

A general introduction in Ecology and Biology of Bamboo.

Perspectives for applying Bamboo in water-and climate management, agro-forestry/biomass production, phyto-remediation and as a bio-based renewable construction-material.

Erik P.C. ROMBAUT, Master in Biology, Asst. Prof. Em.,
KULeuven faculty Architecture (Campus Sint-Lucas),
Hoogstraat 51, B-9000 Gent / Paleizenstraat 65-67, B-1030 Brussels.
Odisee TechnologyCampus Gent, Gbrs. de Smetstraat 1, B-9000 Gent.
+ 32 (0)3 7707147. erik.rombaut@scarlet.be

**BAMBOO
& SUSTAINABILITY**
THANH TAM 2019



**BAMBOO
SUSTAINABILITY**

THANH TAM 2019

10-13 September 2019

National University of Civil Engineering - NUCE
55 Gial Phong road, Hai Ba Trung district, Hanoi

14-18 September 2019

Thanh Tam bamboo ecopark - LASUCO
Lam Son township, Tho Xuan district, Thanh Hoa

Botany of Bambusoideae: taxonomy

Bamboos are evergreen perennial flowering plants¹ in the subfamily Bambusoideae of the grass family (= Poaceae or Gramineae).

Scientific classification

Kingdom: [Plantae](#)

Clade: [Angiosperms](#)

Clade: [Monocots](#)

Clade: [Commelinids](#)

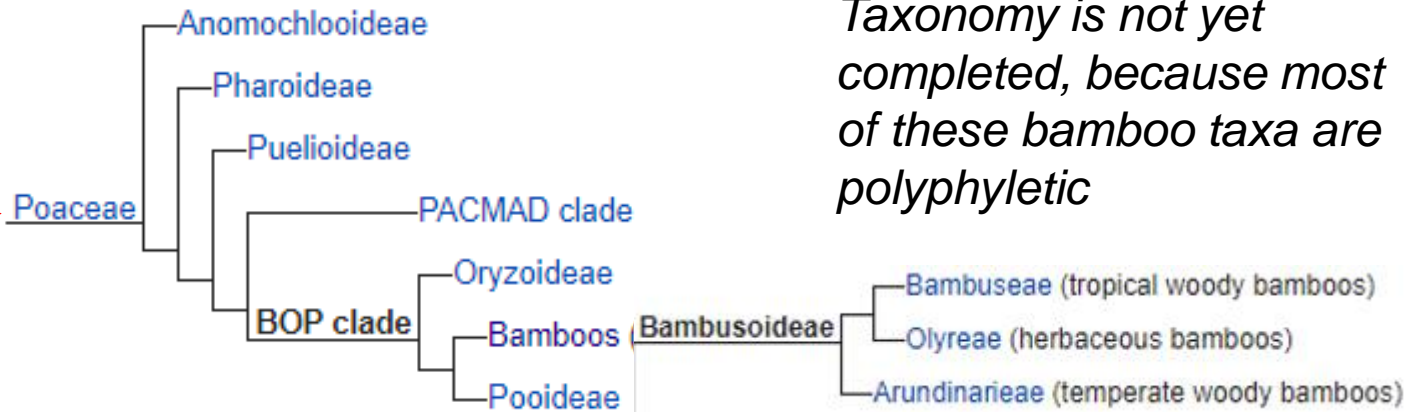
Order: [Poales](#)

Family: [Poaceae](#) → [Poaceae](#)

Clade: **BOP clade**

Subfamilies

- [Bambusoideae](#)
- [Oryzoideae](#)
- [Pooideae](#)



Taxonomy is not yet completed, because most of these bamboo taxa are polyphyletic

<https://en.wikipedia.org>

Grasses normally do not form wood (lignins).
Therefore the majority of grasses are herbs.

Except for bamboos, which do form wooden structures

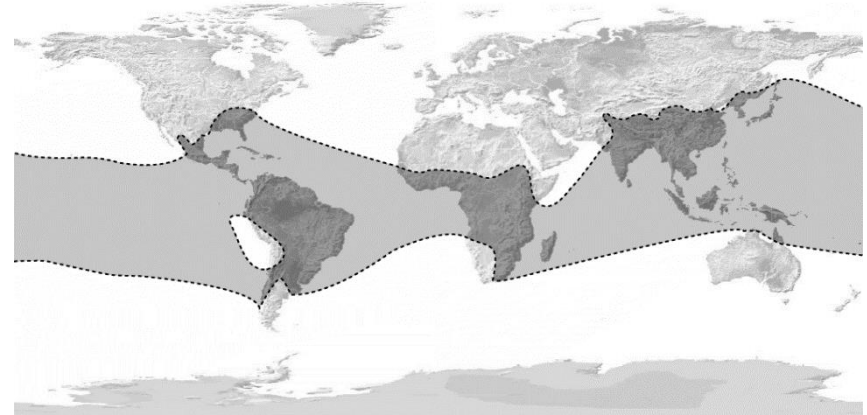
<http://www.explorenook.com.au/product/bamboo-construct-roll/>



Botany of Bambusoideae: distribution

The word "bamboo" comes from the Dutch or Portuguese languages, which probably borrowed it from Malay.

More than 1,400 bamboo species are placed in over 15 genera.



- native to **warm and moist tropical and warm temperate climates**. Bamboos are found in diverse climates, from hot tropical regions to cool mountainous regions and highland cloud forests.
- no native species in Canada and continental Europe.
- As **garden plants**, many species grow readily outside these ranges, including most of Europe and the United States.
- ¹ Bamboos seldom and unpredictably flower, flowering frequency varies from species to species.

<https://en.wikipedia.org/wiki/Bamboo#Distribution>

<http://bamboogarden.com/when%20bamboo%20flowers.htm>



photos copyright: Bamboo Garden *Fargesia murielae*



Fargesia nitida

Bamboo, a very special grass.

Similar to grass, bamboo is characterized by a jointed stem called a culm. Mostly, the culms are hollow.

In all *Monocotyledoneae* (including palms and bamboos), the absence of secondary growth wood, is the reason why their stems are columnar rather than tapering/conical (which is the case in most trees)



Dicotyl stem: conical form



Monocotyl stem: column





<https://www.youtube.com/watch?v=bGdMTIxU9Uc>



<https://www.youtube.com/watch?v=KsbL-xiwlqs>

Bamboo is getting more and more appreciated as a 'miracle plant' providing food, fabric (textile), construction material,...



<https://www.youtube.com/watch?v=bGdMTIxU9Uc>

...and is used to produce all kinds of tools and gadgets...



Bamboo Solar Calculator



Bamboo Sunglasses

BAMBOO: THE VERSATILE MATERIAL

ALMOST 1 MILLION ACRES OF FORESTS ARE LOST EACH WEEK WORLDWIDE. BAMBOO PRODUCTS CAN PROTECT THE FORESTS THAT WE HAVE LEFT

BAMBOO IS BIODEGRADABLE AND CAN BE COMPOSTED



AFTER HARVESTING, VIRTUALLY EVERY PART OF THE BAMBOO PLANT IS USED TO MAKE PRODUCTS



Bamboo Laptop



Bamboo USB Flash Drives



<https://tigerconcept.nl/duurzame-relatiegeschenken-van-bamboo-met-logo-bedrukken/>



<http://www.bamboobotanicals.ca/html/about-bamboo/bamboo-creations-innovations.html>



<https://www.plantationbamboo.co.nz/compressed-bamboo-flooring/>

https://en.wikipedia.org/wiki/Bamboo_musical_instruments#/media/File:Shakuhachi-2.png

<https://www.bol.com/nl/p/verstelbare-bamboeligstoel/9200000056247494/>

5 REASONS TO #THINKBAMBOO

1 BAMBOO - A UNIQUE PLANT

- ▶ There are **1642 known species** of bamboo.
- ▶ Bamboo is technically a **grass plant**, but can grow up to 35 metres tall and up to 30 cm in diameter.
- ▶ Bamboo covers over **30 million hectares of land across the world** - in Africa, Asia, and Latin America.
- ▶ Bamboo is the **fastest growing plant in the world**. Certain species can grow up to 91 cm a day.

3 A NATURE-BASED SOLUTION FOR RESTORING DEGRADED LAND

Bamboo roots and rhizome systems:

Can reach up to **100 kilometres** per hectare

Does **not require replanting** after harvesting

Can live for up to **100 years**

Bind soil, raise the water table and improve **fertility** in even the most degraded soils

In 2014, all Member states of the International Bamboo and Rattan Organisation committed to reforest 5 million hectares of degraded land with bamboo, for the Bonn Challenge.

5 AND IT'S NOT JUST ANIMALS WHICH RELY ON BAMBOO...



Millions of people around the world rely on bamboo for their livelihoods.



There are **over ten thousand** known uses for bamboo.



The bamboo sector has created **10 million jobs** in China alone.



Bamboo can be regularly harvested, without the need for replanting.

2 AN EXCELLENT WAY TO STORE CARBON

Like all plants, **bamboo stores carbon**.



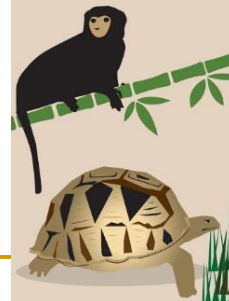
Over a period of 30 years, one hectare of bamboo plants and its products can store up to 600 tonnes of carbon per hectare.

Durable bamboo products include: pipes, shells for transport vehicles, blades of wind turbines, shipping containers, flooring and housing. Bamboo can provide a low-carbon alternative to materials including timber, cement, steel and plastic.



4 A TASTY PART OF BIODIVERSE LANDSCAPES

The giant panda, Angonoka tortoise, mountain gorilla, bale monkey and the greater bamboo lemur are just some of the mammals and reptiles which rely on bamboo for food and shelter.



Bamboos, an all-round group of plants

Bamboo

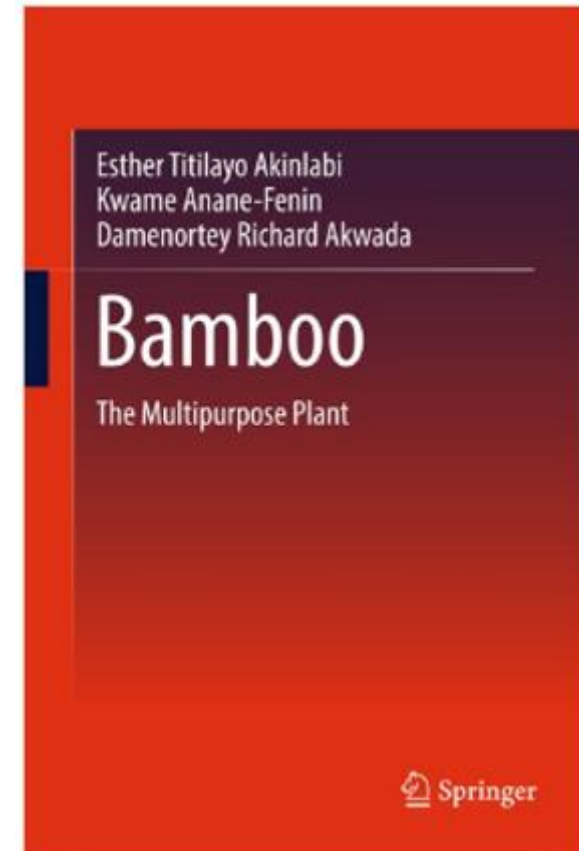
The Multipurpose Plant

by **Esther Titilayo Akinlabi, Kwame Anane-Fenin, Damenortey Richard Akwada**

This book is intended for use both in the industry and the academia. It introduces the physical, chemical and the mechanical properties as well as the characterization of bamboo. Novel industrial applications in structural, non-structural, reinforcement, afforestation, land reclamation, environmental significance, textile, medical, geotechnical, hydraulic, food, pulp and the paper industries are addressed in detail.

Bamboo has been used for centuries as a structural material as well as in diverse engineering applications, food and medicinal purposes, especially in Asia. As a natural fiber composite, bamboo has the potential for many developments in academic and industrial research. Current literature on composites tends to focus on bamboo as a plant or solely as a structural engineering material. This book seeks to bring together these two extremes and provides a holistic resource on the subject.

1 Bamboo Taxonomy and Distribution across the Globe.- 2 Regeneration, Cultivation and Sustenance of Bamboo.- 3 Properties of Bamboo.- 4 Bamboo as Fuel.- 5 Applications of Bamboo.- 6 Current Trend in Bamboo Analysis.- Appendix.- Index.



Springer | 2018
EAN: 9783319860077

Bamboos, an all-round group of plants

Bamboo for Specific Uses

Erosion Control, Land Restoration & Other Ecological Uses



Bamboos have many important ecological roles in the native environments in which they have evolved. In addition, people around the world (and throughout history!) have used bamboo to create, manage and restore landscapes. Some of the things they have been used for include: windbreaks, earthquake refuge, erosion and flood control, soil building, fire breaks, landslide prevention/hillside stabilization, carbon sequestration, phytoremediation of polluted soil, greywater and wastewater treatment, and as a vigorous pioneer plant where the land has been disturbed by fire, flood or landslide.

<http://bamboosourcery.com/project/erosion-soil-control/>

Let us now study briefly some of these features and uses of bamboo in this presentation:

Most Bamboo species grow fastly: *biomass production*

- Bamboos include some of the fastest-growing plants in the world, due to a unique **rhizome-dependent** system. Certain species of bamboo can grow 910 mm (36 in) within a 24-hour period, at a rate of almost 40 mm (1.6 in) an hour.
<https://en.wikipedia.org/wiki/Bamboo>
- This makes Bamboo species interesting for **the production of biomass**. Bamboo biomass can be used for direct combustion or for biochemical conversion with different energy-carrying products as a result (charcoal, syngas, methane, biofuels,...).



Running bamboo rhizome with soil removed

Bamboo to ethanol, India's biofuel industry to explode into a \$15 bn market

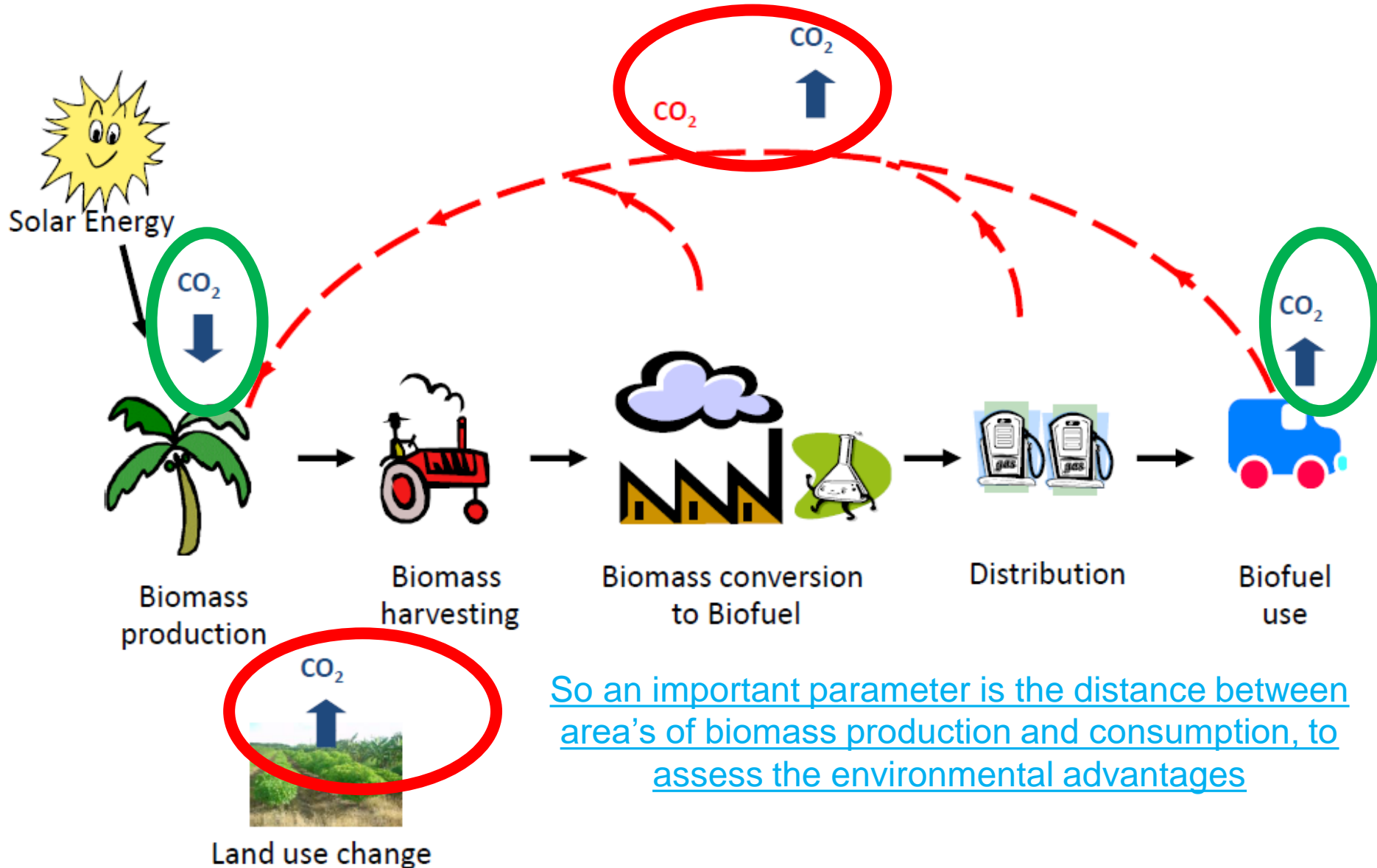
Indian oil companies are investing in biofuel refineries to boost ethanol production from non-molasses sources such as agricultural residues

A \$200 million joint venture between Numaligarh Refinery Ltd. and Finnish technology firm Chempolis Oy will crush bamboo, the longest of the grass family, to produce 60 million liters of ethanol every year in the tea producing state of Assam....

First Published: Tue, April 03 2018.

.... Why are biofuels considered (sometimes NOT) to be green?

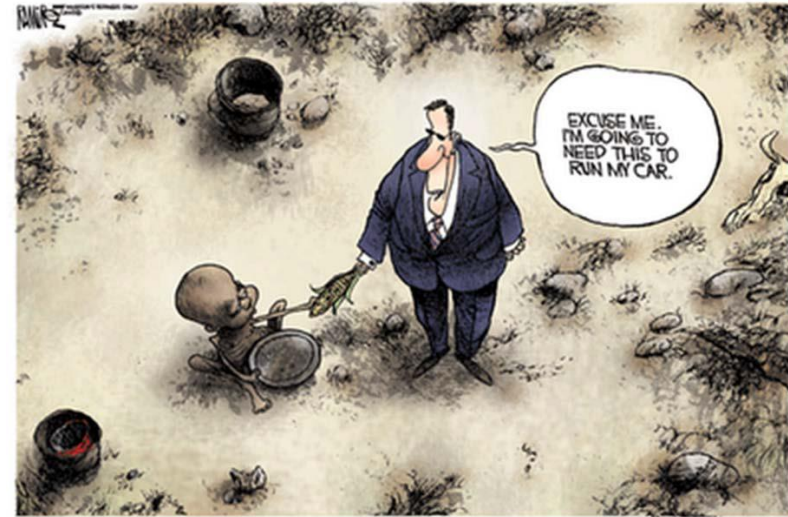
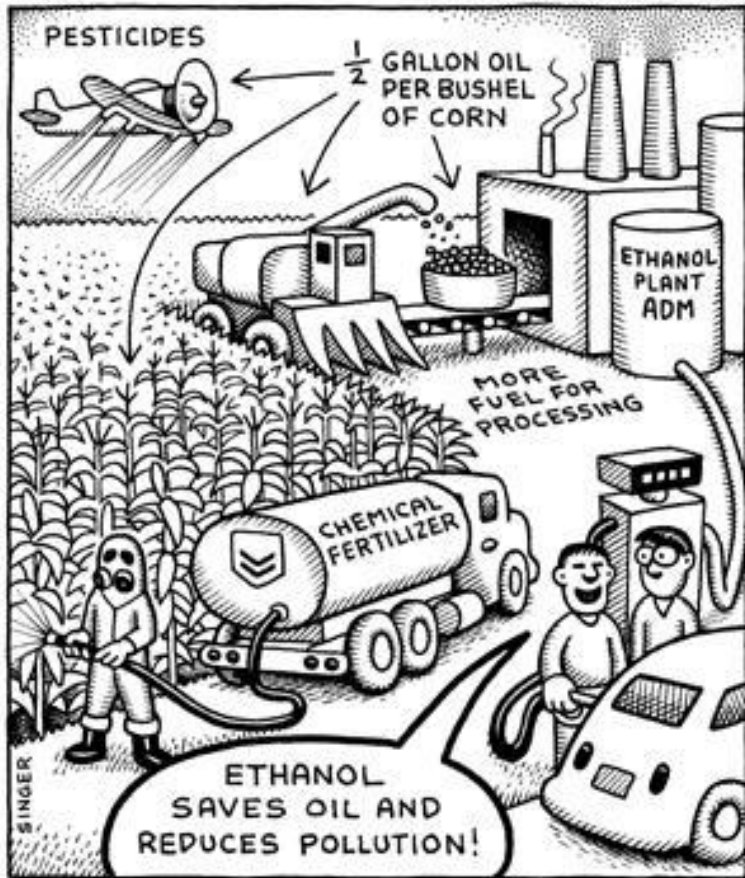
(source: Shabbir H Gheewala, 2013)



So an important parameter is the distance between area's of biomass production and consumption, to assess the environmental advantages

Moreover, combusting edible oils/plants for transportation leads to discussions about sustainability and social impacts.

(source: Shabbir H Gheewala, 2013)



Bamboo biomass



Vietnam Academy of Science and Technology

Hanoi, Vietnam

*Modified after: Truong, An Ha & My Anh Le, Thi. (2014).
Overview of bamboo biomass for energy production.*

- Bamboo biomass has both advantages and drawbacks in comparison to other energy sources. It has better fuel characteristics than most biomass feed stocks and suitable for both thermal and biochemical pathways...
- The problems linked with bamboo biomass are similar to other energy crops (such as palm-oil, ...), plantation of bamboo also has some environmental risks including biodiversity decrease, species invasion, land competition with food crops and the huge ecological (water) footprint...
- Bamboo biomass alone cannot fulfill all the demand for energy. It needs to be combined with other renewable sources...

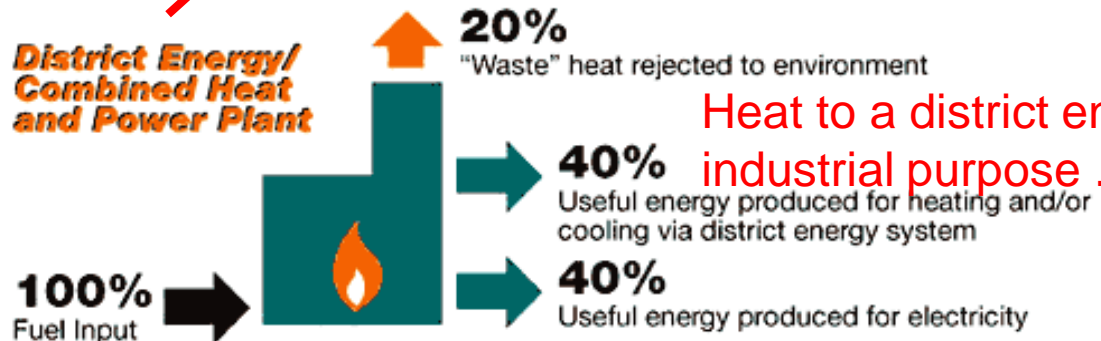
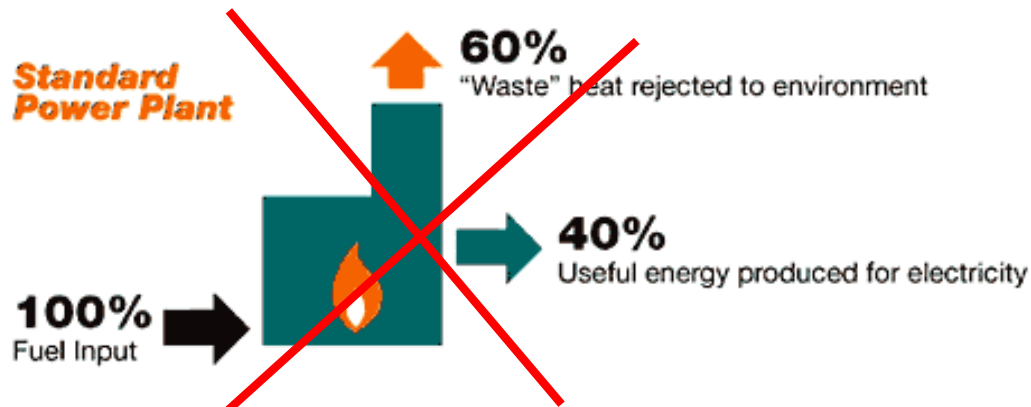
https://www.researchgate.net/publication/278829225_Overview_of_bamboo_biomass_for_energy_production

-
- **My Remark:** Combusting bamboo biomass just for production of electricity alone is not a good idea. Better is to **use a cogeneration plant for heat and power (CHP)**

Comparison of a standard power plant with a CHP plant connected to a district-energy-network



Energy-Efficiency Comparisons

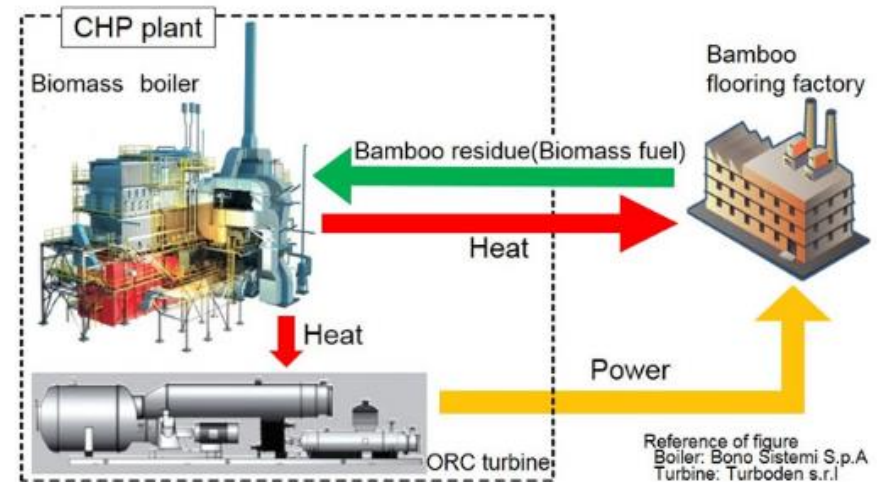


The efficiency of a CHP plant is about 80 %:
40 % heat and 40 % power (=electricity).

Example: A CHP energy-plant powered with bamboo residue

Diesel consumption for supplying heat and power at the new bamboo flooring factory of African Bamboo PLC (Hawassa Industrial Park) is reduced through the installation of a biomass combined heat and power (CHP) plant. The CHP plant consists of a biomass boiler (12MW) and an organic rankine cycle (ORC) turbine(1.2MW) for power generation. The Installed capacity is 12MWth and 1.2MWe. All of the heat and power generated are consumed in the factory. Bamboo residue is used as the biomass feedstock.

Host Country	Ethiopia
Year	2015
Type	JCM Model Project
Sector	Renewable Energy



http://gec.jp/jcm/projects/15pro_eth_01/

■ My Conclusion:

- Also in Vietnam, bamboo biomass energy has some potential to be a part of the alternatives for fossil energy, especially when used in combined heat and power plants (CHP) which produce not only electricity but also heat (for industry,...).
- Due to the very fast growth of Bamboo, potentials for sequestering carbon might be interesting (combined with the smart use of bamboo-biomass)

Growing evidence for using bamboos successfully in *Phyto Remediation*

- **Phyto-Remediation** refers to the technologies that use living plants and micro-organisms to clean up soil, air, and water contaminated with hazardous contaminants, to contain, to bioaccumulate, to remove or to render toxic environmental contaminants harmless.
- Phytoremediation is a cost-effective plant-based approach of remediation that takes advantage of the ability of plants to concentrate elements and compounds from the environment and to metabolize various molecules in their tissues.
- Toxic heavy metals and organic pollutants are the major targets for phytoremediation.

After: <https://en.wikipedia.org/wiki/Phytoremediation>

Bamboo Can Treat Wastewater

See also: <https://slideplayer.com/slide/6281432/>

<https://www.laboratoryequipment.com/news/2013/10/bamboo-can-treat-wastewater>

<https://slideplayer.com/slide/10455600/>

Bamboo and phyto-remediation

The results of an [EU-funded](#) project to treat waste water with bamboo are now being marketed. The [project](#) established the market viability of intensified bamboo-based [phytoremediation](#) for dairy and other food industry grey water applications. In other words, a bamboo forest can treat industrial discharge on a large scale.

The French company Phytorem is selling the managed process as the [Bambou Assainissement](#) (bamboo sanitation) filter. The process can be scaled for both domestic and industrial waste water, and is suitable for hotels, camp sites, retirement homes, housing estates, isolated infrastructures, wildlife parks, landfills, storm water and more.



SCIENTIFIC REPORTS

OPEN **Copper induced oxidative stresses, antioxidant responses and phytoremediation potential of Moso bamboo (*Phyllostachys pubescens*)**

Received: 09 April 2015
Accepted: 30 July 2015
Published: 04 September 2015

Junren Chen¹, Mohammad Shafi², Song Li³, Ying Wang¹, Jiasen Wu¹, Zhengqian Ye¹, Danli Peng¹, Wenbo Yan² & Dan Liu²

<https://www.researchgate.net/publication/281482665> Copper induced oxidative stresses antioxidant responses and phytoremediation potential of Moso bamboo *Phyllostachys pubescens*

<https://lifewithbamboo.com/tag/phytoremediation/>

Bamboo and phyto-remediation

Eco. Env. & Cons. 24 (1) : 2018; pp. (530-539)
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ISSN 0971-765X

Phytoremediation potential of bamboo plant in China

Some conclusions after: Abolghassem Emamverdian,^{a,b} Yulong Ding,^{a,c*} and Yinfeng Xie^{a,b}

- Bamboo plants can be considered as a suitable option for phytoremediation systems because they are the fastest-growing plants over the world...
- Bamboo-species have a high ability to accumulate pollution in roots, shoots, rhizomes, and leaves, and also have high carbon sequestration that could be stored in fibers, rhizomes, and leaves. They can play an important role in reducing environmental pollution, filtration wastewater, soil improvement, conserving natural ecosystems, and improving local climate....
- Moso bamboo, as one of the greatest and most important species of bamboo in China, can play a significant role in the contribution of bamboo species in phytoremediation system...
- **My Conclusion:** more research is needed to assess the promising properties of bamboo in phyto-remediation, especially concerning the possible risk of just moving toxicity rather than removing it and also of contaminating-risks of natural wildlife food-webs

Bamboo wood (and palm leaves)
as a *traditional renewable
construction material*



Hoi An (Vietnam)

Carbon-positive, renewable, biodegradable (++)

BUT

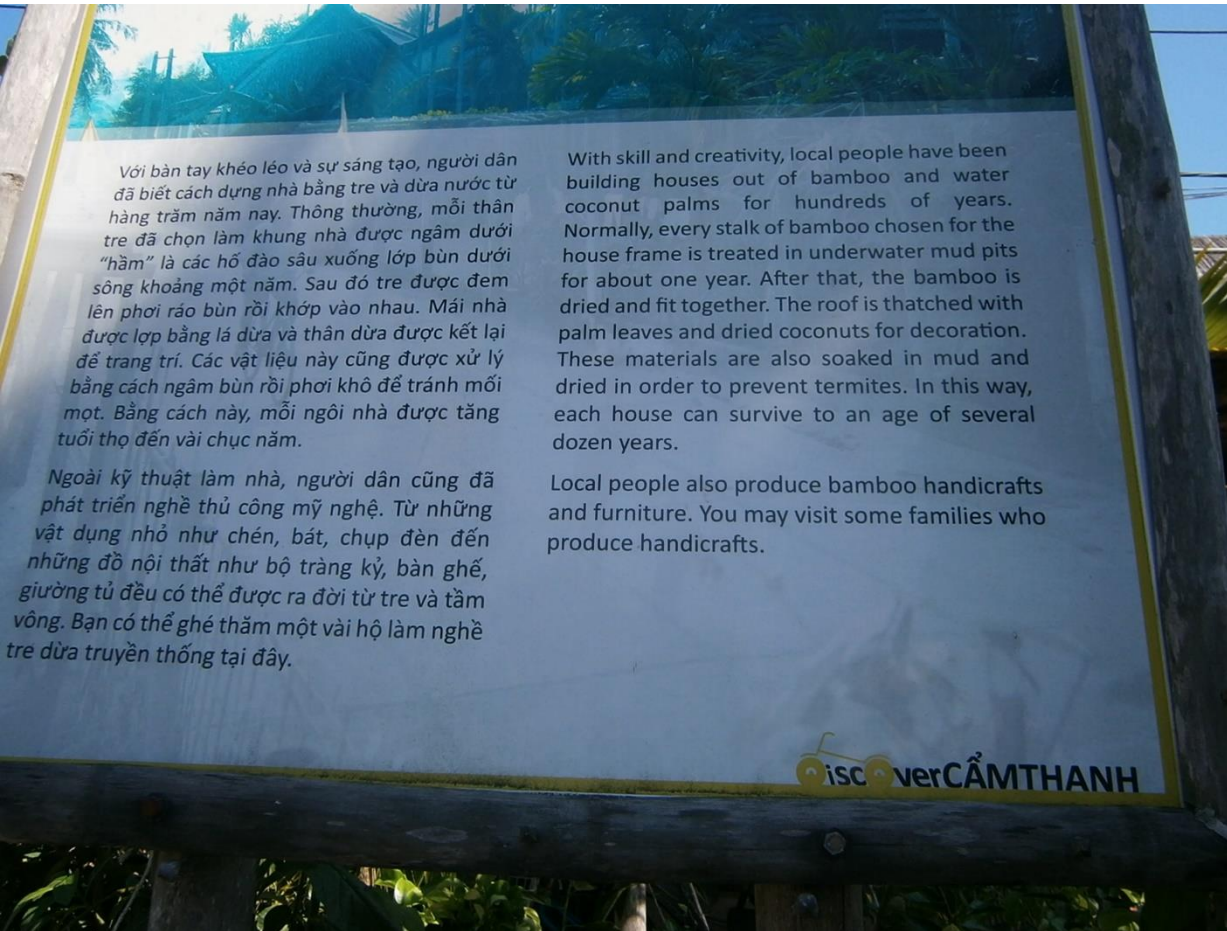
Often vulnerable (insects / water...) and linked
in many minds to poverty (- -)

Traditional Vietnamese bamboo techniques



Hoi An (Vietnam)

Traditional Vietnamese bamboo techniques



Teaching how to use bamboo

All green learning centre (Thailand)



9 Moo 4 Baan Nonkradon, Payayen, Pak Chong, Nakornratchasima
30320 ; Tel. 081-8757172 , 086-4686362
info@allgreenlearningcenter.org

Teaching how to use bamboo

All green learning centre (Thailand)



Teaching how to use bamboo

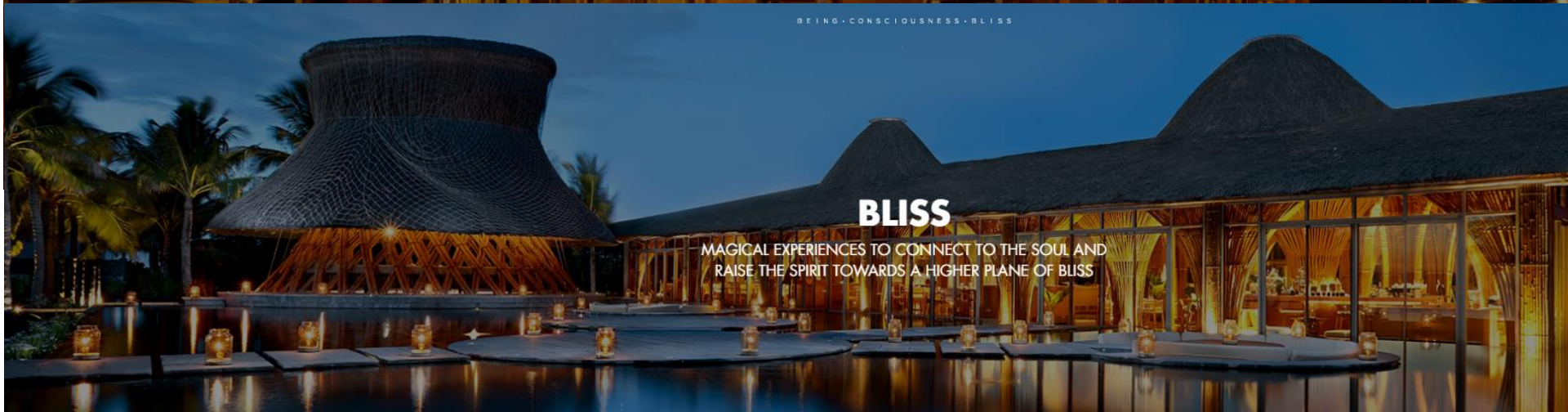
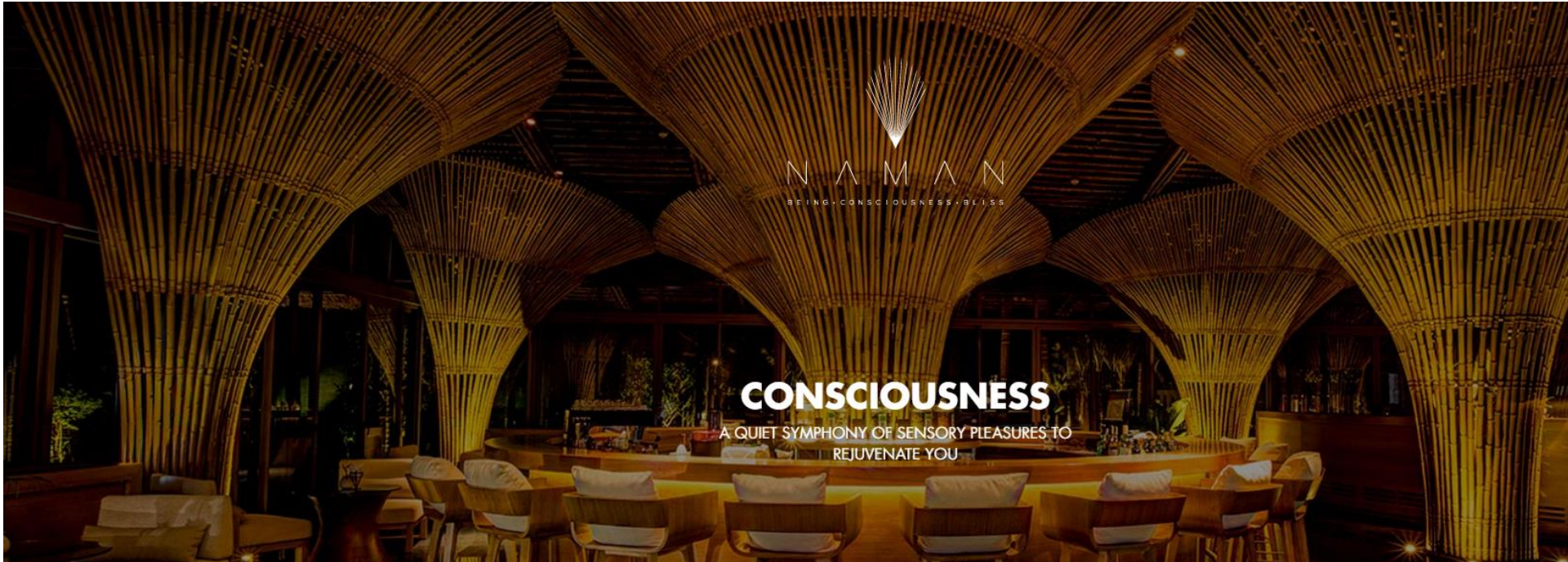
All green learning centre (Thailand)



A key question is:
How to realise a **mind-shift** to detach bamboo
architecture from poverty ... ??



(A key question is:)
...and how to give bamboo a **trendy and flashy image** ??





Naman Residences ; Truong Sa Road, Ngu Hanh Son District, Da Nang (Vietnam)
Vo Trong Nghia Architects / Ho Chi Minh City - Vietnam

Vo Trong Nghia Architects Ho Chi Minh City (Vietnam)



<https://www.youtube.com/watch?v=4w7lsydq8ks>



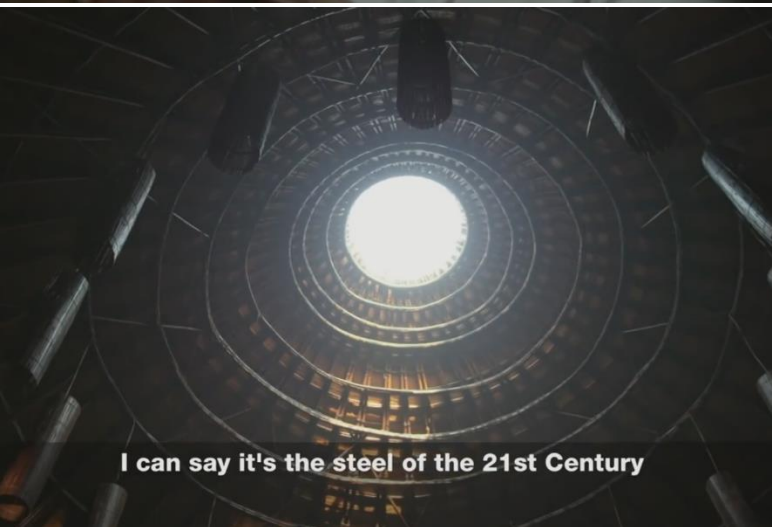
House for trees
arch. : Vo Trong Nghia (Vietnam)

Rebel Architecture: greening the city (Al Jazeera TV)

<https://www.youtube.com/watch?v=bgQoVbEX8-A>

<http://www.uncubemagazine.com/blog/14190359>

Vo Trong Nghia Architects Ho Chi Minh City (Vietnam)



My original motivation was that bamboo is cheap and beautiful

Then I realised that bamboo is also durable and eco-friendly

Some other Vietnamese projects.



Eco-resort Pavilion. La Vong, Hanoi.



Vinata Bamboo Pavilion. Cau Giay, Hanoi.



Nocenco Cafe. Vinh city, Nghe An.



Roc Von Restaurant. Xa Phu Cat, Huyen Quoc Oai, Hanoi.

Growing interest from architects, developers and designers in bamboo-projects: examples from BALI (Indonesia)



Magical houses, made of bamboo | Elora Hardy
TED talk, 12 may 2015

https://www.youtube.com/watch?v=kK_UjBmHqQw



Bali/Indonesia - bamboo projects

https://www.youtube.com/watch?v=kK_UjBmHqQw



Testing the compressive strength and other features, necessary for using bamboo as construction material.

Bali/Indonesia - bamboo projects

https://www.youtube.com/watch?v=kK_UjBmHqQw



Bali/Indonesia - bamboo projects

https://www.youtube.com/watch?v=kK_UjBmHqQw

My Conclusion:

More research is needed to assess the promising properties of bamboo as a construction material. It will be important to find environmental sound pathways to treat bamboo in order to avoid problems of bamboo with insects and water.

Conclusions

- It will be extremely important to stimulate a broad mind-shift for everyone still associating bamboo as a material and a plant of the 'poor past'. It is **time to give bamboo a flashy and trendy image again**, to power a renewable and sustainable future.....
- Good to see that also **academic interest on this topic is growing fast**. Every attempt to find solutions for worldwide environmental and climate problems is important and urgent. **Bamboo might be a part of the solutions we are looking for.**
- We hope this bamboo-initiative of NUCE, LASUCO and KULeuven, can help to put bamboo on the (academic and industrial) **research-agenda** and on the **political agenda**, also in Vietnam.
- We are looking forward to the outcome of this congress day and of the workshops in the coming days.

Conclusions: Initiatives like these can help to achieve the mind-shift,
in the future also in Vietnam ?



BAMBOO SOCIETY OF AUSTRALIA (BSA)

World Bamboo Day

September 18 is World Bamboo Day!



Towards a bamboo-society in Vietnam ?

<https://www.bamboo.org.au/>

<https://worldbamboo.net/world-bamboo-day>

<https://www.bamboo-society.org.uk/2017/08/21/world-bamboo-day-18th-september/>

Thank you so much for your attention

contact:

erik.rombaut@scarlet.be



Bamboo tree and its connection with Vietnamese daily life

