NATURAL ENEMIES & LIVING CONTROLS

Conservation of Natural Enemies and Living Controls

All but the most sterile of human made environments have some biotic [living] agents influencing pest populations. Appropriate consideration must be given to living control agents. In some fortunate situations, the living agents are all that is necessary to have satisfactory economic control. The failure of natural enemies to keep a given pest under control should not cause us to invoke control practices that disrupt the controlling action of natural enemies of other species in the same agroecosystem.

Pests and Diseases that attack bamboo culms are divided into three groups; those that attack:

- Bamboo seedlings in nursery
- Living bamboo clumps

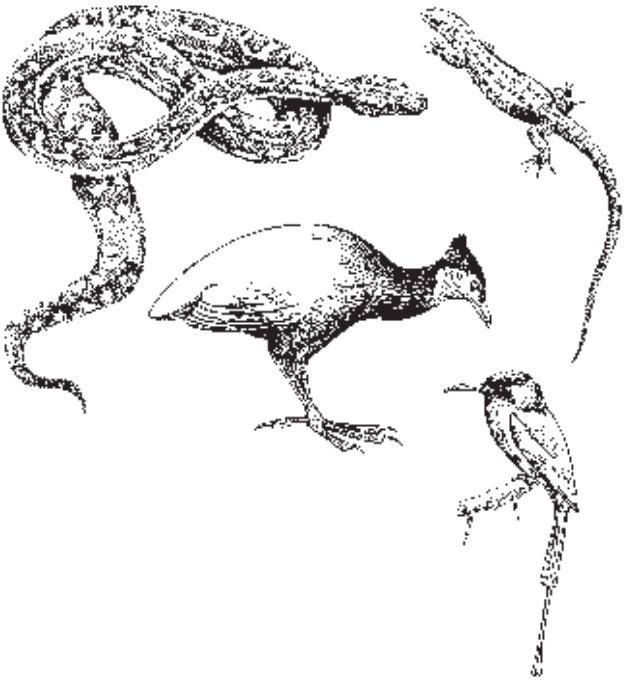
- Bamboo that is in storage or manufactured bamboo

The following pages will provide descriptions of a few alternative solutions to pesticide use, to counter-act attack from pests and disease.

Of these natural or living controls, encouraging natural predators to control bamboo pests is amongst the most important and least labor intensive. REFER TO PAGE 148

Predators are among the most important natural enemies of bamboo pests. Together with parasites and insect pathogens they keep populations of biological pests down.

Spiders - An important group of predators commonly found in bamboo clumps are spiders. Of particular importance are the hunting spiders, such as the Wolf Spider, Lycosa psuedoannulata. This generalist is often found hunting in the bamboo plant feeding on a variety of insects.



Birds – Birds can eat hundreds to thousands of insects a day. Some species eat over 150,000 worm eggs per month. Others can devour 20 large caterpillars a minute. Encourage a variety of birds in your forest.

Birds like areas with moving water, berry bushes, and seeding grasses. Birds do not like men and boys with air-guns who want to shoot them and lock them up in little cages.

Toads and Snakes – Toads eat pests and predators alike. Snakes are good controls for baby porcupines (which eat bamboo shoots in the tropics)

Flies and Parasitic Wasps– Some flies and wasps are parasites which can control beetles, caterpillars, moths, worms, grasshoppers, aphids, earwigs etc.

3.6.6.1
LIVING CONTROL APPROACHES

Intent: Appropriate, non-chemical controls, of pests and diseases that have already been determined as damaging to a significant amount of a bamboo crop.

Approach:
Once you have determined that a certain pest species is damaging a significant amount of your bamboo, you may need to spend some time and energy in controlling the pest.

- Hand-Picking

Hand-picking of insects which you are sure are a pest and are harmful to the bamboo can be effective means of control. Grind a few of these insect pests into a powder, dry, burn and sprinkle around your bamboo to reduce the risk of re-colonization.

- Spraying with Natural Pesticides

Many books exist with recipes for natural pesticides for both tropical and temperate areas. These may contain neem, tobacco, garlic/pepper juice etc. Something to keep in mind, is that most pests are plant specific. Spraying bamboo culms, leaves or shoots with a solution made from nearly any other plant is likely to work as a temporary natural pesticide. Natural pesticides, however, are water-based and tend to wash away in the first heavy rain.

- Spraying with Natural Fungicides

The liquid fertilizer recipe on page 161 contains several natural fungicides from the ginger family. This liquid fertilizer can be sprayed on the bamboo plant at the onset of the rainy season, and subsequently throughout shooting. Tea-tree oil from Australia, diluted with water, is also an excellent fungicide. Replacements for tea-tree oil in other tropical countries can be experimented with.

3.6.7
COMMON PESTS & DISEASE THAT ATTACK LIVING BAMBOO

Experienced bamboo growers will in general know the most common soil borne and plant pests which are visible to the eye. The very small ones (such as root aphids) and some soil-borne fungus are not known by all farmers, and the microscopic ones (ex. nematodes) are not known at all.

Below is a starter list of some common bamboo pests. Detailed field observation and sampling will yield more (please fill in the list below with local pests).

ENGLISH NAME	SCIENTIFIC NAME
Shoot weevils	*Colleotera curculionidaea*
Bamboo shoot worm	*Lepdoptera noctuidae*
Shoot maggot	*Deiptera anthomyiidea*
Bamboo locust	*Orthoptera acrididae*
Bamboo Aphids	*Homoptera Aphididae*
Bamboo scales	*Homoptera coccidae*
Lymantrid bamboo defoliator	*Lepidotera lymantridae*
Sooty moth	*Lepidoptera Zgaenidae*
<add local pest here>	

If bamboo is growing poorly, and if there are no immediate indications of limiting factors or visible pests, it is a good idea to dig into the ground and have a look at the roots. If the roots are damaged, have an unusual shape, or if there are a large number of organisms attached to the roots, a soil-borne pest is likely damaging the plant. More study by both scientists and farmers will be needed to better understand pest population dynamics in a bamboo agroecosystem. Again, this is best done by setting up field trials.

3.6.7.1
BAMBOO & FUNGUS

Beneficial vs. Detrimental Fungus
There are, in general, two kinds of fungus that live in and around the bamboo clump.

- Beneficial fungus - helps to break down soil organic matter

- Detrimental fungus - directly decays bamboo material

Since there are hundreds of species of fungus which live amongst bamboos, this book can not go into great detail on fungus types. Field studies are suggested to determine if fungal damage is serious enough to require control actions.

Approach: For the most part, fungus attacks bamboo which is already sick or diseased. In this case, the important management action is to raise healthy bamboo plants, with proper amount of nutrition, soil, water, and sunlight.

It is seldom the case that fungus attacks healthy bamboo. If the situation occurs where a significant amount of bamboo is being attacked by fungus, there are environmental issues in your bamboo area.

Fungus usually only becomes a problem for otherwise healthy bamboo when there too much moisture in the surrounding environment. Standing water should be routed away from the bamboo.

Increasing soil organic matter (SOM) around a bamboo stand is also an suggested method for improving drainage and reducing excessive moisture.

Considerations: It is important to note, that some fungus are not only good for your bamboo (those that break down soil organic matter) but also economically valuable as food, medicine or both.

3.6.8
CONCLUSIONS ON PEST MANAGEMENT

- **Killing pests does not always reduce their abundance**
  The existence of diverse populations of natural enemies, supported by abundant alternative food species, assures that populations of pests are consistently maintained at low levels. All the key variables can be found in any healthy bamboo agroecosystem—only when the process is disrupted do pest populations explode, causing serious damage. Given this a set of implications for pest and disease control can be determined.

- Avoid use of poisons

  The use of insecticides disrupts and destabilizes natural enemy populations. The use of insecticides is by far the most common cause of pest outbreaks in many agroecosystems, such as the rice brown plant hopper in irrigated rice. These kinds of pest outbreaks are generally referred to as "pesticide-induced resurgence."

- Understand pest biology
  - Eggs of many pests, are not susceptible to chemical sprays.
  - Insecticides create a refuge for the development of pest populations by reducing the abundance of natural enemies.
  - Migratory abilities of pests are generally better and their generation many times faster than those of natural enemies. After spraying of a broad spectrum pesticide, pests and natural enemies alike decrease in numbers, but pests re-populate the agroecosystem more quickly.

- Maintain a healthy soil environment

  "Healthy" soils, high in organic matter, are the foundation for a healthy ecosystem. Soil organic matter is the foundation for energy cycles that ultimately support high populations of natural enemies. High soil organic matter is crucial to soil fertility. Organic matter (OM) improves soil structure and porosity; it keeps the soil plentiful with bioavailable nutrients (and phytophenolic acids bind to nutrients and minimize leaching), it helps soil water holding capacity, OM moderates soil pH (depending on the type of organic matter) and it protects the plants from iron and alumunium toxicity which occurs in lower pH soils. Metal toxicity is especially detrimental to root hairs.

3.7
DATA SHEETS

The following are examples of several data sheets that can be used to collect and log data about bamboo from farms or community land. Sheets can be adapted to provide the information deemed only necessary or to include as much information as can be gathered. For experimental purposes, when comparing different variables of bamboo clump management it is advisable to use data from at least six samples of the same treatments. Collecting data is very important. You can"t manage what you don't measure!

3.7.1
PLANTING INFORMATION

Number Planted	Bamboo Type	Month	Year	Where	Fertilizer	Survival
420	Guadua	Jan	2006	Location1	no fertilizer	89%
600	Guadua augustifolia	Mar	2006	Location2	no fertilizer	90%
900	Patung	Feb	2008	Location3	Bamboo leaf mulch	97%
11,000	Bamboo hitam, tutul & Guadua	April	2008-10	Location4	no fertilizer	85%
800	Bamboo Duri	June	2011	Location5	50 litres combined fertiliser	70%
410	Bamboo duri	Nov	2011	Location6	50 litres cow manure fertiliser	98%
1,200	Patung	Dec	2011	Location7	50 litres	96%
250	Bamboo Duri	Jan	2012	Location8	50 litres	95%

3.7.2 FARM DATA COLLECTION SHEET

													Other notes:
GPS coordinates	Location name	Bamboo species	Date		Ages								Roots Leaves Soil Fertilizer
					1	2	3	4	5	6	?	All	
				#									
				Length									
				Diameter									
													Other notes:
GPS coordinates	Location name	Bamboo species	Date		Ages								Roots Leaves Soil Fertilizer
					1	2	3	4	5	6	?	All	
				#									
				Length									
				Diameter									
													Other notes:
GPS coordinates	Location name	Bamboo species	Date		Ages								Roots Leaves Soil Fertilizer
					1	2	3	4	5	6	?	All	
				#									
				Length									
				Diameter									
													Other notes:
GPS coordinates	Location name	Bamboo species	Date		Ages								Roots Leaves Soil Fertilizer
					1	2	3	4	5	6	?	All	
				#									
				Length									
				Diameter									
													Other notes:
GPS coordinates	Location name	Bamboo species	Date		Ages								Roots Leaves Soil Fertilizer
					1	2	3	4	5	6	?	All	
				#									
				Length									
				Diameter									

3.7.3
HARVEST DATA

Clump#		GPS Coordinates:		Location:
Bamboo Type	Culm Age	#/Age	#Harvested/Age	#Remaining/Age
	1			
	2			
	3			
	4			
	5			
	6			
Clump#		GPS Coordinates:		Location:
Bamboo Type	Culm Age	#/Age	#Harvested/Age	#Remaining/Age
	1			
	2			
	3			
	4			
	5			
	6			
Clump#		GPS Coordinates:		Location:
Bamboo Type	Culm Age	#/Age	#Harvested/Age	#Remaining/Age
	1			
	2			
	3			
	4			
	5			
	6			
Clump#		GPS Coordinates:		Location:
Bamboo Type	Culm Age	#/Age	#Harvested/Age	#Remaining/Age
	1			
	2			
	3			
	4			
	5			
	6			
Clump#		GPS Coordinates:		Location:
Bamboo Type	Culm Age	#/Age	#Harvested/Age	#Remaining/Age
	1			
	2			
	3			
	4			
	5			
	6			
Clump#		GPS Coordinates:		Location:
Bamboo Type	Culm Age	#/Age	#Harvested/Age	#Remaining/Age
	1			
	2			
	3			
	4			
	5			
	6			

3.7.4
MONITORING DIFFERENT TREATMENTS

Mar-12	single rhizome offset	4-6 mother rhizome offset	seedling
Control	6	6	6
50 L soil/mulch/compost 5:3:1	6	6	6
EM4	6	6	6
50 L soil/mulch/compost 5:3:1 + EM4	6	6	6
Roots Stripped	6	6	
Roots Stripped + EM4	6	6	
Roots Stripped + 50 L soil/mulch/compost 5:3:1	6	6	
Roots Stripped + 50 L soil/mulch/compost 5:3:1 + EM4	6	6	
Totals	48	48	24
Apr-12	single rhizome offset	4-6 mother rhizome offset	seedling
Control	6	6	6
50 L soil/mulch/compost 5:3:1	6	6	6
EM4	6	6	6
50 L soil/mulch/compost 5:3:1 + EM4	6	6	6
Roots Stripped	6	6	
Roots Stripped + EM4	6	6	
Roots Stripped + 50 L soil/mulch/compost 5:3:1	6	6	
Roots Stripped + 50 L soil/mulch/compost 5:3:1 + EM4	6	6	
Totals	48	48	24
May-12	single rhizome offset	4-6 mother rhizome offset	seedling
Control	6	6	6
50 L soil/mulch/compost 5:3:1	6	6	6
EM4	6	6	6
50 L soil/mulch/compost 5:3:1 + EM4	6	6	6
Roots Stripped	6	6	
Roots Stripped + EM4	6	6	
Roots Stripped + 50 L soil/mulch/compost 5:3:1	6	6	
Roots Stripped + 50 L soil/mulch/compost 5:3:1 + EM4	6	6	
Totals	48	48	24
Jun-12	single rhizome offset	4-6 mother rhizome offset	seedling
Control	6	6	6
50 L soil/mulch/compost 5:3:1	6	6	6
EM4	6	6	6
50 L soil/mulch/compost 5:3:1 + EM4	6	6	6
Roots Stripped	6	6	
Roots Stripped + EM4	6	6	
Roots Stripped + 50 L soil/mulch/compost 5:3:1	6	6	
Roots Stripped + 50 L soil/mulch/compost 5:3:1 + EM4	6	6	
Totals	48	48	24
Jul-12	single rhizome offset	4-6 mother rhizome offset	seedling
Control	6	6	6
50 L soil/mulch/compost 5:3:1	6	6	6
EM4	6	6	6
50 L soil/mulch/compost 5:3:1 + EM4	6	6	6
Roots Stripped	6	6	
Roots Stripped + EM4	6	6	
Roots Stripped + 50 L soil/mulch/compost 5:3:1	6	6	
Roots Stripped + 50 L soil/mulch/compost 5:3:1 + EM4	6	6	
Totals	48	48	24
August	single rhizome offset	4-6 mother rhizome offset	seedling
Control	6	6	6
50 L soil/mulch/compost 5:3:1	6	6	6
EM4	6	6	6
50 L soil/mulch/compost 5:3:1 + EM4	6	6	6
Roots Stripped	6	6	
Roots Stripped + EM4	6	6	
Roots Stripped + 50 L soil/mulch/compost 5:3:1	6	6	
Roots Stripped + 50 L soil/mulch/compost 5:3:1 + EM4	6	6	
Totals	48	48	24
September	single rhizome offset	4-6 mother rhizome offset	seedling
Control	6	6	6
50 L soil/mulch/compost 5:3:1	6	6	6
EM4	6	6	6
50 L soil/mulch/compost 5:3:1 + EM4	6	6	6
Roots Stripped	6	6	
Roots Stripped + EM4	6	6	
Roots Stripped + 50 L soil/mulch/compost 5:3:1	6	6	
Roots Stripped + 50 L soil/mulch/compost 5:3:1 + EM4	6	6	
Totals	48	48	24

Culm Age 1	Culm Age 2	Culm Age 3	Culm Age 4	Culm Age 5
Culm Age 1	Culm Age 2	Culm Age 3	Culm Age 4	Culm Age 5
Culm Age 1	Culm Age 2	Culm Age 3	Culm Age 4	Culm Age 5
Culm Age 1	Culm Age 2	Culm Age 3	Culm Age 4	Culm Age 5
Culm Age 1	Culm Age 2	Culm Age 3	Culm Age 4	Culm Age 5
Culm Age 1	Culm Age 2	Culm Age 3	Culm Age 4	Culm Age 5
Culm Age 1	Culm Age 2	Culm Age 3	Culm Age 4	Culm Age 5

3.7.5 COMPARING HARVEST MANAGEMENT

	count						Harvest 20% of bamboo with 4:3:2:1 age ratio ratio					
	age1	age2	age3	age4	age5	Total	age1	age2	age3	age4	age5	Total
year 1												
year 2												
year 3												
year 4												
year 5												

	count						Harvest with 4:3:2:1 age ratio remaining and miniumum 5 x 4 year old culms					
	age1	age2	age3	age4	age5	Total	age1	age2	age3	age4	age5	Total
year 1												
year 2												
year 3												
year 4												
year 5												

							Harvest all bamboo older than 2					
	age1	age2	age3	age4	age5	Total	age1	age2	age3	age4	age5	Total
year 1												
year 2												
year 3												
year 4												
year 5												

							Harvest all bamboo greater than 3					
	age1	age2	age3	age4	age5	Total	age1	age2	age3	age4	age5	Total
year 1												
year 2												
year 3												
year 4												
year 5												

							Harvest no bamboo					
	age1	age2	age3	age4	age5	Total	age1	age2	age3	age4	age5	Total
year 1												
year 2												
year 3												
year 4												
year 5												

3.8
CONCLUDING REMARKS - CHAPTER 3

Congratulations! You just made it through a long and important chapter of this book. As was stated earlier, chapter 3 is not as much a prescription of how to manage sympodial bamboo, as it is a thought process which will enable you to think in new ways about managing your bamboo, given your own specific conditions. The focus of chapter 3 was at the clump level of bamboo, and centered around the theme of growing a healthy plant. Chapter 4 will take on the challenge of scaling-up. We will pull out the wide-angle lens, and look at bamboo management concepts from an agroecosystem and landscape perspective.

We will learn much about resilient bamboo forestry in the future through field trials of the concepts presented in this book, as well as new ideas being tested around the world. Keep sharing your important thoughts, actions and reflections, and please send us your critiques and comments to resilientbambooforestry@gmail.com

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4

Increasing Scales - Agroecosystem Management and planning

1. Increasing Scales Agroecosystem & Landscape View
2. Agroecosystem Analysis & Field Studies
3. Shelterbelts
4. Bamboo-Based Agroforestry
5. RBF Management Planning

CHAPTER 4 LAYOUT

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- 4.1.1 Landscape Ecology

4.2 Agroecosystem Analysis & Field Studies
- 4.2.1 Agroecosystem Analysis & Field Studies
- 4.2.2 Landscape Ecology as a Tool for Resilient Bamboo Forestry

4.3 Shelterbelts
- 4.3.1 Use of Shelterbelts For Differentiating Agricultural Landscapes
- 4.3.2 Composition of Shelterbelts
- 4.3.3 Characteristics of Species For Shelterbelts
- 4.3.4 Establishment of Shelterbelts
- 4.3.5 Pointers in Establishing Shelterbelts
- 4.3.6 Potential Species for Shelterbelts in S.E. Asia

4.4 Bamboo-Based Agroforestry
- 4.4.1 What is Bamboo-based Agroforestry?
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- 4.5.2 Resilient Bamboo Forestry - Management Planning
- 4.5.3 Intercropping
- 4.5.4 Content of Bamboo Agroecosystem Planning
- 4.5.5 Planning Sheet
- 4.5.6 RBF Management Planning: Some Social Issues
- 4.5.7 Understanding Bamboo Commodity Chains

4.6 Chapter 4 Conclusion

4.1
INCREASING SCALES AGROECOSYSTEM & LANDSCAPE VIEW

This Chapter builds on the knowledge, theories and practices presented in the previous chapters. It culminates in the undertaking of Resilient Bamboo Forestry planning, and integrating better practices with the Seasonal Bamboo Calendar (Chapter 2) work plans. Humans can efficiently make large scale improvements with limited resources by designing habitat enhancement projects with bamboo. Biomass and biodiversity are natural endowments- at some threshold, a given area of land has the capacity of continually increasing the amount of light and energy it captures when left on its own, accruing interest.

This chapter presents ideas for cohesive agroecosystem design, jointly reducing pests and providing a deliberate income from bamboo products, cohesive landscape ecology for resilient bamboo forestry. The phrase "increasing scales" suggests the scaling up of a resilient bamboo forestry operation. This chapter uses conceptual terminology to talk about scale in a physical sense- a holistic view inclusive of size and number of clumps/harvestable culms/communities involved/market served. This applies sympodial bamboo clump management to the context of the agroecosystem, landscape ecology, and most importantly, the ecosystem services provided by bamboo and selected companion plants. Application of these principles should increase the long term efficiency of collaborative harvests of an appropriately managed piece of land. These principles will give way to successful bamboo-centered agroecosystem management planning:

- Manage existing bamboo clumps according to the steps in Chapter 3
- Integrate in companion plants according to the appropriate characteristics of the existing landscape ecology
- Prevent the loss of ecosystem services by promoting biodiversity
- Integrate multiple crops into areas where single high value agricultural crops are suffering from disease and pests
- Design data sheets for appropriate planting according to the piece of land and check the success of plans with follow up stocktakes of organisms and their abundance.

What is Agroforestry?

Agroforestry is the deliberate growth and management of trees along with agricultural crops and/or livestock in systems that are ecologically, socially and economically sustainable. Agroforestry is simply the use of trees in farming systems (FAO/IIRR, 2003).

Resilient Bamboo Forestry requires proper planning as well as coordination between bamboo growers and other stakeholders, such a collaborative production is likely to result in both a better plan and greater commitment to the venture. Resilient Bamboo Forestry exemplifies adaptive systems of SEE values in heterogeneous mosaics of landscapes.

What is Bamboo-based Agroforestry?

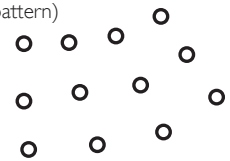
Bamboo is an anomaly. It is a grass whose edible shoots can be harvested annually. In this way, it acts like an agricultural product. Some bamboos are also exceedingly large, providing a superior timber-like product. In this way, bamboo acts like a tree. In most management systems this anomaly is a detriment to bamboo. In many countries neither forestry nor agricultural departments are interested in its management. It is bamboo's enigmatic character that lends itself perfectly to agroforestry. It is a tree whose timber can be harvested yearly without replanting. It provides a myriad of the environmental functions of a forest, but to the bamboo farmer, poles and culms can be harvested regularly like many other agricultural products.

What are the aims of Bamboo Based Agroforestry?

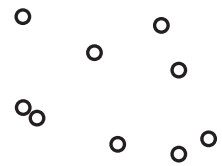
- Increased annual productivity/income over short, medium and long-terms.
- Improved equity in benefit-sharing sustainable forestry management.
- Work effectively with bamboo growers, primarily rural farmers, researchers, development workers and plantation managers.
- Approach agroforestry from a farming systems perspective.
- Maintenance and design of natural habitats interspersed with agricultural fields for pest and disease control.

Bamboo-based agroforestry takes advantage of bamboo's dual nature. The system that results can be of two patterns:

1) Bamboo managed in a regular pattern (agricultural pattern)



2) Irregular Spread (natural forest)



Typical multi-layered canopy structure of a tropical forest.

Bamboo, in an agroecosystem setting, is a system modified by people to produce food (bamboo shoots, mushrooms, medicine, cash crops, etc.), fibre (processed bamboo), timber, livestock and various other agricultural and natural products for human use. Biodiverse landscaping is the antithesis of monocultural plantations. Of course, many large profits in forestry are driven by plantations growing only products such as coffee, cacoa or palm. Associated with the lack of diversity of these systems are thriving pest populations which demand appropriate pest management. Though toxic chemicals can be used for pest control, we recommend using natural pest management. Integrating multiple crops can, more than serving as financial security for the failure of a single crop, also reduce pest impacts and foster ecosystems of natural enemies. The integration of bamboo into shelterbelts for these crops is of great potential for social, economic and environmental security. Multi-species forests not only tend to harbor more animal species, but these animal species are also likely to fertilize the land and introduce new seeds and greater biodiversity.

Bamboo could potentially play an important role in a sustainable resource management. Annual bamboo profits could provide an economic stepping stone to sustain communities while creating more complex social agroforestry ecosystems. Mixing crops in an ecosystem can also improve crop yields. For instance growing nitrogen fixing trees in a nitrogen poor forest will help increase the overall productivity of the area. The use of bamboo in shelter belts for ecostystem protection of other crops by shielding against dessicating winds, intense sun, and erosion prevention can also warrant success where an all food product agroforestry system might fail. Just as a monoculture of bamboo would be more susceptible to pests, a monoculture of other tree crops would be more susceptible to pests. The principle is that if a pest exists and the only plant that the pest parasitizes is the only plant being grown, then the pest has the opportunity to thrive on everything growing, more so than in a mixed crop system. The other principle is that with increased biodiversty in the form of multiple plant crops, decomposers, insects, and foraging animals, there are many controls regulating the stability of a mixed system. The obvious contributions to bamboo success through this paradigm is the management of termites and wood boring insect infestations by "natural enemies" such as spiders. This concept is also used in permaculture practices where alternative, like chickens, can be used as a natural enemy of insects like termites.

The invisible microbial world also plays a role in productivity. Bamboo root systems and culms have shown more optimal growth when the soil is innoculated with certain fungi (Muthukumar and Udaiyan, 2006). Bamboo roots are associated

with mycorrhyzal fungi This could be a factor for differential growth between tissue cultures and plants in their natural soil systems.

Bamboo, watersheds and streams are one and the same at ecosystem level- a connected system. "75 percent of bamboo stands are found in the lowlands, which are also sparsely distributed throughout the countryside in either backyard type planting or along riverbanks" (M. Rivera 1999).

In Bali, EBF surveys of natural water springs and bamboo resources are strongly geographically linked. It is obvious that bamboo coincides with and protects springs. Greening Red Earth (Kutty and Narayanan, 2003) shows evidence that foresting brick mining impacted land with bamboo raises the water table significantly. More watershed data related to bamboo resources is needed, as significant amount of water are retained in bamboo root systems and throughout the plants. When you see bamboo it is common to ask, "where is the water?"

The bamboo in the picture to the left has a more outstanding growth rate near water resources.

A pertinent question for resilient bamboo practitioners is how to restore nutrients levels to an impacted ecological system containing a bamboo stand, and what will replace the logs of forest products removed. Bamboo is, at times, a forest gap pioneer, and in at least some cases, bamboo forests sprout in areas of previously felled trees and deforested areas (Tabarelli, and Mantovani, 2000). One must acknowledge that there is a competition in the forest for light, water and nutrients. It is responsible to monitor the potential impact of exotic species on natural populations of forest plants. Reintroducing nutrients back into bamboo forests, such as through compost, NPK fertilizer, and the addition of other micronutrients can compensate for quantities of ash content removed as trees or previously harvested bamboo culms and leaves. The most efficient practice is to recycle organic matter back into bamboo clumps with compost and mulch, such as from leaves and bent, old, and broken bamboos. Chemical fertilizers have their own environmental impact on global climate change, especially ammonia derived fertilizers manufactured by the Haber-Bosch process, so it is wise to prioritize using organic fertilizers.

Bamboo has been grown in such a setting for thousands of years in Asia. Nearly all rural households in Indonesia have some form of access to bamboo, in many cases planted generations ago, due to its household usefulness. Thus, traditional bamboo management practices are more often than not, management of bamboo in an agroecosystem setting.

Bamboo agroecosystems may have characteristics of three separate systems:
1. Agricultural systems (farms).

2. Natural forest ecosystems,

3. Disturbed or regenerating forest ecosystems.

As such, a management plan for a bamboo agroecosystem needs to take into consideration the points of view of the farmer, forester and conservationist.

Within a plot of bamboo forest reside different organisms. On the global scale this will vary greatly, but given any plot it is important to determine what are the crops, what are the weeds, what are the pests, and what are the natural enemies of the pests. The ease of assessing these will depend on the bamboo system of focus and the level of diversity.

Check One

Sample	Drawing	Size	#	Crop	Weed	Pest	Natural enemy	Other (describe)
1								
2								
3								
4								

The point of the agroecosystem analysis in the following section is to carefully reconsider the characteristic potentials and constraints of agricultural and forest lands, and weigh them against each other. This is the direction towards fair and rational compromises between development and conservation.

4.1.1
LANDSCAPE ECOLOGY

Landscape ecology is the science of studying and improving the relationship between spatial pattern and ecological processes on a multitude of landscape scales and organizational levels. Les Ryszowski was a key thinker in landscape ecology, which seeks to find practices more suitable for land than open field monocultures, emphasizing the relationship among pattern, process and scale and its focus on broad-scale ecological and environmental issues. Wu & Hobbs (2002) balance these biophysical needs with socioeconomic sciences. Patches and ecosystems are spatially linked into heterogeneous geographic areas. These various systems range from human-dominated environments, including agricultural and urban settings, to natural terrestrial and aquatic systems such as forests, grasslands and lakes. We will look at ecological flows in landscape mosaics, land use and land cover change, scaling, relating landscape pattern analysis with ecological processes, and landscape conservation and sustainability.

4.2
AGROECOSYSTEM ANALYSIS & FIELD STUDIES

Whole field guide manuals, such as Stephen Gliessman's. "Field and Laboratory Investigations in Agroecology" have been written to address this subject. Here we will present a seedling of the concept for integrating bamboo into agroforestry.

4.2.1
AGROECOSYSTEM ANALYSIS & FIELD STUDIES

The agroecosystem is commonly defined as "a unit composed of the total complex of organisms in the crop area together with the overall conditioning environment." To determine population dynamics and mortality factors operating on pest populations the agroecosystem must be an analysized. This is a more focused analysis into the ecological dynamics of the bamboo agroecosystem than was presented in Chapter 3, where agroecosystems were assessed along with bamboo clumps and the landscape.

Approach: There is a minimal amount of information available on pest dynamics in a bamboo forest. Support for scientific studies; the compilation of existing studies, and field studies undertaken directly by bamboo growers are needed. This would help attain a better understanding of the complicated interactions that take place between bamboo clumps, pest populations and their natural enemies. This would require identification of the organisms in the bamboo ecosystem and their population counts, or indicators such as the number of culms destroyed by termites. The highest priority for study should be the pest which destroys the most economic value of a bamboo harvest.

Alongside scientific studies, bamboo growers and farmers need to be involved in their own field studies and analysis. These field studies should stress:

- Decision making in the bamboo agroecosystem.
- The integration of various pest and disease management tactics.
- The determination of tolerable thresholds of pest and disease in a bamboo crop.
- Determination of which insects and fungus can be considered pests and which are neutral or beneficial to the bamboo plant.

A field study usually continues for an entire cropping cycle, which in the case of sympodial bamboo, is an entire year. The simplest type of field study is the comparison study two plots, one treated for pests and the other left alone.

These plots could be further divided into sub-plots to conduct additional studies, often known as supporting studies.

The following is an example of a supporting field study on bamboo fungal disease :
Choose twenty similar clumps.
Harvest ten of the clumps, one culm from each clump, using recommended harvest practices (see section 3.5), making clean cuts just above the 1st or second internode of culms of the same age.

In the other ten clumps, cut the culms just below the internode, allowing rainwater to collect in the stump.

Over a year-long period, make observations about the condition of each cut stump, new shoots, and young culms. Is there a relation between the health of the cut stump, and the health of new bamboo culms?
The study is a good demonstration of the capacity of a plant to compensate for damage due to fungal growth on cut stumps.

Considerations:
After each field study it is important to undergo some form of analysis. Keeping track of weekly, monthly and yearly changes using data sheets or a journal, provides bamboo growers with information needed to analyze the field study and the effect of field trials on bamboo growth.

4.2.2
LANDSCAPE ECOLOGY AS A TOOL FOR RESILIENT BAMBOO FORESTRY

Landscape ecology provides pathways for improving bamboo forestry and general agroecosystem management. The recognition of feedback mechanisms between the functions of landscapes, and the exploitation of goods or services needed by human society, should form a first step in developing strategies for sustainable development of the countryside. Most regions where bamboo grows in the tropics have experienced environmental deterioration caused by human activities. In many cases, the relationships underpinning such phenomena are poorly recognized, or recognized too late. In many regions, there is still a belief that human economic activities cannot co-exist with protection of nature. Land-use conflicts arise out of such situations; conflicts which are "won" by wealthy investors and strong-armed governments in many bamboo growing regions. "However, with increasing recognition of a landscape's basic processes, such as

energy fluxes, organic matter cycling, and mechanisms of their management, there is a growing conviction that it is the way in which natural resources are used, not the fact that they are exploited, that has led to environmental degradation." (Ryszkowski, 2000)

Do all human activites degrade an ecosystem/landscape or can a resilient system be devolped using knowledge of landscape functions control the negative feedbacks loops between natural and human-induced processes? Such an approach facilitates a more objective evaluation of alternative technologies of production, with objectives that seek to meet social needs, production needs and environmental protection at the same time. This goal cannot be achieved on a scale smaller than the landscape, and that landscape ecology therefore becomes a very important pillar for the implementation of sustainable development of agriculture, more specifically, in this instance; bamboo forestry.

Scale and heterogeneity (incorporating composition, structure, function and pattern)
A major concept in landscape ecology is *scale*. This book focuses on three ecological scales of relevance to bamboo forestry; the individual bamboo clump (Chapter 1); and the agroecosystem; and the landscape *scales*. Larger and smaller *scales*, such as the global and the molecular *scales* have also come into discussions in topics such as climate change as well as soil management. The important ecological concepts of *composition, structure*, and *function* are all components of *scale*. *Composition* describes the relative abundance of patches. A different vegetation and land-use present on a landscape. For example, the extent of a bamboo stand amongst other agroforestry crops can be an aspect of landscape *composition. Composition* is determined by the structure, the configuration, and the proportion of different patches across the landscape. Function refers to how each element in the landscape interacts based on its life cycle events. Pattern is the term for the contents and internal order of a heterogeneous area of land.

A landscape with structure and pattern suggests spatial *heterogeneity,* or the uneven distribution of objects across the landscape. *Heterogeneity* is a key element of landscape ecology that separates this discipline from other branches of ecology. In discussing bamboo forestry, a difficult pitfall to avoid is delving into a homogenous discussion of a bamboo forest or plantation. A resilient bamboo forest or agroecosystem has a high degree of *heterogeneity.* Resilient bamboo forestry is aimed at accommodating a heterogeneous mosaic of landscape types, each with social, economic and ecological value, and managed in an adaptive system.

Influence of Landscape Mosaic Structures on Diversity of Wild Plant and Animal Communities in Agricultural Landscapes

Semi-natural habitats, maintained in the agricultural landscape, can constitute important refuge for many plants and animals, thereby supporting biological diversity in the bamboo agroecosystem. Diversification of the agricultural landscape pattern through introduction of refuge sites can mitigate biota impoverishment due to intensive farming, at least with respect to some plant and animal communities. Thus, the introduction of a mosaic landscape, composed of cultivated fields, bamboo stands and semi-natural habitats, to some extent compensates for the negative effects exerted by agriculture on the biota. The effects of stimulating biodiversity can appear very quick when a new shelterbelt (see below) is planted, and in 2 to 3 years higher measures of biodiversity are achieved. The effect of planting nitrogen fixing trees allows a greater diversity of plants to cope with soil nutrient levels. Varying levels of shade and moisture from multiple crops, allow a gradient of microhabitats for organisms to live in. The colors and smells of mixed agroforestry crops can bring more birds and insects, and thus more seeds and pollination.

Intensification of an agroforestry crop like bamboo, or even simple agriculture, alters landscape structure. Crop rotation patterns are frequently simplified when plant production becomes more specialized and when field size is increased to allow the use of machinery. During large field consolidations, patches of mid-field forests, shelterbelts (rows of mid-field trees), hedges, field margins, stretches of meadows, and riparian (riverside) vegetation strips are eradicated. This also occurs with the proliferation of homogenous bamboo plantations. Drainage of mid-field small wetlands or small ponds also leads to the simplification of the agricultural landscape structure. Plantation forestry and agricultural landscaping tend to eliminate refuge sites for many organisms. Therefore, these interests are mutually exclusive to the conservation of nature. This conclusion is a broadly disseminated discussion on nature protection problems.

Where a secondary tropical rainforest meets a natural bamboo forest (a natural monospecific bamboo stand), the edge is often abrupt, as the bamboo stand likely came into being due to disturbance to the forest. The colonizing nature of bamboo, coupled with their thick canopy, can inhibit natural succession of the tropical forest for long periods of time, unlike an adjacent grassland.

4.3
SHELTERBELTS

4.3.1
USE OF SHELTERBELTS FOR DIFFERENTIATING AGRICULTURAL LANDSCAPES

Shelterbelts are strips of vegetation composed of trees, bamboo, shrubs and vines to protect croplands from destructive winds, and act as living fences and firebreaks. The protective role of shelterbelts against wind erosion and severe climatic phenomena, has been long known. When established on hills, they can also act as buffer strips to minimize soil erosion. Along rivers, streams or creaks, they serve as bank protection, wildlife corridors, and various watershed functions. The plants composing shelterbelts can also serve as a source of agroforestry products.

More than a dozen different functions favorable to the environment, human economy, health, and culture have been listed in papers concerning the role of shelterbelts. (National Resources Conservation Service). One can distinguish, however, the following more general categories of function that should be considered for agricultural landscapes:

- Increase of water retention by the restricting surface run-off and drying effect of wind
- Purification of ground waters and counteraction of non-point pollution spread in the landscape
- Prevention and restriction of wind and water erosion effects
- Mitigation of effects of unfavorable climatic phenomena (extreme temperatures, long-lasting droughts, storms, etc.)
- Isolation of polluting elements in the landscape (dumping sites, industrial areas, animal farms, etc.)
- Preservation of biological diversity in agricultural areas and stimulation of pest control efficiency

4.3.2
COMPOSITION OF SHELTERBELTS

Properly established shelterbelts should be dense in the lower canopy and more open in the middle to upper canopies. The vegetative mixture of a good shelterbelt is approximately 65 percent shrubs, and vines and 35 percent tall and medium trees and bamboos.

4.3.3
CHARACTERISTICS OF SPECIES FOR SHELTERBELTS

In choosing species to be used in shelterbelts, the many things should be considered. The species must be:

- Wind resistant. (Larger bamboos used only in the middle of shelterbelts, smaller bamboos on the edges, no large, heavy bamboos on steep slopes, i.e. > 35 degrees)
- Deep rooted and/or have a well-spread root system (Bamboos are not deep, but extremely well-spread).
- Small crowned and have a light branching habit.
- Easy to propagate and maintain.
- Able to coppiced – this is beneficial (prune the top, not applicable to bamboo, except for stimulation of sub-branching for propagation).
- Able to provide other economic benefits (food, fodder, sustainable timber, etc).

4.3.4
ESTABLISHMENT OF SHELTERBELTS

Establishment of shelterbelts is an efficient environmental management tool. The need to reforest large areas of land can be costly. Where shelterbelts are properly managed, natural reforestation takes place over time. Where other competing land-uses exist, such as agriculture, shelterbelts can serve to enhance the resilience of agricultural crops, while still providing the ecological services of a forested area.

The number of shelterbelts, the spatial structure of their networks, and their species composition, should be adjusted to the kinds and intensity of environmental threats that they must counteract. They should be designed according to the principle of maximum high quality farmland economy.

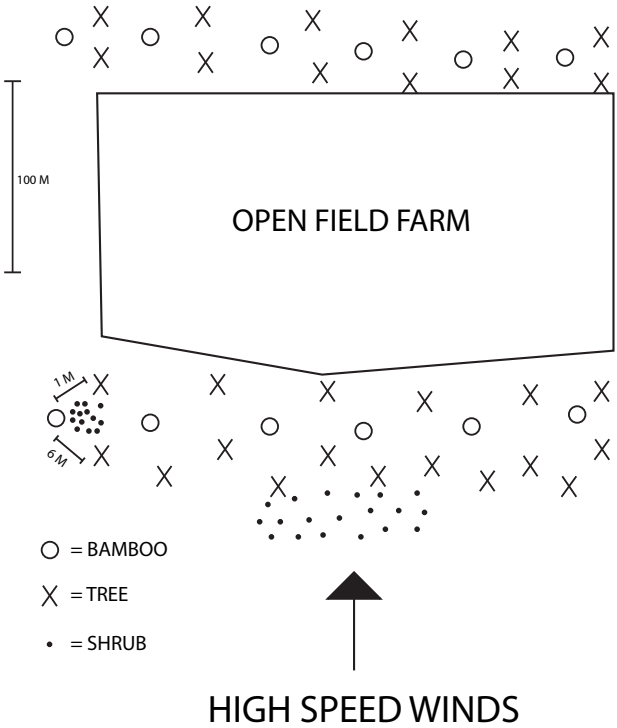
4.3.5
POINTERS IN ESTABLISHING SHELTERBELTS

Shelterbelt establishment and protection should be considered a priority in regions of serious water shortage and pollution (especially non-point pollution), and in areas threatened by various kinds of erosion. In areas of diversified relief, their water protective functions ought to be combined with anti-erosive ones.

The strips should be more or less perpendicular to the main wind direction; on sloping land, the strips should follow contour lines based on natural topography. Parallel strips may lead into a common perpendicular strip. This perpendicular strip should be developed into a thicker forest where possible. The overall design is similar to a herring-bone pattern. This continuity promotes environmental flows and acts as a corridor for migration of flora and fauna.

The number of rows in the strips largely depends on the velocity of the wind. The higher the velocity, the broader the strip. Usually, the strip for shelterbelts is 1-5 rows. The first and the last rows should be planted mainly to shrubs and smaller bamboos, with clusters of medium and taller trees as well as larger bamboos in the center rows. Planting in clusters of 2-5 plants of the same species is recommended.

Use the quincunx (triangular) method of planting at 1 meter spacing between shrubs and 4-8 meter spacing between larger trees and bamboos, depending on space requirements for individual species.
In areas with high wind velocity, the shelterbelts should be about 100m apart, and about 200-300 meters in ordinary conditions.



4.3.6
POTENTIAL SPECIES FOR SHELTERBELTS IN S.E. ASIA

The following species can be used to design agroecosystems, perhaps organizing specific needs of a project into data sheets which can be sorted by parameters such as altitude, soil type, canopy height, spacing and economic value.

Tall Trees/Palm (over 15m)

Scientific Names	
Livistona rotundifolia	*Acacia magnum*
Casuarina equisetifolia	*Albizia procera*
Pterocarpus indicus	*Pithecellobium dulce*
Tectona grandis	*Diospyros philippinenses*
Gmelina arborea	*Cassia siamea*
Vitex parviflora	*Cocos nucifera*
Artocarpus blancoi	*Pinus caribaea*
Sandoricum koetjape	*Corypha elata*
Tamarindus indica	*Durio zibethenus*

Large Bamboos (over 15 m)

Scientific Names	
Gigantochloa atter	*Bambusa blumeana*
G. apus	*B. vulgaris*
G. atroviolacea	*B. spinosa*
G. schortechinii	*B. tuldoides*
G. robusta	*B. bambos*
G. pseudoarundinacea	*B. balcoa*
G. levis	*Dendrocalamus asper*
D. strictus	*D. membranaceus*

Medium Sized Trees/Palm (5-15 m)

Scientific Names	
Chrysophylium cainito	*Casuarina rumphiana*
Manilkara zapota	*Syzygium cumini*
Anacardium occidentale	*Azadirachta indica*
Lagerstroemia speciosa	*Erythrina orientalis*

Leucana leucocephala	*Piliostigma malabaricum*
Glircidia sepium	*Anacardium ovatum*

Shrubs (up to 5 m) and Small Bamboos

Scientific	Names
Acacia famesiana	*Bambusa spinosa*
Bougainvillea spectabilis	*Bambusa multiplex*
Cajanus cajan	*Bambusa ventricosa*
Bixa orellana	*Thyrsostachys siamensis*
Phyllostachys aurea (monopodial)	*Schizostachyum spp.*

4.4
BAMBOO-BASED AGROFORESTRY

Please refer to Chapter 3.2 (Understory Plant Management) on introducing companion plants into bamboo based agroforestry. We are now expanding this technique into multiple canopy levels.

4.4.1
WHAT IS BAMBOO-BASED AGROFORESTRY?

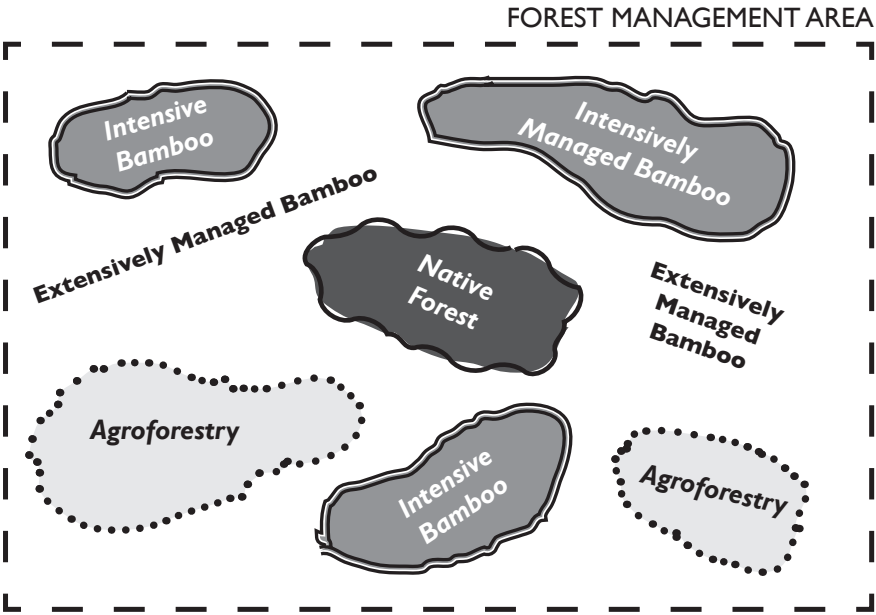
Bamboo is an anomaly. It is a grass, whose edible shoots can be harvested annually. In this way, it acts like an agricultural product. Some bamboos are also exceedingly large, providing a superior timber like product. In this way, bamboo acts like a tree. In most management systems, this anomaly is a detriment to bamboo, in many countries, neither forestry nor agricultural departments are interested in its management. But it is bamboo's enigmatic character that lends itself perfectly to agroforestry. It is a tree whose timber can be harvested yearly without replanting. It provides a myriad of the environmental functions of a forest. But to the bamboo farmer, poles and culms can be harvested regularly like many other agricultural products. Bamboo based agroforestry is a solution.

4.4.2
WHAT ARE THE AIMS OF BAMBOO BASED AGROFORESTRY?

- Increased annual productivity/income over short, medium and long-terms.
- Improved equity in benefit-sharing.
- Sustainable forestry management.

To work effectively with bamboo growers, primarily rural farmers, researchers, development workers and plantation managers must be able to approach agroforestry from a farming systems perspective. Maintenance of natural habitats interspersed with agricultural fields for pest and disease control. Design this interspersion if possible.

Suggested Pattern for Bamboo Agroforestry
The design and creation of a mosaic of intensively managed bamboo, inside of a larger area of forest (both bamboo and non-bamboo) is a suggested practice. The following diagram provides a visual example of what this might look like.



4.4.3
POTENTIAL DRAWBACKS OF INTENSIVE BAMBOO MANAGEMENT

It takes a high investment in labour to intensively manage a bamboo forest.

Intensively managed bamboo stands, tend to age faster than bamboo stands which are managed more extensively. By aged, we mean that the bamboo clump itself loses vigor and over time it will become less productive and it will die at a younger age, than a bamboo clump not under intensive management.

Because of this trade-off, the suggested practice is the above mosaic of intensively (high input of resources such as labour and time) managed and extensively managed areas (low input of labour and time).

4.4.4
BAMBOO-BASED AGROFORESTRY EXAMPLE - KUNINGAN WEST JAVA

The example of a bamboo-based agroforestry system on the next two page spread comes from West Java Province in Indonesia. The composition and structure of this agroforest is approximately equal to the composition and structure of a natural forest. More than 150 of the 250 agricultural species found in Citibung farmlands come from the native forest. In most agroforests of the region dominant species that exist in the upper and mid- canopy, are fruit trees, including; durian, Parkia speciosa, jengkol, mango, kemang, embacang, Mangiferia foetida, rambutan, guava, mentend and mangosteen. This traditional agroforest system usually contains 5 species of palm tree and 6 species of bamboo (*Dendrocalamus asper, Gigantochloa apus, G. atter, G. atroviolacea, G. pseudoarundinacea and Schizostachyum spp.).* Many species of herbs, gingers, shrubs, weeds and ground cover can be found on the forest floor.

4.4.5
EXAMPLE: BAMBOO-BASED AGROFORESTRY SYSTEM, CITIBUNG, WEST JAVA

This sketch shows a mixed agrofrestry system containing the following plants: Durian, Langsat, Gandaria, Menteng, Tangkil, Kupa, Kemang, Rambutan, Huni, Jackfruit, Jengkol, Picung, Sandoricum koecape, Parkia speciosa, Guava, Snakeskin fruit, Averrhoa bilimbi, D. asper, G. apus, G. atter, G. atroviolacea, G. pseudoarundinacea, Schizostachum spp.

These are potential plant and tree species for other bamboo-based agro-forestry.

4.4.6
MIDDLE TO HIGH UNDERSTORY SHADE TOLERANT CROPS

The following species grow well in the understory of taller tree species. They occupy the middle to high understory. Although they are shade-tolerant, they still need some light to penetrate the canopy (about 50 percent shade/light)

LATIN NAME	COMMON NAME	USES
Acacia meamsii		Fuelwood, poles, green manure, tannin, erosion control, soil improvement
Albizzia lebbek		Fuelwood, timber, fodder, soil improvement
Alnus nepalensis		Fuelwood, timber, fodder, soil improvement
Annona muricata		Fruit
Averrhoa bilimbi		Fruit
Bixa orellana		Fruit (cosmetics, dye, live fence
Calamus merilli		Furniture, fiber
Caliandra calothyrsus		Fuelwood, fodder, erosion control, soil improvement
Coffea spp.		Coffee beans, fuelwood
Desmodium gyroides		Fodder, erosion control, soil improvement
Flemingia macrophylla		Erosion control, soil improvement
Lancium sp.		Fruit
Livistona rotundifolia		Fiber, food (fruit, buds, shoots), small timber
Musa textilis		Fiber
Musa spp. var. saba		Fruit
Pithecellobium dulca		Fruit, fuelwood, small timber, fodder, fencing, soil improvement
Psidium guajava		Fruit fuelwood, erosion control
Theobroma cacao	Cacao	Cacao, chocolate

4.4.7
LOW UNDERSTORY SHADE TOLERANT CROPS

The following species grow well in the understory of many tree species. They occupy the low understory. They can be attempted under bamboo canopies.

LATIN NAME	OTHER NAMES	ELEVA-TION (m)	SOILS	YIELDS
ARACEAE				
Acorus calamus		< 200	Clay loam	3000kg/ha
Amorphophallus campanulatas		< 800	Sandy loam	
Amorphorphallus variabilis		< 700	Sandy loam	2.5kg/tuber
Colocasia esculenta		< 1000	Adaptable	1-17 tons/ha
Xanthosoma nigrum		< 1000	Adaptable	3.25 tons/ha
MARANTACEA				
Maranta arundinacea	Arrowroot	< 900	Sandy loam	7.5 - 37 tons/ha
TACCACEAE				
Tacca palmata		< 900	Sandy humus	
DIOSCOREACEAE				
Dioscorea alata	Sweet Potato	< 800	Loamy clay	10-35 tons/ha
Dioscorea bulbifera	Sweet Potato	< 800	Loam, clay	0.5kg/tuber
Dioscorea esculenta	Sweet Potato	< 700	Sand/clay loam	
Dioscorea hispida	Sweet Potato	< 850	Humus	
CANNACEAE				
Canna edulis	Edible canna	< 2000	Rich in humus	18-38 tons/ha
BROMELIACEAE				
Ananas comosus		< 1000	Adaptable	38-75 kg/ha
ORCHIDACEAE				
Vanilla fragrens				
(V. planifolia)	Vanilla	400-1000	Rich in humus	800 kg/ha
URTICACEAE				
Boehmaria nivea		<1200	Rich sandy loam	
CAPSICACEAE				
Capsicum spp.	Chilli		Adaptable	

LATIN NAME	OTHER NAMES	ELEVA-TION (m)	SOILS	YIELDS
ZINGEBERACEAE				
Amomoum cardamomum				
Cardamon		300-1500	Humus	
Boesenbergia pandurata		< 700	Calcareous	
Catimbium malaccenisis		< 1500	Clay	
Costus spp		< 1000	Fertile	
Curcuma aeruginosa	Wild turmeric	400-700	Adaptable	
Curcuma domestic		< 2000	Clay loam	13-35 tons/ha
Curcuma heyneana		< 750	Adaptable	
Curcuma purpurascens		< 1000	Adaptable	
Curcuma xanthorizza		< 750	Adaptable	
Curcuma zeodaria		< 1000	Adaptable	
Elettaria cardamomum	Cardamon	< 1500	Rich humus	100-350kg/ha
Hedychium coronarium		<2000	Deep, rich	5.7 tons/ha
Kaempferia galanga	Galangal	80-600	Sand, clay	
Kaempferia rotunda		< 750	Clay	
Languas galanga	Lesser galangal	< 750	Loose, fertile	
Zingiber aromaticum	Wild ginger	< 1000	Clay	
Zingiber cassumunar		< 1300		
Zingiber officinale		250 - 900	Loose, fertile	
PIPERACEAE				
Piper betel L	Betel vine	<700	Clay	
Piper cubeba	Forest pepper	<400		
Piper nigrum	Black pepper	<1000	Rich alluvium	
Piper retrofactum	Long pepper	<600	Sandy	

Low Understory Shade Tolerant Crops (continued)

LATIN NAME	OTHER NAMES	ELEVA-TION (m)	SOILS	YIELDS
LEGUMINOSAE				
Calapogonium mucunoides		< 700	Adaptable	6 tons/ha
Centrosema pubescens	Centrosema	< 300	Adaptable	
Desmodium gyroides	Desmodium	400-1000	Adaptable	2 tons/ha
Dolichos lablab	Lablab bean	< 500	Fertile	1.4 tons/ha
Mucuna pruiens	Velvet beans			
Pacyrrhizus erosus	Yam bean	< 500	Sandy loam	95 tons/ha
Vigna unguiculata var. sesquipedalis	Long bean		Adaptable, well-drained, neutral	
CONVOLVULACEAE				
Merremia mammosa				
LABIATAE				
Coleus ambonicus	Oregano	< 250		
Ocimum basilicum	Basil	450-1100	Clay	
Orthosiphon aristatus		< 1000	Rich in organic matter	
Pogostemon cablin	Patchouli			
GRAMINAE				
Brachiaria decumbens				
Panicum maximum	Guinea grass			

4.5
RESILIENT BAMBOO FORESTRY (RBF) MANAGEMENT PLANNING

4.5.1
PLANNING

A bamboo forestry venture, without proper planning will be ineffective and inefficient. Time and resources spent in proper planning will lead to success

- Concentrate on both harvest of bamboo and the larger scale issues (social well being, sustainable economic benefit, environmental health).
- Consider carefully the reasons why the forestry venture might fail.
- Have a sensible process for making decisions.
- Work together with other bamboo growers to form a cooperative.
- Engage in continuous business planning and refinement of business processes.
- Link to other stakeholders (government, business, academics).

4.5.2
RBF - MANAGEMENT PLANNING

The kinds of crops, agronomic practices, patterns of land use, weather, total complexity, and self-sufficiency, affect the stability of an agroecosystem. As complexity increases, particularly among trophic interactions, there is usually an increase in the stability of the agroecosystem. Resilient Bamboo Forestry Management preserves and improves this complexity.

Sympodial bamboo exists in two major types of environments.

1. Sympodial bamboos can be found interspersed in natural forest stands at all elevations. In these situations, various species of bamboo exist in the upper and mid-canopy of a biodiverse forest, but in low densities. Risk of significant spread of pests or disease is minimum in this situation, as the natural forest stand acts as a barrier between bamboos.
2. Some species of sympodial bamboos will

come in as pioneers after a disturbance to natural forest types. In these cases, the bamboo appears as a large mono-specific stand, low in complexity. Bamboo plantations, whether planted by a single industry, or developed over time by rural communities, behave in the same way as natural, monospecific stands.

Although natural, lack of complexity and lack of other species of trees and plants, reduce the buffering capacity of the bamboo stand. Bio-geo-chemical cycles, that would normally be effective in helping a species develop ecological resilience, have limited success. Although the stand may thrive at low harvesting densities, significant harvesting can lead to the degradation of both the stand, and surrounding environment without proper planning and management.

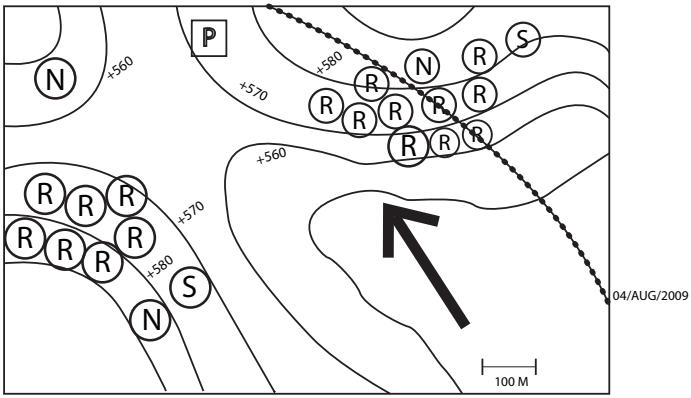
Intent:
To develop a complex bamboo-based agroecosystem exhibiting social, economic and ecological resilience.

Approach:
Agroecosystem planning, is an activity which can be useful in planning for a complex, bamboo based agroecosystem, which is resilient to disturbances. Below is an overview of agroecosystem planning that will need to be facilitated with bamboo growers for planning, as well as a sample design of a complex bamboo agroecosystem.

1. Visit An Existing Bamboo Agroecosystem
   Organize a facilitated tour of local bamboo agroecosystems with local bamboo growers. This can be done as part of assessment activities from Chapter 2, or as a separate activity.

2. Draw An Existing Bamboo Agroecosystem Layout

Each bamboo grower draws a diagram of her or his existing bamboo forest layout. Alternatively, several bamboo growers can work together on a single diagram. The diagram should indicate slope and elevation, and include all crops, trees, water sources etc. This diagram will form the basis of the agroecosystem plan.



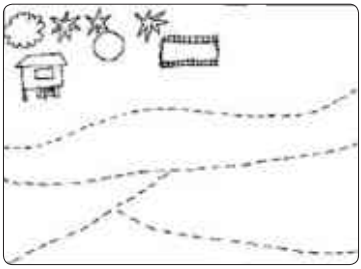
P = Spring
R = Bamboo Clump (Petung)
N = Jackfruit
S = Albizia

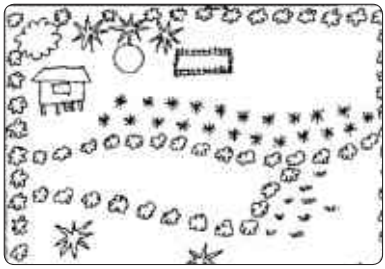
= Predominant wind direction

= Sun track (dated)

3. Discuss the Alternatives

Bamboo growers, extension workers and forestry officials can hold a discussion on integrating bamboo with other crops and tree species. Extension workers should have a working knowledge of bamboo ecology, agroforestry, shelter-belts, participatory planning and business planning. Previous maps and local landscape plans should be reflected on when possible. Resources for agroecosystem plans, for example government maps and NGO's with physical layouts for the area, should be identified. It is important to etablish the hierarchy for land use in the particular area.





4. **Design Improved Bamboo Agroecosystem**

Bamboo growers discuss possible changes and design improved bamboo agroecosystems based on the existing layouts and the alternatives suggested. Bamboo growers may modify the ideal models to suit their own situations, capabilities and objectives. For instance, one bamboo grower may focus on livestock production and desire a minimal amount of bamboo mixed with fodder species. Another grower may wish to maximize bamboo culm production. The facilitator helps prepare short, medium and long term plans for bamboo grower to achieve desired income goals.

4.5.3
INTERCROPPING - REDUCING RISK OF PESTS AND DISEASES:

Leaving spaces between bamboo plants- reduces the risk of the spread of disease and attack by insects. Appropriate spacing for several economically valuable bamboos are provided in the table below:

Genus	Spacing
Dendrocalamus	8-12 meters
Gigantochloa	6-10 meters
Bambusa	4-6 meters
Thyrsostachys	3-5 meters

Intercropping with companion plants- further reduces the risk of the spread of disease and attack by insects, and increases habitat for natural enemies.

Maintaining a variety of bamboos- decreases the risk of pest and disease damage causing major economic losses in a bamboo stand.

4.5.4
CONTENT OF BAMBOO AGROECOSYSTEM PLANNING

- Problems
- Objectives of farm improvement (expected output, yield and income, timeline)
- Available resource or potentials
- Areas or site to be planted
- Limitations
- Bamboos, crops and trees to be selected
- Combinations of bamboo, crops and trees, planting patterns and distance between plantings
- Supporting management steps to be adopted
- Seedlings, seeds and other materials required
- Source of information, technology
- Activity, schedule and responsible person

4.5.5
PLANNING SHEET

Example of Bamboo Agroecosystem Planning Sheet Problems:

- Low price for bamboo culms and shoots
- Soil fertility decreasing, erosion
- Difficult access to roads for collection
- Community more interested in quick growing timber species such as Albizia

Objectives:

- Short term (1-3 years)
- Better price for bamboo culms
- Plant other valuable bamboos
- Post harvest processing of bamboo in village
- Improve soil condition (fertility management and erosion control)
- Improve access to main road

Long term:

- Improve income
- Improve yield and quality of bamboo
- Mix valuable timber and fruit crops with bamboo

Activity Planning Schedule

Available Resources:

- 3 hectares of land, partially planted with fruit trees, quick growing timber and high value timber, under utilized bamboo (*G. apus, G. atroviolacea and D. asper*)
- 1 cow, 6 goats, grazing on the grass and in pens at night
- River and two natural springs

Limitations:

- Highly sloping land
- 4-5 month dry season
- Poor access

Bamboo/Tree Selection

- *Dendrocalamus asper* (shoots and high quality culms)
- *Gigantochloa apus* (village use, sale)
- *G. atroviolacea* (construction/furniture)
- *G. atter* (furniture)
- *Thyrsostachys siamensis* (handicraft)
- Coconut (fruit/timber)
- Rambutan (fruit)
- Banana
- Durian (fruit)
- Jackfruit (fruit/timber)
- *Parkia speciosa* (edible legume)
- *Acacia villosa* (fuelwood)
- Mahogany (timber)
- *Pterocarpus indicus* (timber)
- *Coffea arabica* (coffee bean)

Planting pattern

Uphill

- Small diameter bamboos (3-5 meter spacing), tree crops, fruit, fodder, average spacing

Mid-Hill

- Medium diameter bamboos (5-8 meter spacing), timber crops, fruit, tight spacing

Valley/Stream-side

- *D. asper* 10-12 meter spacing
- Banana trees, fuelwood

Supporting Management Steps & Technologies

- Nursery techniques
- Shelter belt creation
- Improved bamboo management
- Organic fertilizer production

Materials and Support Needed

- Tree seeds, bamboo cuttings
- Polybags
- Training on bamboo management
- Training on fertilizer production
- Information on other valuable bamboo species
- Marketing assistance for bamboo

Activity	**Months**	**Responsible Person**
Farmer's Meeting for Farm Planning	April	Farmer Org
Training on Bamboo Management	May	Community-at-large
Initial Bamboo Management	May-Jun	Bamboo Group
Collect seeds	Jun - Sept	Self/Group
Construct nursery	Jun-Jul	Self/ Bamboo Group
Plant nursery	Jul-Sept	Bamboo Group
Maintain and care for nursery	Jul-Jan	Bamboo Group
Prepare soil	Aug-Nov	Self/ Bamboo Group
Training on Organic Fertilizer	Aug	Farmer Org/ Bamboo Group
Fertilizer production	Aug-Sept	Farmer Org
Fertilizing of Bamboo Clumps and Trees	Oct	Self/ Bamboo Group
Transplant Seedlings	Nov	Farmer Org/ Bamboo Group
Understory Mgmt	Dec	Self
Understory Mgmt II	May	Self
Harvest Edible Bamboo Shoots	Dec-Mar	Self
Construct animal house for waste collection	Mar	Bamboo Group
Sell goat		Self

4.5.6
RBF MANAGEMENT PLANNING: SOME SOCIAL ISSUES

- Plans are usually prepared on a yearly basis, although bamboo growers also have long-term objectives.
- Plans sheets and diagrams are kept at the bamboo growers house. Every year this diagram will be improved. It will also serve as the bases for annual planning of any participating bamboo forestry business, government agency, or NGO.
- Bamboo growers may not be able to, or want to, improve their whole bamboo growing area, if they do not have enough resources to make changes, or are unsure of the financial outcomes. Starting with several key bamboo growers and tracking outcomes is a recommended strategy.
- People who will facilitate the bamboo agroecosystem planning process must be carefully selected and trained. They must be broad-minded to relate to local social, economic and biophysical issues. They should have a good community approach and communication skills.
- Using existing farmer organizations and community groups facilitates the planning process. These organizations should be strengthened through leaders, members participation in cross-visits, workshops, trainings and planning sessions. It may be necessary to strike compromises with government policies and strategies, adapting these as necessary to suit local conditions.

4.5.7
UNDERSTANDING BAMBOO COMMODITY CHAINS

Facilitating community members to trace the movement of their products to market is important. People need to understand who buys their bamboo, what the market value of bamboo is, for what quality. They can then broaden their awareness of the market structure. This will provide a basis for understanding business and marketing potential of bamboo from their forests. In appendix B is an example of a simple exercise to introduce basic marketing concepts to forest communities.

4.6
CHAPTER 4 CONCLUSION

This chapter has outlined example planning for bamboo agroforestry and management. Without any doubt there will be variation in the compatibility of certain plants with certain ecosystems, in the same way that management and planning are compatible with certain communities. The recipe for success is integrity and determination.

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APPENDIX A

Example Report of Participatory Rural Appraisal in Iseh, Bali-Indonesia 2007

1. Introduction
2. Ecology
3. Economy Aspect
4. Socio-cultural Aspect
5. Conclusion and Recommendation

APPENDIX A LAYOUT

1. Introduction
    - 1.1 Background
    - 1.2 Goal
    - 1.3 Output
    - 1.4 Method
2. Ecology

3. Economy Aspect
    - 3.1 Occupation
    - 3.2 Job Division
    - 3.3 Bamboo Stakeholders
    - 3.4 Bamboo Handicraft

4. Socio-cultural Aspect
    - 4.1 Local system
    - 4.2 Local value

5. Conclusion and Recommendation
    - 5.1 Conclusion
    - 5.2 Recommendation

This Participatory Rural Appraisal of Iseh, Bali was intended to support the formation of a cooperative to develop bamboo resources in the area

"Wood (kayu) and Bamboo (bambu) are very important in our life; "The word 'kayu' or 'kayun' means 'mind' while 'bambu' or 'tieng' means behavior. That's why we can not live without bamboo"

(I Nengah Regig, Vice of Bendesa (traditional village head of Iseh)

1
INTRODUCTION

1.1
BACKGROUND

Ecologically, bamboo gives benefit to environment as it produces *a biomass* seven times that of other forest plants and it can prevent erosion by holding soil particles together, while saving groundwater as well. Bamboo also absorbs large amounts of carbon, can be regenerated, and is widely available in Indonesia. Of 1.250 kinds of bamboos known in the world, 11% are native to Indonesia, mostly in Sumatera (56 species) and Java-Bali (60 species).

Unfortunately, in Indonesia, bamboo does not get serious attention and is considered 'something owned by poor people,' therefore it isn't maintained properly. It is no wonder that many bamboo forests have been converted to residential areas and plantations. One area in Bali that still has vast bamboo forest is Banjar Iseh, Sidemen, Karangasem, Bali. We might be able to learn ecological and economic sustainability from Iseh by observing how to run a bamboo business without damaging the environment, while benefiting the local community.

1.2
GOAL

This research investigates the potential of bamboo forest in Iseh and how to run the bamboo business. It is assumed that the continuing bamboo businesses are mainly influenced by three factors: availability, professional entities and a market

for the products. Hence, we discuss three aspects of bamboo in this study: ecology, economy, and socio-cultural value.

1.3
OUTPUT

This study collects data on:

1. forest size and ownership of plots of bamboos plants that are ready to be run collaboratively.
2. social and cultural conditions of the community which support bamboo business.
3. the importance of bamboo for the local community.

1.4
METHOD

The goal and output mentioned above collects data on ecology, economy, and socio-cultural aspects of bamboo using the following methods:

Ecology of Bamboo. Data on ecology of bamboo includes species, number, clumps, bamboo plants with economic value, and the landscape (mainly the type of soil and the slope of the land). The data was collected by transect and *purposive sampling. Transects are* performed with people who understand the desired information, such as farmers, hamlet leaders *(kelian adat)*, bamboo brokers and the community elders. The results of interviews are recorded, illustrated and classified. The interviews are guided by prepared questions. Maps and GPS are also utlized. Sampling methods assess how many bamboo clumps are available in one hectare. Two locations were used in this study; one location near, and one location far from a local street. There is a signifigant difference of physical appereance and number of clumps of bamboo between these two locations.

Economy. Data on the economy and business opportunities include composition of the population based on occupations, community work organizations, existing bamboo businesses in Iseh, bamboo stakeholders, networks, and markets. Network refers to parties with business opportunities who can influence or promote bamboo business in Iseh; they are bamboo craftsmen, bamboo business, businessmen, academics and bamboo activists. Data on economic conditions and business potential is gathered by: secondary data from monography, stakeholder identification (both key stakeholders and the supporting ones) and discussions.

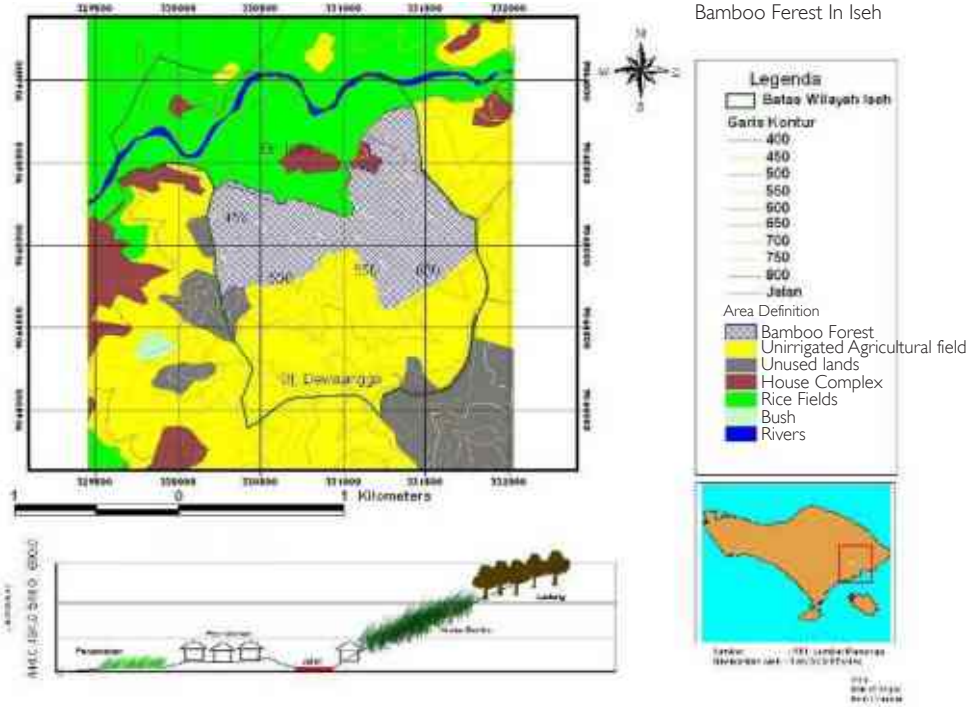
Discussions are done informally at foodstall or in community elder houses.

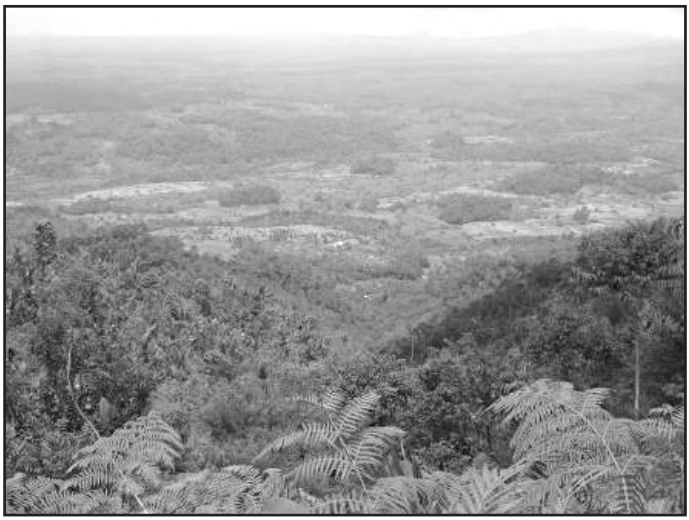
Socio-Cultural. The people in Iseh value maintaining bamboo forests, which is shown in their actions and institutions. They know which bamboo culms should be cut- only straight and old bamboo. Their local values are important in developing the bamboo business. Their self-conciousness and active participation are important too. Interviews have been carried out to obtain socio-cultural data. Through interviews the cognitive and affective aspects of the informant can be effectively collected, as the interviews were done informally but in focused, systematic, and indepth common conversations. Interviews also obtained perceptions of bamboo, the problem and their need for bamboo for building, traditional construction techniques and the use of bamboo for their daily life and industry. The informants are from the biggest bamboo location. They are from different ages and professions; farmers, labourers, brokers, village elders and civil servants who are considered to understand the situation.

2
ECOLOGY

Iseh is roughly 200 hectares consisting of rice fields, unirrigated agricultural fields and settlement. Rice fields compose about 140 hectares (400 – 450 m above sea level), the settlement is about 16 hectares (450 meter above see level), and the bamboo forest is about 30 hectars (450 – 600 meter above sea level). See the "Map of Bamboo Forest of Iseh" for more detail.

Bamboo Ferest In Iseh





Iseh Village from unirrigated agricultural field (650 above see level)

Iseh represents a typical Balinese agricultural village. The temperature is about 27 degrees Celsius during the day and 24 degrees Celcius during the night. Half of the village is unirrigated agricultural fields and bamboo forest and the other half is rice field. Each family has at least has 50 *are* of land. The bamboo forest and unirrigated agricultural field functions to save water and maintain the reserve of spring water. There are about 5 big water springs in in Iseh in which their water is used for drinking, bathing, washing and other uses. The spings are Beji Iseh, Kultul, Tangkluk, Kayuan Anyar, and Slau. Each spring has its own spirit to guard. The respected one is Bata Pusa in Beji Iseh. Menstruating women are not allowed to enter, nor one who has just carried a corpse to the cemetery. For self-purification, one who has just in contact with corpse must have a holy bath in Slau first before entering Beji Iseh.

There are additional springs in the forest to the five springs. Their water comes up through the ground and from the roots of the plants. The water runs in rivers and irrigates rice fields under an established 'subak' organization system. In the north of the village a big river flows all throughout the year. These springs and rivers provide the people with sufficient water. Water collected from the springs for drinking is not boiled first.

From the bottom to the top: rice fields, bamboo forest, and unirrigated agricultural field.

The main road in Iseh Village connects Sidemen District and Selat District. From Denpasar you can reach Iseh via Klungkung, and from Klungkung go to Sidemen. The village is situated by the road between Sidemen-Selat; a strategic location with good access to the rice fields, unirrigated agricultural fields, as well as the market.

The people of Iseh are not aware of the ecological benefits of bamboo. They use the bamboo for ceremonial purposes and sell them when they need money. They note that bamboo grows like a grass and that it doesn't need proper maintenance. They never worry that the bamboo forest will be gone. "Just let them grow wildly and there will be more and more of them," says Mr. Regig, the secretary of the village *subak* organization.

Several different varieties of bamboo grow in Iseh; they are *apus, sowet, tamlang, ampel, gading and petung*. The majority is apus while other kinds of bamboo make up less than 20 clumps and are at spread through different locations, while apus is grouped in one location. The community divides bamboo forest into 2 locations, West and East, because the soil condition and the bamboo characteristics are different in both locations.

The difference between West and East locations

West	East
Thin ground layer	Thick ground layer
Soapstone soil type	Red colored soil
Strong type of bamboo	High water level
Suitable for building	Suitable for plants
Black solid fibre	
Short joint	Long joint
Small diameter	Big diameter

The conditions of bamboo forest are very different by the street and far from the street. Bamboos near the street are more often chopped and in bad condition. By sampling method it is estimated that a single hectare of bamboo forest near the street is composed of 440 clumps with 7,270 bamboo culms, which means that one clump consists of 16.52 bamboo culms. A hectare of bamboo forest that is far from the street consists of 290 clumps, or about 9,490 culms, approximately 32.7 culms per clump. This fact tells us that bamboo plants farther from the street are far healthier and numerous.

Bamboo forest in Iseh: close to the street (left) and far from the street (middle and right).

Comparison between bamboo clumps close to and far from the street in one hectare.

	Close to street (0 – 200 m)	Far from street (more than 200 m)	Average
Number of clumps	440 clumps	290 clumps	365 clumps
No. of culms	7.270 culms	9.490 culms	8.380 culms
Avg. culms/clump	16,5 culms	32,7 culms	24,6 culms

3
ECONOMY ASPECT

The people in Iseh use bamboos for daily purposes such as ceremonies, furniture, building construction, roofs, handicrafts, musical instruments and food. However, much has changed due to modernization. Concrete and timber have replaced many construction uses of bamboo, house utensils have been replaced by plastic ones, agricultural tools have been replaced by machines, and now musical instruments are bought from the neighbouring villages. Currently bamboo is used for ceremonial purposes and sold to Klungkung through brokers, especially if one needs money. In order to assess if the benefit of bamboo has decreased we need to understand the economic condition of Iseh village, an important step in developing a bamboo business there.

3.1
OCCUPATION

In 2007 the population of 265 households in Iseh totalled 1,217, mostly composed of farmers (rice farmers and non rice farmers). There are also vendors, civil servants, labourers, and craftsmen. Some of them work in the tourism sector outside of the village in some towns in Bali, but mostly in Denpasar.

Other natural resources in Iseh beside bamboo

Commodities	Unit	Price	Commodities	Unit	Price
Rice first quality	Kg	5,000	Raw coffee	Kg	5,000
Rice sec. quality	Kg	2,200	Coffee seed	Kg	20,000
Red chilies	Kg	15,000	Long bean	Kg	2,500
Chilies	Kg	7,000	Peanut	Kg	3,000
Sweet potato	Bunch	2,500	Tomato	Kg	2,000
Cloves	Kg	50,000	Snake fruit	Kg	2,000

The main income of the villagers comes from the agricultural sector from commodities such as rice, snake fruit, clove, chilies, coffee, durian, tomato, sweet potato, peanut and bamboo.

Some of them work in other sectors, especially the craft industry between the planting and harvesting period. Most of them are women who manufacture *ikat* for sale in Sidemen, which costs Rp. 350.000 per piece for the lowest quality. A woman gets Rp. 250.000 per piece of finished *ikat*. It takes 20 days to make one *ikat*. Some 20 families make handicrafts from bamboo which are used for ceremonies. They also weave bamboo for walls, which costs Rp. 25.000 per meter.

3.2
JOB DIVISION

Most of the men in Iseh work in rice fields and are helped from the women. The men also make woven bamboo and the women make woven fabric *(ikat)* in between the harvest time. The women have no right in political affairs, although they play important roles in the economic sector. Only the men have access to decisions on public policy and join traditional *(adat)* meetings. Women are limited to family and ceremonial affairs. Customarily, women have no equal economy right against the men. Women have no right to inheritance, only the men do. Therefore when a family has no boy, the inheritance will be given to the man with the closest family relationship

3.3
BAMBOO STAKEHOLDERS

Most of the families in Iseh have their own bamboo plantation, or at least some clumps at their own land. They only sell bamboo when they need money and

don't actively manage the bamboo. They think the bamboo still grows well without maintainance.

Aside from private ownership, 3 hectares of bamboo is also village owned and about 2 hectares belongs to a family temple. The bamboos owned by the village is sold for village revenue. Those belonging to the family temple property are used for ceremonies and sold as well. In Iseh the only family temple is owned by Nengah Hantan.

Bamboo owners sell their bamboos to brokers. There are 8 full time and 4 part time brokers. All farmers from Iseh have their own bamboo plantations, *from 1 – 30 ares* (0.1 – 0.3 hectares).

Pak Tebeng (a broker) cutting bamboo, accompanied by the writer.

The only bamboo for commercial purpose is *apus*, as 98% of bamboo in Iseh is this type. Brokers purchase bamboos at different price ranges depending on location. The bamboos located in flat areas and close to the street are much more expensive compared to those from locations farther away. Besides paying the price of bamboos, brokers must pay people for cutting and carrying the bamboo to the street. Usually the brokers cut the bamboos themselves and pay other people to carry the culms to the street. Cost for carrying to the street also varies depending on the distance and difficulty of the terrain. The price of carrying the bamboo is per piece or bunch (4 pieces).

Table of bamboo price

Location	Price at the place	Price for cutting	Cost for Carrying per pc	Total Cost per pc
Easy; close to the street (0 -200 m) flat – a little steep) easy access	Rp. 7,000	Rp. 1,000	Rp. 2.,000	Rp. 10.,000
Moderate; a bit far (200 – 400 m); a bit steep; easy access	Rp. 5,000	Rp. 1,500	Rp. 3,000	Rp. 9,500
Difficult More than 400 m from street very steep, difficult access	Rp. 3,000	Rp. 2,000	Rp. 4,000	Rp. 9,000

Once the bamboos are delivered to the street they are transported to Klungkung by truck, costing Rp. 100,000/trip. One truck can accommodate 300 bamboos (3 – 4 meters long) or 100 hundred bamboos, so the price to transport the bamboos to Klungkung is Rp. 1,000/pc. The net cost spent by a broker for a piece of bamboo is Rp. 10,000 – Rp. 11,000.

Bamboos are cut, tied, and then transported to Klungkung

A broker will cut a bamboo into 4 piece; *bongkol* (bottom), *siakan* (middle), *muncuk* (upper part), and *laudan* (top part). The first three parts are sold for scaffolding in Klungkung, while the last (laudan) is sold to local farmers for stick for creeping plants such as string beans.

Table of bamboo price per piece

Part	Traditional size	Size in meter	Price
bongkol (bottom)	8 joints	3,5 meter	Rp. 5,0000 per pc
siakan (middle)	6 joints	3,5 meter	Rp. 3,500 per pc
muncuk (upper part)	7 joints	3,5 meter	Rp. 2.,500 per pc
laudan (top part)	4-7 joints	2 – 3 meter	Rp. 6,000 per bunch

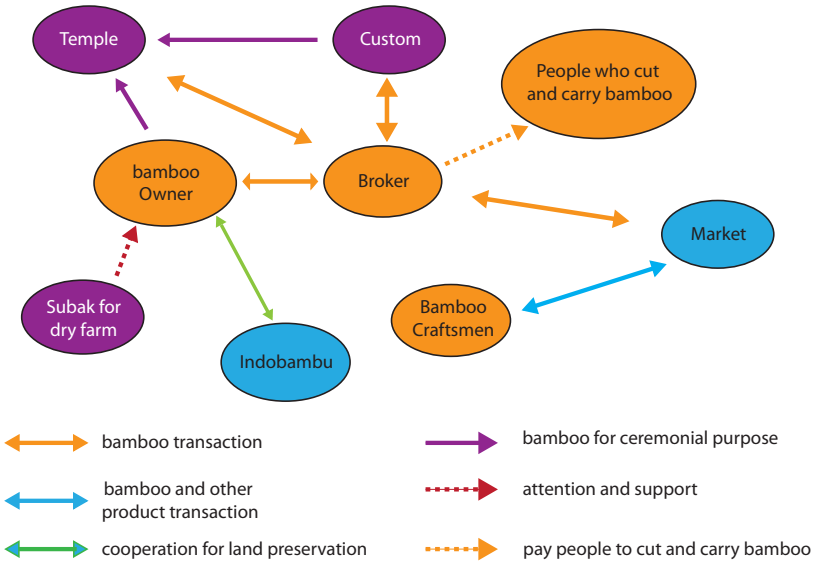
Based on the above table, a broker receives Rp. 11,000/pc and an extra Rp. 6,000 from a bunch of *laudan*. After deducting his expenditures he will only receive Rp. 1,000 profit, or sometimes break even. To make more profit a broker often cuts the bamboos himself, reducing costs by Rp. 1,000 – Rp. 2,000/pc. His working time is equivalent to 3 days per week, during which time he is able to cut and sell 100 bamboos. So, in three days earns Rp. 100,000 – Rp. 300,000 profit. Some work alone and some with a partner, in which case the profit is shared. Beside selling bamboos, some of them also change the bamboo into some products to increase the value They produce furniture, bamboo roof *(sirap),* and woven bamboo.

Implementation of rice field systems, government programs and bamboo forest management are carried out by *subak abian* (*subak* for dry land area). However, as bamboo is never considered a commodity by community nor authorities, the *subak abian* does not pay serious attention and support to the owner of bamboo plantations.

Subak meeting hall and map Wanagiri territory

Lack of appreciation from the community towards bamboo is mirrored by a lack of appreciation from outside parties as well. The contact with outside parties is just limited to business transactions. The only party who has built cooperation with the community is the company *Indobambu*, which leased 3 hectares of land from one of the villagers as a pilot project.

Map of Bamboo Stakeholders in Iseh



3.4
BAMBOO HANDICRAFT

In spite of lack of attention from the community and the authorities, Pak Nyoman Gunung of Iseh is seriously involved in bamboo business and has just begun his business to produce bamboo roofing *(sirap)*. An additional two to eight people daily workers and an experienced villager who has worked in a furniture factory in Gianyar, Bali help him produce bamboo furniture. They are paid based on finished products. On average, each are paid Rp. 30,000 – Rp. 40,000/day. Although they get paid less than in Gianyar, they are happy to work in their own village. Their products are made based on orders. Most orders are from domestic consumers. His business promotion is by word of mouth. He considers the absence of support and attention a real challenge for him in running his business.

4
SOCIO-CULTURAL ASPECT

As for Iseh community, wood and bamboo cannot be separated from their daily life. This is in accordance with the opinion of Pak Regig (mentioned above). According to the community, human beings are nothing without mind and action. Based on this philosophy, the community preserves and makes use of bamboo forests from generation to generations.

According to some village elders, such as 85 year old Pak Sante, bamboo has grown on Iseh from long ago. "Bamboo plants were already bushy like this when I was a child," he says. According to him, the bamboo forests must be preserved as the community needs bamboos for ceremonies and building material. Before the 1970's the structures, walls and roofs of houses in Iseh were made of wood and bamboo. "When Mount Agung erupted in 1963, all houses in Iseh had bamboo roof *(sirap)*," says Pak Mangku. "Only some had *alang-alang* (thatched roof)," he added.

Pak Mangku and Pak Sante seem to enjoy talking about their past. "When our houses were made of bamboo we could sleep well, we weren't afraid of earthquakes, and it was cool. When it rained, it wasn't noisy like today," says Pak Sante.
Now some villagers have changed their bamboo plantations into snake fruit, clove and coffee plantations, but some are afraid to do so as they consider bamboos an inheritance from their ancestors.

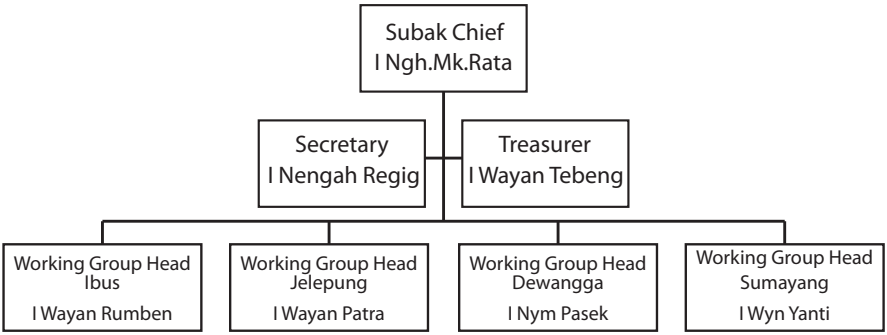
4.1
LOCAL SYSTEM

The administration system in Bali is very unique. It is a dual system; traditional administration *(adat)* and formal administration *(dinas)*. Administratively, Iseh is a *dusun* (hamlet) under Sinduwati village administration. A formal administrative village is run by a '*perbekel*' (village head). A *dusun* is headed by a *kepala dusun dinas*. Traditionally, Iseh is a *desa Pekraman* (traditional village). A *desa adat/ pekraman* usually consists of a few *banjars* (the same level as *dusun*). *Desa adat* is headed by a *kelian adat (bendesa)*. A *banjar* is headed by a *kelian banjar.* Iseh is a *desa adat* or *pekraman* which consist of one *banjar* only. So it is both a *desa adat* and *banjar.* Formal matters are managed by *dusun* and *desa,* while social, traditional, and economy matters are carried out by the *banjar* and *subak.*

Agricultural matters are carried out by *subak*. There are two *subak* in Iseh, that is *subak sawah* (irrigated rice field) and *subak abian* (unirrigated agricultural field) organizations. *Subak* is responsible for work in preserving the village land, monitoring types of plants, planting periods, irrigation, supply and monitoring and support for farmers, and delivering assistance (money, goods, information and training from outside parties, especially the authorities) to farmers.

As there is no job description for *subak abian* in relation to types of plants, planting period, and irrigation, *subak abian* is limited to monitoring and delivering assistance. In running the village properties, the community is divided into five *tempekan* (smaller units of *banjar* or working groups) for rice fields, and four *tempekan* for unirrigated agricultural fields. The villagers (*krama*) do the fields owned by the traditional village by turns. The *subak abian* organization of Iseh is called *Subak Wanagiri*. This organization has 64 active members.

Organization Chart of Subak Abian Wanagiri



Aside from subak, other organizations such as the village bank *Lembaga Perkreditan Desa (LPD)*, provides micro credit to the community. However, the village bank is not working at the moment. The economic system has been included in the *subak* organization. Perhaps this is the reason why a village bank is not functional.

4.2
LOCAL VALUE

From generation to generation the people of Iseh have preserved the bamboo forests. The fact is that each household has its own bamboo plants, either in their

gardens, house, or yard. The villagers look after their bamboo plants wisely. Although they don't think it is necessary to manage the bamboos, they are smart enough not to sell all of their bamboo. They consider their bamboo as a 'savings' that they can sell as they need money. A broker sometimes has a problem when he has many orders but the bamboo owners are unwilling to sell their bamboo.

The community has no special method in cultivating bamboo, however, an unwritten rule prohibits cutting bamboo on Sunday. Bamboo for construction purposes is not allowed to be cut on Mondays. Additionally, bamboo is not cut when new shoots are growing during the sixth to eighth month of the Balinese calendar. This research was conducted in the sixth month of Balinese calendar (December).

According to village elders, cutting bamboos when the shoots grow can ruin new shoots as they will not get proper nutrition supply. Despite these unwritten rules, brokers continue to cut them.

"It is still okay to cut bamboos when the new shoot grow, as long as the bamboos with shoots are not cut. Pulling the cut bamboos from the clumps should be done carefully, " says Pak Tebeng when he was seen cutting bamboos in the plantation.

The people of Iseh do not know if there is a special spirit that lives in bamboo plants. However, Balinese believe that there is a spirit that live in bamboo plants called Giri Putri. Once every three years they hold a ceremony dedicated to the forest and mountains at the temple located in Puncak Sari. Every fifth full moon of the Balinese calendar (October-November) community also holds a special ceremony dedicated to preservation of the springs.

5
CONCLUSION AND RECOMMENDATION

5.1
CONCLUSION

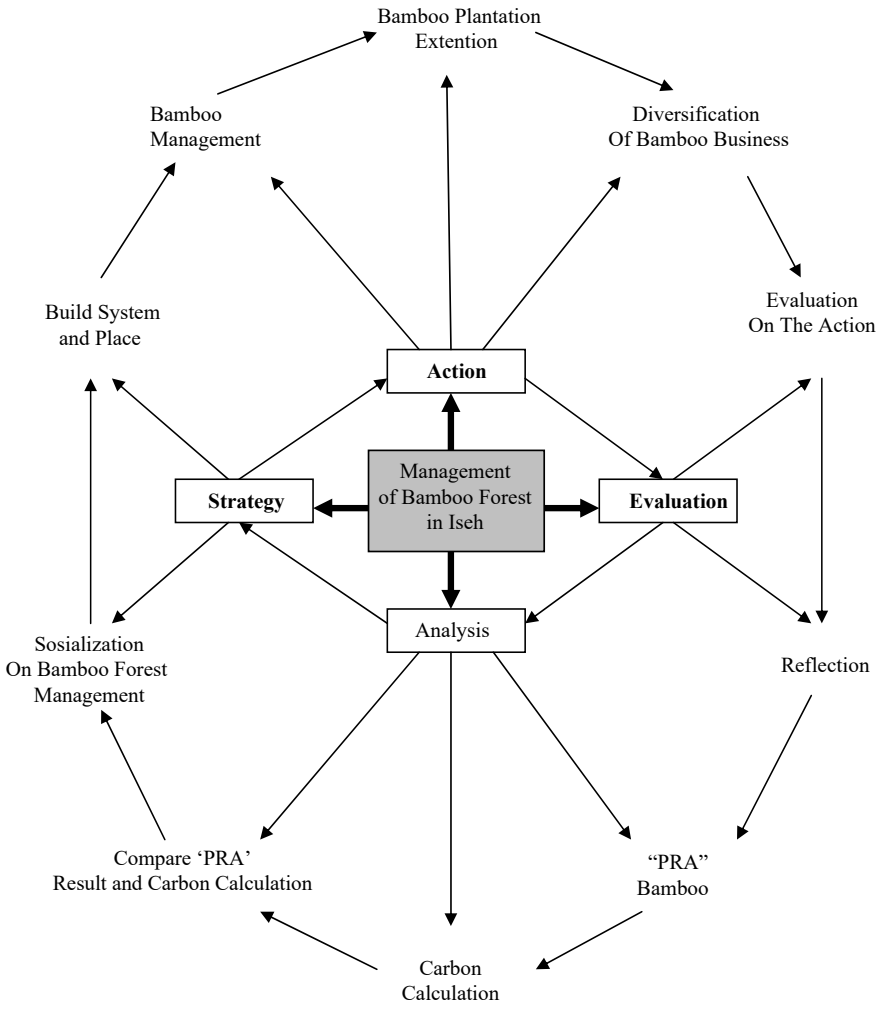
- There are 30 hectares of bamboo forests in Iseh, the majority of which is *apus* (98%). The plantations are owned by 64 people and of those 8 own more than one hectare. Three hectares are owned by the *banjar.*
- In one hectare, there are 365 clumps totaling 8,380 culms of bamboo. If 4

- bamboos are harvested from each clump then 43.800 bamboos can be selectively cut in one year from Iseh. So far in Iseh, 2,000 bamboos are cut monthly (24,000/year) for scaffolding, umbrellas, and ceremonial use. Thus far bamboo cutting has been focused on old bamboo in locations of easy access. It is still possibile to increase harvest numbers as long as the clumps are maintained properly.
- The bamboo forests are within the territory of *Subak Wanagiri,* but they don't have special rules for running bamboo businesses. The bamboo cutting system in Iseh is controlled by brokers. There are about 12 brokers, eight permanent and four part time.

5.2 RECOMMENDATION

- In order to save carbon in bamboo, there should be a bamboo business plan allowing bamboos to last for another 25 years. The comprehensive plan should involve preservation, charcoal business and bamboo roof *(sirap)* businesses. The old, straight and unbroken bamboos should be sent to be preserved. The old, bent and broken ones can be cut into pieces for *sirap.* The unused pieces can be processed into charcoal. The preservation facility should accommodate 3,650 bamboo plants or 7.300 pieces (one tree cut into two with 6 meter long each). The business plan should involve the local system, the *subak* system, instead of a cooperative or other system that may not fit with the local characteristics.
- To support the bamboo business plan, there should be a clump maintainance program, which the *Banjar* Iseh council and Subak Wanagiri are ready to support. They suggest taking the following actions: (1) socialization in *banjar* and *subak* organizations; (2) holding a workshop for brokers and bamboo plantation owners to show them the proper way to cut bamboos; (3) building a control system in dealing with bamboo clumps by assigning *pecalang* (traditional vigilante) within the *banjar.*
- Another program that is recommended is to extend the bamboo plantations into 5 hectares of unused land and an additional 15 hectares of unproductive land. The *apus* type of bamboo (or the others such as *petung, wulung, tamlang,* and *ampel gading* which are needed by the community) can be utilized to extend the plantation.
- If this recommendation is approved, the next step is to prepare a strategic plan involving the designers (Ishwara) and bamboo stakeholders in Iseh. The study that has been done and strategic plan that will be prepared should be

should be incorporated in the management program as shown below.



Program for Bamboo Plantation Management in Iseh

Attachment
List of Subak Abian Wanagiri's Members

1. I Ngh M. Rase
2. I Ngh Regeg
3. I Wyn Tebeng
4. I Nym Dauh
5. I Gd Winde
6. I Wyn Caci
7. I Ngh Kerti
8. I Ngh Ratep
9. I Nym Sudiansare
10. I Ngh Wene
11. I Kt Degeng
12. I Ngh Rempeg
13. I Wyn Rumben
14. I Nym Rendeh
15. I Kt Ribek
16. I Kt Sene
17. I Wyn Singgin
18. I Wyn Karen
19. I Wyn Sadre
20. I Ngh Ngence
21. I Nym Genti
22. I Wyn Mileh
23. I Nym Tawe
24. I Wyn Rented
25. I Nym Pasek
26. I Kt Sante
27. I Wyn Teges
28. I Nyn Giri
29. I Ngh Mangku Dongdong
30. I Nym Dare
31. Jero Mangku Saba
32. I Nym Sanding
33. I Kt Tebeng
34. I Kt Badung
35. I Wyn Goye
36. Mangku Kitis
37. I Ngh Sanah
38. I Nym Dangin
39. I Wyn Regeg
40. I Ngh Sililo
41. I Ngh Sante
42. I Kt Dunye
43. I Kt Merte
44. I Wyn Patre
45. I Nym Giri Open
46. I Wyn Regeg
47. I Nym Gemplek
48. I Wyn Dauh
49. I Kt Rume
50. I Ngh Ngenes
51. I Wyn Gentos
52. I Wyn Kirig
53. I Kt Oke
54. I Wyn Sabe
55. I Wyn Togog
56. I Ngh Bebeh
57. I Kt Santi
58. I Nym Dawe
59. I Ngh Hulas
60. I Wyn Sute
61. I Wyn Kukseh
62. I Ngh Sarke
63. I Ngh Kari Meres
64. I Nym Wage

REFERENCE

Asia Forest Network. 2002. Participatory Rural Appraisal for Community Forest Management. Tools and Techniques. Asia Forest Network. Santa Barbara, California, USA.

APPENDIX B: INTRODUCING MARKETING CONCEPTS EXERCISE

Intent:

- To introduce basic marketing concepts
- To generate information on the local market structure, e.g. prices, presence or absence of middle persons, brokers, presence or absence of cooperatives, infrastructure support, credit facilities, mark-ups/profits, taxes, etc.
- To identify and analyze marketing issues that need intervention.
- To broaden the community's awareness of the local market structure and economy.
- To develop marketing strategies for the products of the community.

Requirements:

Human Resources	Materials
- Trainer	- Large paper
- Facilitator	- Markers
- Marketing specialist	- Masking tape

Approach:

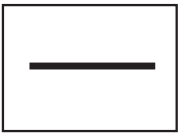
1. Ask participants to identify key bamboo commodities they produce and sell.
2. Divide the participants into groups composed of 5-8 members. Ensure that

all groups work on the same commodity, or commodities to ensure wider sharing of experiences.

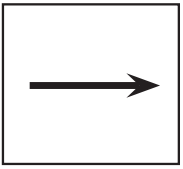
3. Explain the four important symbols used in the tool.

The illustration of the **commodity.** This represents the commodity being analyzed and is a reference point for the participants.

The size of the circle. This refers to the **volume of product** each market outlet absorbs.



The length of the line. This refers to the **relative distance of the market outlet from the community.**



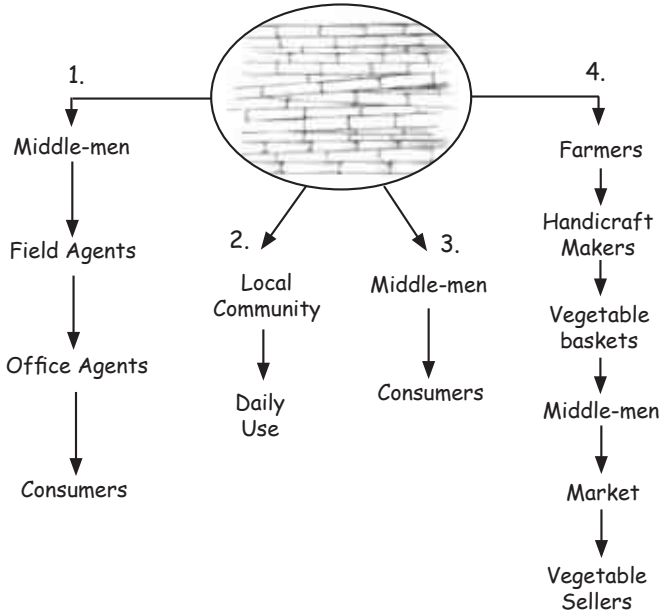
The arrow. The **direction indicates the mode of transporting the commodities to the market.** Commodities are either delivered (arrow points to the buyer) or picked up (arrow points to the seller) at certain areas.

4. Ask the participants to illustrate the flow (from producer to consumer including middle persons) of each of their various bamboo commodities (whole culms, split culms, shoots, woven mats, etc.)
5. Give the groups at least 15 minutes to work on the exercise, then, ask each group to present their workshop results.
6. Synthesize the results by pointing out the common or similar features of each small group workshop output. Try to resolve conflicting perceptions until the bigger group reaches a consensus.
7. Analyze the results and draw out significant observations, learning and recommendations into a commodity flow diagram that summarizes the group consensus.

OUTCOMES:

- A comodity diagram illustrating the flow of bamboo products.
- An analysis of market-related problems/issues affecting the community product
- Information on the local economy and market structure.

Example of a Commodity Flow Diagram for Bamboo from Jambewangi Village, Central Java



Example from Jambe Wangi Village, Central Java: Information of Local Economy and Market Structure

1. Whole Culms: Growers sell to middlemen:
    - *G. apus* $0.50,
    - *G. atter* $.80,
    - *D. asper,* $2.00,
2. Middlemen sell to Wholesalers:
    - *G. apus* $070,
    - *G. atter* $1.00,
    - *D. asper,* $2.50
3. Middlemen bring product to Yogyakarta (major city) for furniture production.
4. No charge for local use with permission from owner
5. Lathes (used to support clay roof tiles): *D. asper* only. $0.10/meter un-soaked, $0.12 per meter pre-soaked for two months in fresh water.
6. Baskets from makers sell for $0.40 for *G. apus*, and $0.50 for *G. atter* to middle-men and double that price at the market.

BAMBOO USES

Upper Culm (Leaves & Branches):

- Arts & Crafts
- Medicinal
- CO2

Mid-Culm:

- Houses
- Furniture

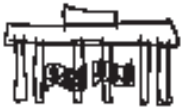
Base:

- Construction
- Charcoal
- Furniture

Root System:

- Food
- Water Shed
- Erosion control
- Toxic Cleanup
- Charcoal
- Medicinal

Financing



Loans are given

bamboo forests are planted

houses are built

products are made & consumed

products are sold

bank gets loan back plus interest

Variations:

This can be used as a project-specific planning exercise focusing only on one commodity (for example, split bamboo products - rafters and lathes). Targeting specific groups during the exercise can be done among women, youth, farmers and other homogenous groupings (based on ethnicity, gender, age etc.). Note that there might be differences in the price and market structures and availability of credit facilities for the products of men and those produced by women. You can potentially provide support for individuals or groups to travel, following the path of their commodity.

Strengths:

- Low-cost.
- Opens discussion on trader-producer relationships, particularly on financing.
- Can be a very good introduction to a savings and credit component of a project.

Limitations:

- Price of the products is not usually provided accurately
- People tend to keep the information secret to protect their own interests.
- Mean price of commodity fluctuates. This means that some data will only be relevant for a certain period of time. The use of a seasonal calendar to plot fluctuations can help project trends on bamboo commodity prices.
- Farmers find it difficult to change market systems even if results of analysis suggest change because they are often times indebted to local traders.

APPENDIX C

Vertical Soak Diffusion Method

1. Preface
2. Introduction
3. Harvesting Bamboo
4. Planning a Treatment Center
5. Tools and Materials
6. Mixing the Borax Solution
7. Information about Borates

APPENDIX C LAYOUT

1. Preface

2. Introduction

3 Harvesting Bamboo
    3.1 The Powderpost Beetle

4 Planning a Treatment Center
    4.1 Elevation View
    4.2 Floor Pan

5 Tools and Materials

6 Mixing the Borax Solution

7 Information about Borates
    7.1 Reuse Guidelines
    7.2 Disposal Guidelines

1
PREFACE

The use of bamboo products requires often its protection against biodegradation by chemical treatment. Its application is hindered by the structure of the culm, the need for larger technical installations and the danger of environmental side-effects. The VSD method developed by EBF is obviously an efficient method to obtain well treated culms, safe to be handled. Its wider application, also to other species, will strengthen its base.

Walter Liese
Universität Hamburg, Germany

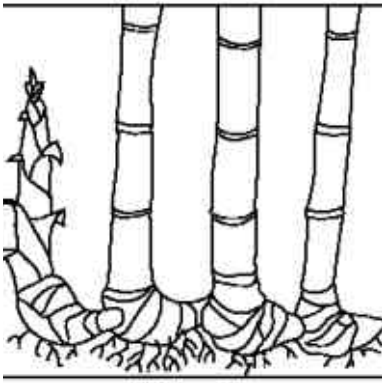
2
INTRODUCTION

Bamboo culms are a natural material susceptible to insect and fungal attack. Without treatment products made from bamboo can be expected to last for only up to 3 years.
There are many different techniques for curing and treating bamboo culms in order to prevent splitting, insect infection and fungal growth.

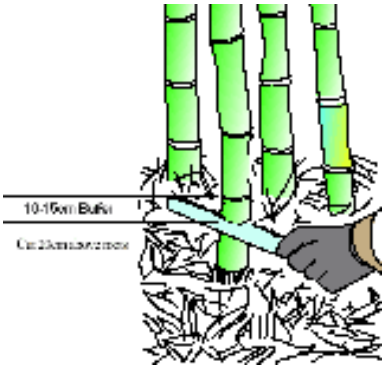
We present the Vertical Soak Diffusion (VSD) method which uses minimally toxic borates as preservatives. The method has been tested in Indonesia using three species of bamboo:
Dendrocalamus asper*
Gigantochloa apus*
Gigantochloa atter*
If you are intending to use other species of bamboo, follow the methodology in this booklet to treat a small section (1-2 internodes) and observe the rate of penetration of the red dye discussed in step 14.

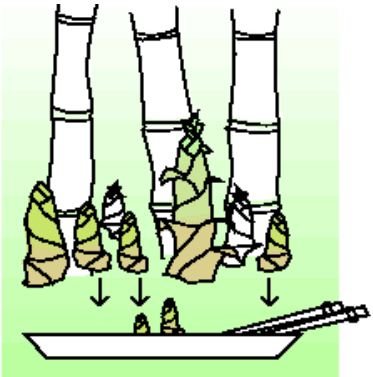
Whereas bamboo treated by the modified boucherie system (a pressure system introduced by Prof. Dr. Liese, Hamburg, Germany) is appropriate for large scale plantations growing bamboo for construction timber, furniture, and some crafts the VSD system works well with small-plantation situations , and community development work in rural villages

Clumping bamboos are non-invasive. They do not ruin buildings, they grow very fast when young and the culms are larger than those of the running bamboo. They require little maintenance, although simple clump management will benefit both the grower and the bamboos.



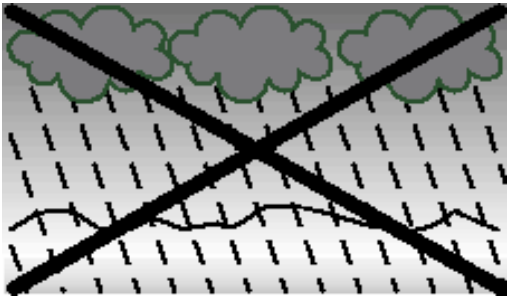
In the dry season, almost all culms that are 3 years or older can be removed from a clump by cutting them just above a node about 20cm above the ground. Some younger ones have to remain for further nourishment of the rhizome.

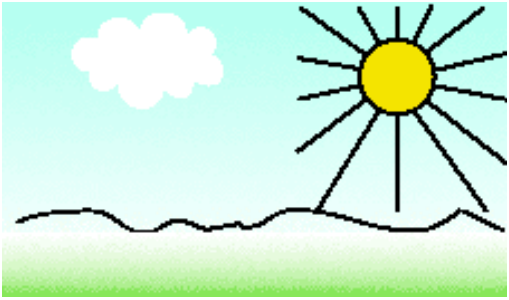




In the shooting season, remove any shoots that are going to create overcrowding (many species are edible, cooked). Leave only the shoots of good diameter which have potential to produce straight strong poles for timber use.

3
HARVESTING BAMBOO





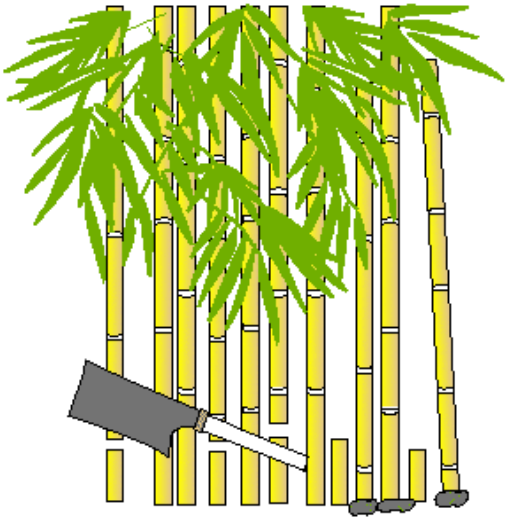
Harvest Bamboo during dry season

The best season for harvesting is after the rainy season when starch content in the bamboo sap is low. Starch is the favourite food for pests. Don't harvest during shooting season! Cut bamboo that is 3-5 years old. Bamboo older than 5 years is harder and the inner culm wall becomes impermeable to the BORAX BORIC ACID Solution.

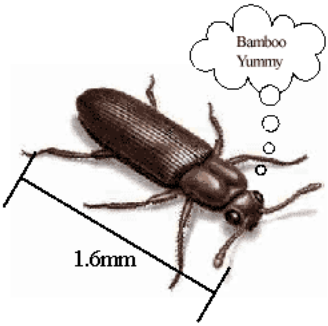
There are 2 different ways to tell the age of bamboo culms:

1. Mostly, culms at the inside of a clump are the oldest.
2. Label the new shoots, this is the safest method.

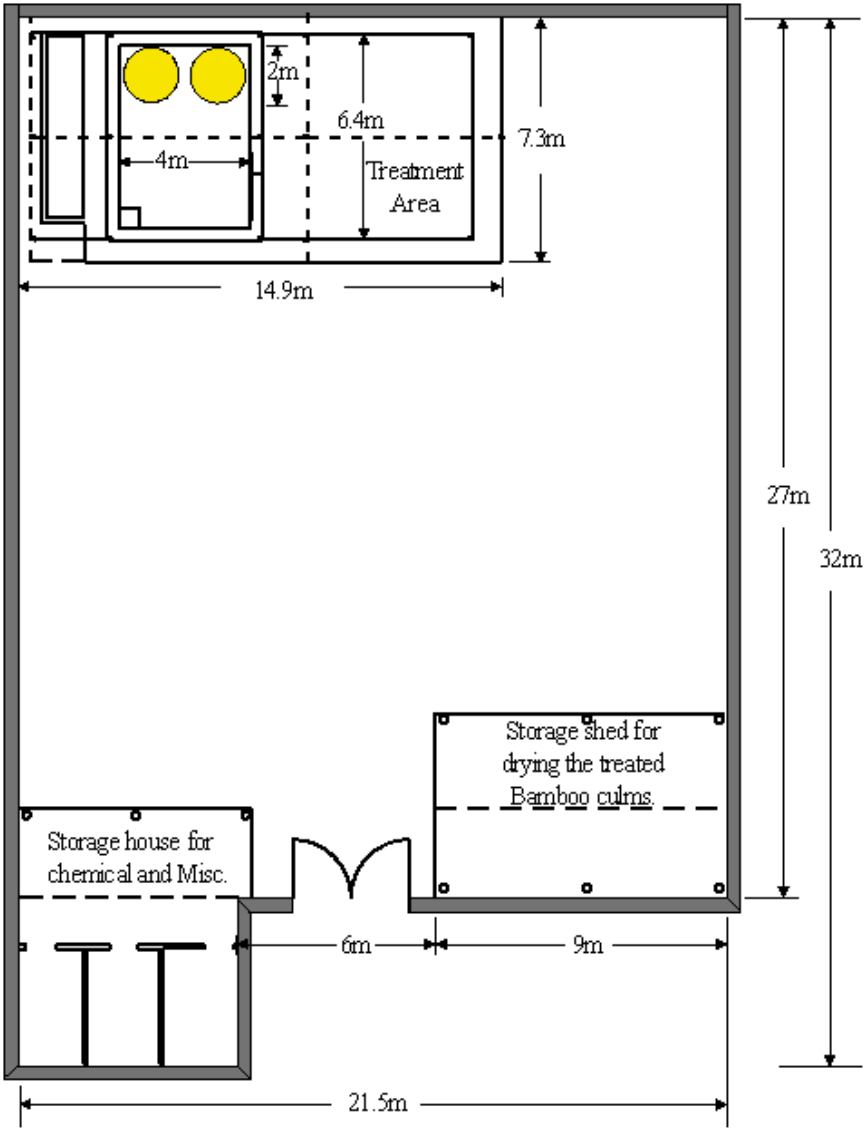
The culms should be treated soon after having been cut, but can be left for a few days standing upright, placed on a stone. Due to the ongoing transpiration by the leaves the culm will loose some of its moisture and also starch, which is the food for the pest, i.e. the Powderpost Beetle. But don't wait too long, since moisture is required for the following diffusion process.



3.1
THE POWDERPOST BEETLE

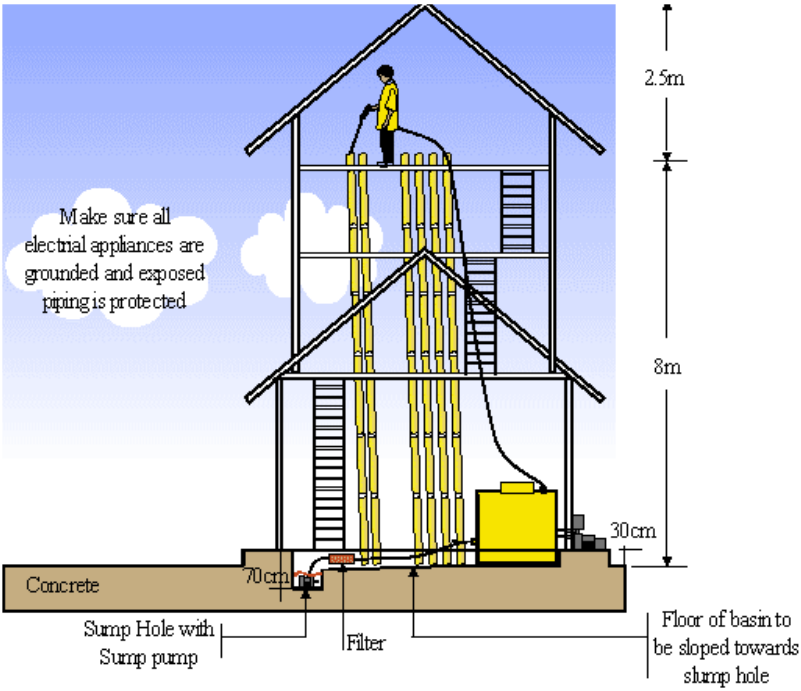


Stored bamboo is endangered by beetle infestation which can be recognized in the form of a talcum-like powder and small holes in the area of the nodes and along the internodes.

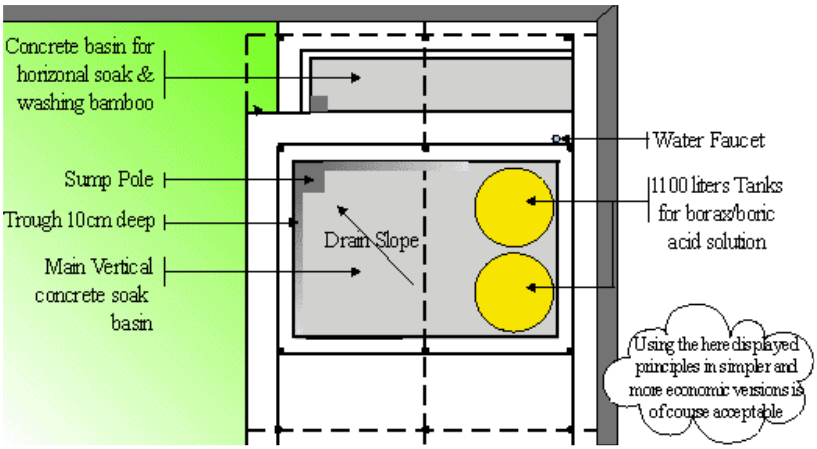

2m
6.4m
7.3m
4m
Treatment
Area
14.9m
27m
32m
Storage shed for
drying the treated
Bamboo culms.
Storage house for
chemical and Misc.
6m
9m
21.5m

Floor Pan

4.1
ELEVATION VIEW



4.2
FLOOR PLAN TREATMENT AREA



5
TOOLS AND MATERIALS

Eye Protection

Rubber Gloves

Rubber Boots

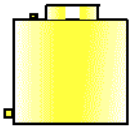
Boric Acid

Red Textile Dye Aniline

Water

Filter

Containers For Solution



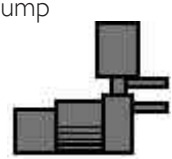
Rope (for tying culms)

Hacksaw

Iron Rod with hex Nut

Bamboo Stick for Stirring

Pump

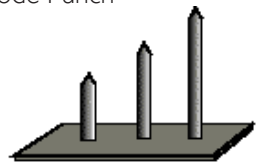


Small Sum pump

Rubber Hose

Hydrometer

Node Punch



Brushes for cleaning

6
MIXING THE BORAX SOLUTION

STEP 1

Calculate the internal volume of the culms.
There are 3 differrent ways to do this:

1. Volume in liters = inner radius squared x 3.1416 x height in cm of culm divided by 1000.
   Example: bamboo with radius = 6cm, height = 400cm
   ((6x6) x 3.1416 x 400)) / 1000 = 45 liters
2. Fill one punctured culm with water and simply measure how many liters it takes to fill it up. Multiply by the number of culms.
3. Fill one average internode; measure the amount in liters and multiply by the number internodes and by the number of culms.

STEP 2

Mix 3 kg of BORAX with 2 kg of BORIC ACID and add 45 liters water. This gives a 9 to 1 or 10% solution

Borax 3kg

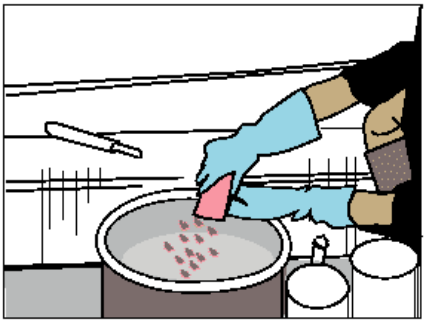
Boric Acid 2kg

Water 45 litres

1.5 litres each

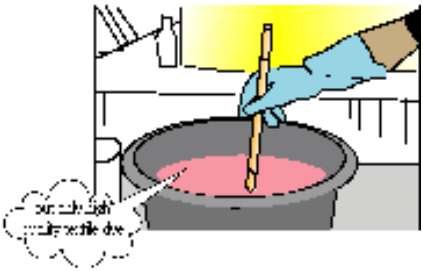
STEP 3

Add red analyn textile dye. It should completely penetrate the tissue of the culms from the inside all the way to the outside skin. If the particles of the dye are too large they will only partially dissolve and "plug" the openings in the tissue thus preventing penetration of the preservative.



STEP 4

Slowly add water stirring constantly until BORAX/BORIC ACID and dye are completely dissolved and no more crystals are at bottom of container.



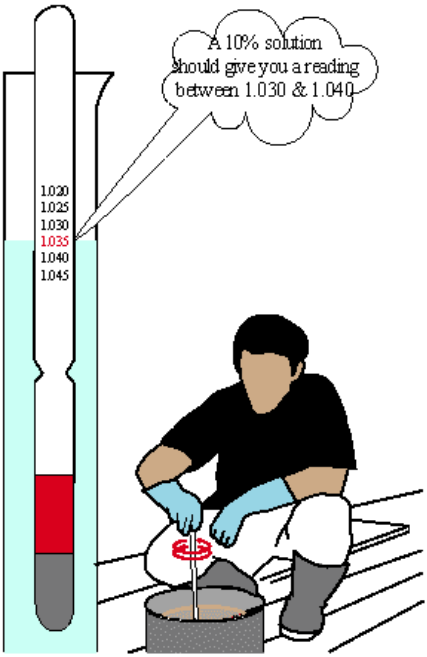
STEP 5

Test the solution with a hydrometer under normal temperatures of your region.

Fill a small test container with the Borax/Boric Acid solution slowly, so as to not form air bubbles. Lower the Hydrometer into the container and give it a quick twirl like spinning the top.

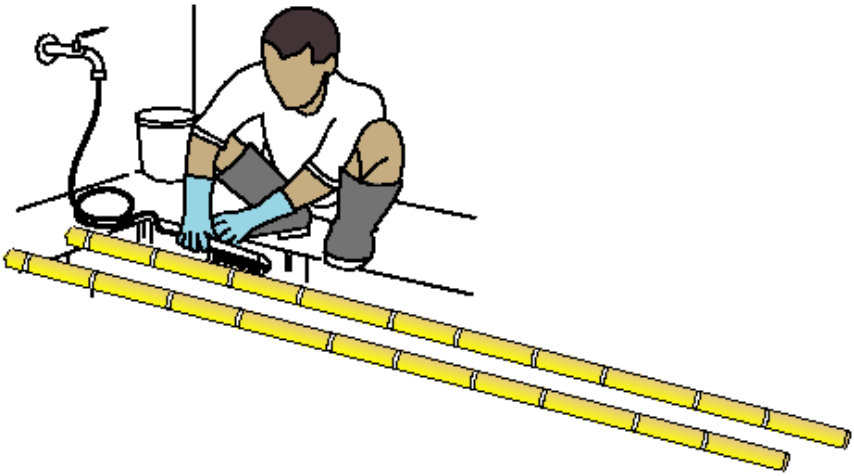
This will get rid of air bubbles that might have accumulated on the hydrometer.

Then read the number where the solution crosses the scale on the hydrometer, like reading a thermometer: 1.035 (or whatever a close number is) will be your benchmark for re-testing the solution later.



STEP 6

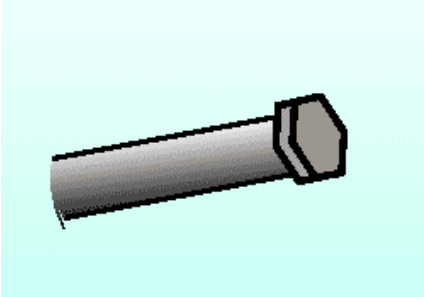
Thoroughly clean the outside of the bamboo culms with water and brushes (or coconut husks and sand, or scotch brite)



STEP 7

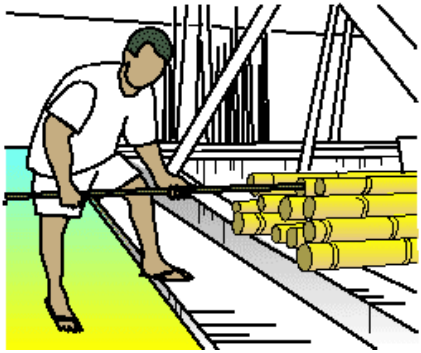
Weld hex nut to one end of iron rod. With this rod you can punch holes through the diaphragms.

The hex nut will create large diameter holes thus preventing air bubbles from forming in the culms during the filling procedure.



STEP 8

Place the bamboo against a wall. Insert the iron rod and punch holes through the nodes. Make sure the last node is not punctured.



STEP 9

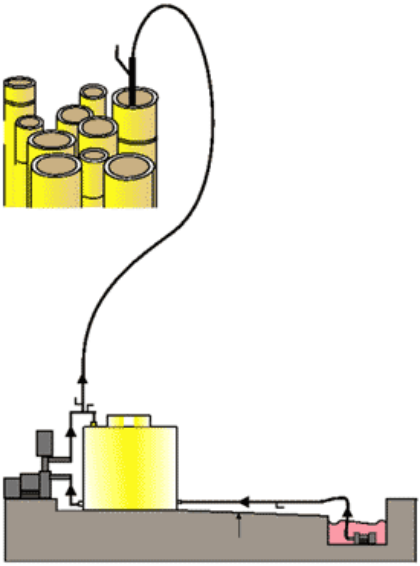
Move the bamboo to the concrete basin. Stand up vertically. Tie culms securely together so that they cannot move when they are being filled with the BORAX/BORIC ACID SOLUTION. Culms become very heavy when filled.

STEP 10

Connect a hose to the container which holds the mixture. Pump the solution into the culms.

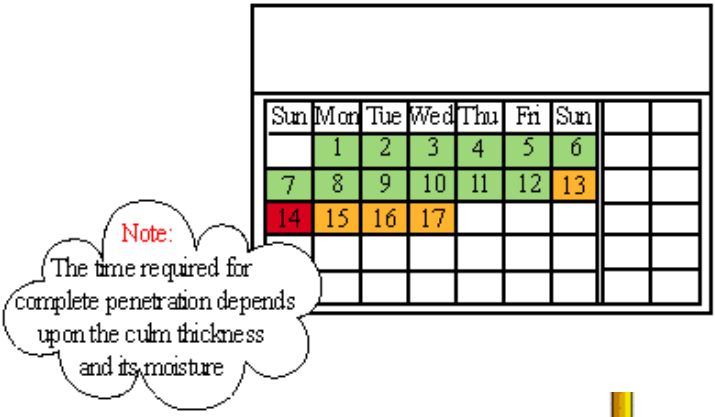
STEP 11

Fill the entire bamboo with the solution. Every morning refill the culms which have absorbed approximately 1% of the liquid overnight. Every day absorption rate is less.



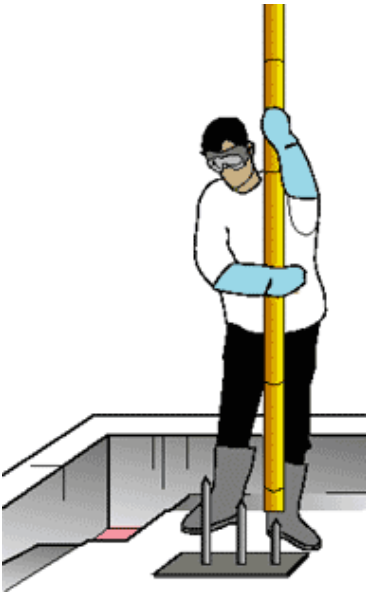
STEP 12

On Day 13 don't add more solution. Allow the level to go down to avoid overflow when the last node is broken.



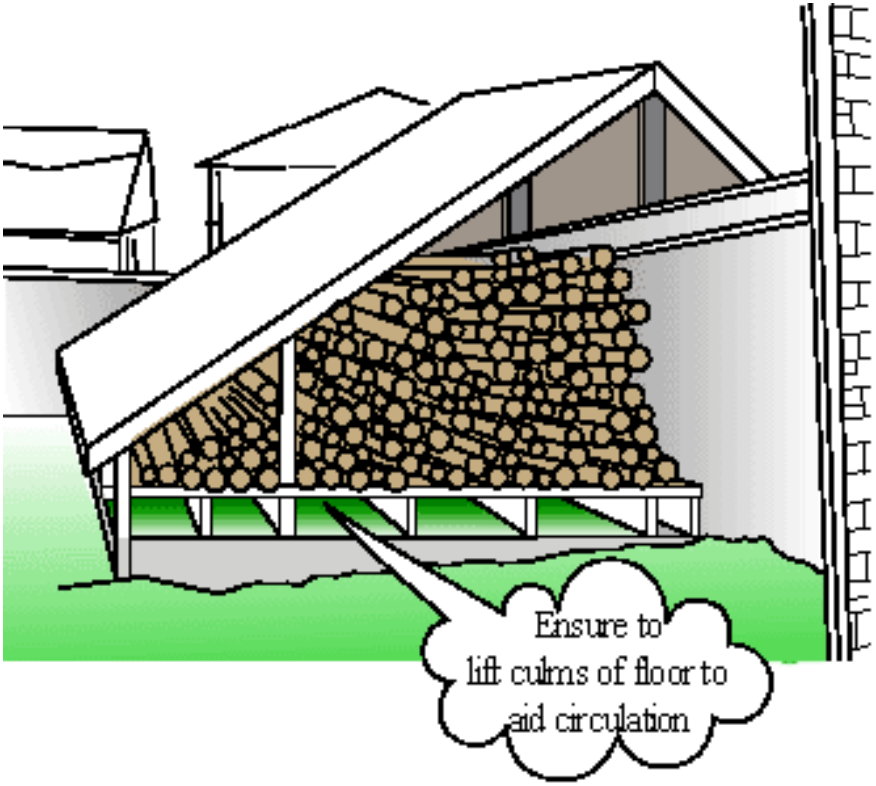
STEP 13

On Day 14, test check the culm by sawing off the upper internode. The fabric dye has now penetrated the culm walls sideways and coloured them pinkish. Carefully carry the filled culm close to the sump hole and break the last node using a metal punch. Make sure you wear face protection. The diaphragms of large culms should be punctured by using the iron rod. The solution will now flow on the sloped basin floor into the sump hole.



STEP 14

Leave the bamboo for a minimum of one hour in the basin for the solution to fully drain out of culms into the sump hole. Pump leftover solution back into container through a filter for re-use. The filter should be regularly changed. Test again with the hydro meter and add more BORAX/ BORIC ACID if necessary (see appendix page 23). Wipe down the whole culm to remove excess borate.



STEP 15

Store the bamboo horizontally or vertically in the shade (hot sun splits it) to slowly dry. Make sure that it is not exposed to rain which could wash out the preservative.

7
INFORMATION ABOUT BORATES

BORAX/BORIC ACID is more environmentally friendly than other wood preservatives currently used.

7.1
REUSE GUIDELINES

The BORAX/BORIC ACID SOLUTION can be used more than once for treating bamboo, as long as the hydrometer reading of the solution is still at the initial

level, of approximately 1.035.
Keep in mind that, as the bamboo sap gets partially drained out of the culm, the starch/sugar from the sap will move into the treatment solution. This can lead to inaccurate hydrometer readings. After the 3rd or 4th use gradually increase the BORAX/BORIC ACID concentration to 1.040 and 1.050.

At the point when the drained solution foams significantly and/or mold is forming on the surface of the solution and on the bamboo culm it is time for the solution to be disposed of.

7.2
DISPOSAL GUIDELINES

BORAX/BORIC ACID is non toxic to the environment, but is highly saline.

When a moderate amount of it is absorbed into the ground, the ground filters out the salt to the point where it does not pollute the ground water. However, it is advisable to dispose of it safely and out of reach of children. When diluted with more water the discarded solution could be used as a herbicide on terraces and walkways.

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