TECHNICAL RESEARCH PAPER

How can integrated bamboo industries solve ecological and societal dilemma caused by violating textile industry in pre-urban Kampung in Indonesia?

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Technical Research Paper

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ABSTRACT

Industrialization is still the theme of development in many parts of the world, of which Bandung City in Indonesia is exemplary. In vast outskirt region of Bandung, there used to be many agricultural Kampungs(the word "village" in Indonesian). However, decades of violating industrialization have already triggered vicious circle causing series of negative influence on ecological environment and the pre-urbanized Kampungs as a habitable and well functioned social structure. Textile industries dominating the upper stream land of Kampungs pours untreated waste water in to rivers from which villagers draw irrigation water producing food sold to market all over the country, and work with barefoot soaked in. Pollution of surface water also enlarge the demand for groundwater as resource of domestic as well as industrial water. the over-extract of groundwater has already cause surface subsidence in Bandung basin. In the long run, with pollutants in surface water leaching into soil and groundwater, clean water scarcity will be more severe, which is awkward in a humid area like Bandung. Societally, farmland was stroked not only by water and soil pollution but also the limited profit it made compare to factories. with the factories expanding and more migrant workers moving in, the Kampungs will shortly become part of the homogeneous industrial region and lost its identity as well as the once picturesque and habitable living environment.

A systematic solution to the problematic circumstances is introduced which is integrated bamboo industries. If applied and managed appropriately, it will no only benefit the natural environment, but also be a generator of new profitable yet sustainable industry chain. Thus a new balance of nature, society and economy can be achieved.

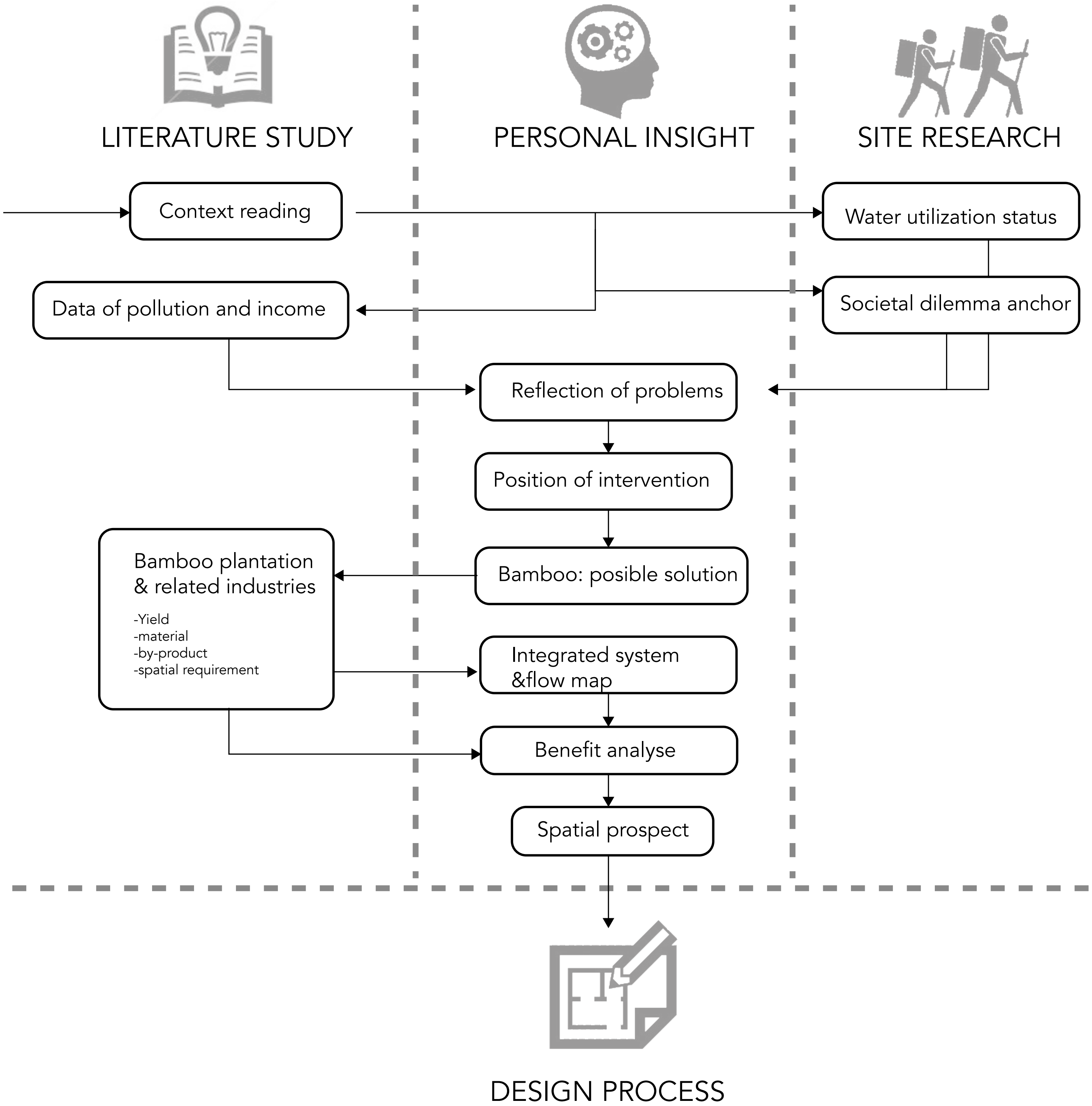
This paper will first illustrate the problems in Cigondewah, a pre-urbanized Kampung in Bandung, Indonesia from a flow point of view. Followed by study on integrated bamboo industries and how they, individually and integratedly, evolve local material and profit flow.

CONTENTS

METHODOLOGIES

Methodology of this research mainly consists of two part: literature study and site research. Each of them complement each other to form a coherent and convincing output. Site research, including observation, interview and sampling, contribute to first part of the research, which is the study of current material flow in Cigondewah and analysis of the systematic problem involving nature, community and industry. Literature study contributes to both part of the paper. In the first part, literature help understand the observed problem more precisely. In the second part, where a totally new industry system is introduced, existing writings about various industries and key products provide important information how they perform separately, which is the key knowledge to interrelate them forming a well functioned entirety.

This research will also help the design phase afterwards. The problem study and understanding of related industries helps configuring program of the design. The re-organized flow map, which can also be seen as first step of design, will give insight of what is the spaces needed and how they related to each other.


LITERATURE STUDY
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Bamboo plantation
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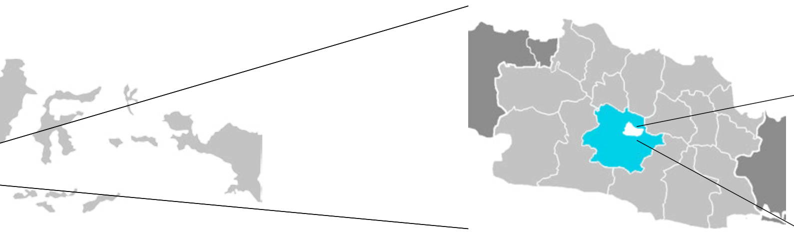
DESIGN PROCESS

1.1 CONTEXT INTRODUCTION

Bandung, the capital city of West Java Province, Indonesia, has a traceable history of more than 600 hundred years. Located in a basin area, where there used to be a prehistory lake 55,000 years ago, Bandung has the most pleasant climate and fertile soil on Java Island, and therefore, has long functioned as a major agriculture center. This role was even maintained during colonial time after East Indian Companies of Netherlands dominating the country, when Dutch people used land for sources of raw material. Things changed in 1950s when Indonesia got independence and, like other new comers of the world, industrialization was the procedure that need to be experienced to keep up the pace of the rest of the world. Meanwhile, first batches of industrial countries were searching for places to transplant part of their industry systems elsewhere, due to rising labor cost, their increasing demand, exploding scale of production, and, more importantly, recognition of side effects of over-industrialization. With experience and strong capital entering from developed regions, the late comers do have advantage of backwardness, which result in even faster pace of industrialization and modernization.

In Bandung, according to data in 2012, industry contributed 22.55% of the total annual GDP, while agriculture only 0.1%. 50 yeas witnessed the rapid rise of industry and stagnation of agriculture . Still, industry is the main focus of Bandung nowadays. In 2013, Bandung government announced a new batch of industry centers, among them are Cigondewah, the textile industry center. New industrial centers complement each other forming an integrated fashion industry chain within Bandung City.

Along with booming economy comes even more fierce societal and ecological maladjustments. Bandung Basin is now known for severe water pollution, which, on the one hand, result from lack of infrastructures that disposal domestic garbage, on the other hand,



violating industry can never escape involvement. Textile industry has long been considered as one of the most contaminative industries. According to local policies, a wastewater treatment plant is compulsory for registering the factory legally. However, among estimated 1500 factories of various size in Bandung Basin, only 300 was registered. Others operate outside the regulation. Large amount of others dump waste water directly into river .

Cigondewah, just like many other former rural Kampungs, is under considerable threat of factories. Spatially, Cigondewah is a relatively enclosed typology with 1.1 hectares of farmland laying in the center, residences standing on the outer layer and a plentiful river running through in the middle. Nowadays, large scale industrial area occupies upper stream land on the north of the Kampung, which triggers systematic water threats and societal problems.

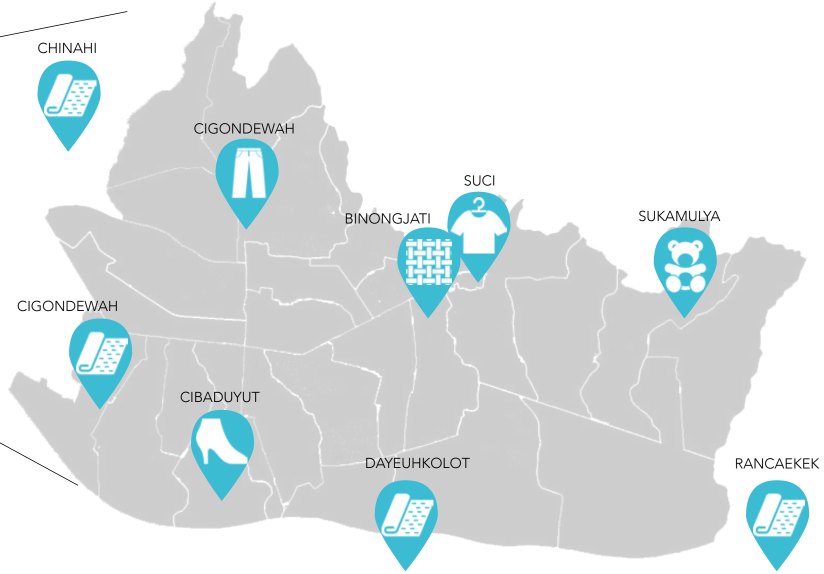


Figure 1.1 Fashion related industry center around Bandung City
[Self illustration]

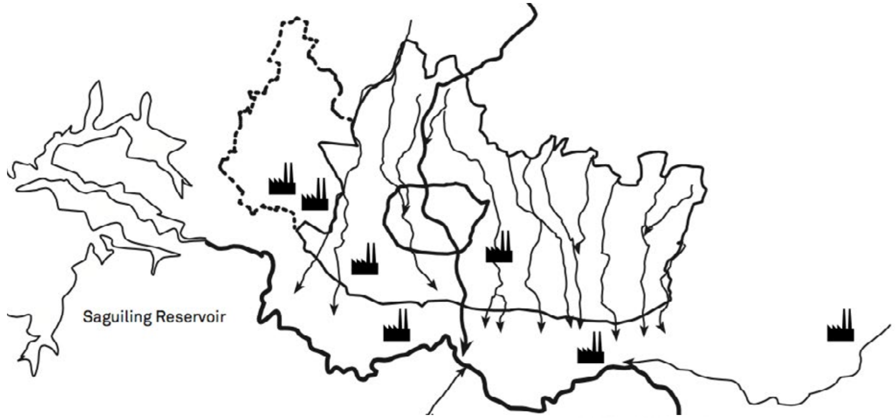


Figure 1.2 Cigondewah is located in factory surrounding area in the lower stream direction
[Resource: 15]

1.2 WATER RESOURCE AND UTILIZATION IN CIGONDEWAH

Water utilization in Cigondewah can be divided in two part: irrigation and domestic water.

Water transported from river by factories undertake irrigation for over two-thirds of the farmland in Cigondewah. Other, those adjacent to river, is watered by river water which was stored temporarily in water ponds built by villagers.

According to an interview with local farmer who has worked on field for more than 40 years, conflict burst out when factories first took over the land for it blocks original water supply system for constructing strong enough foundation for massive factory plants. After negotiation, factory owners agreed to take the responsibility transporting river water to the Kampung. Based on the observation we had on site, water comes in the same canal as open sewage. Despite the fact that it is highly likely polluted by domestic waste, water quality and quantity in this channel is greatly influenced by factory upstream. Water supply system is hidden inside factory plants, which is not accessible for outsiders, therefore, no one in the Kampung can tell whether factory maintain water hygiene while letting it run pass their plants. Outage also happens in some cases, for instance factory plants construction and equipment failure, water supply in this channel will be cut off. When we arrived in Cigondewah between November 16th and 25th of 2016, water stream in the drainage is very weak, sometimes stagnated. Luckily it was in rain season, so that water irrigating water-consuming rice paddy survive.

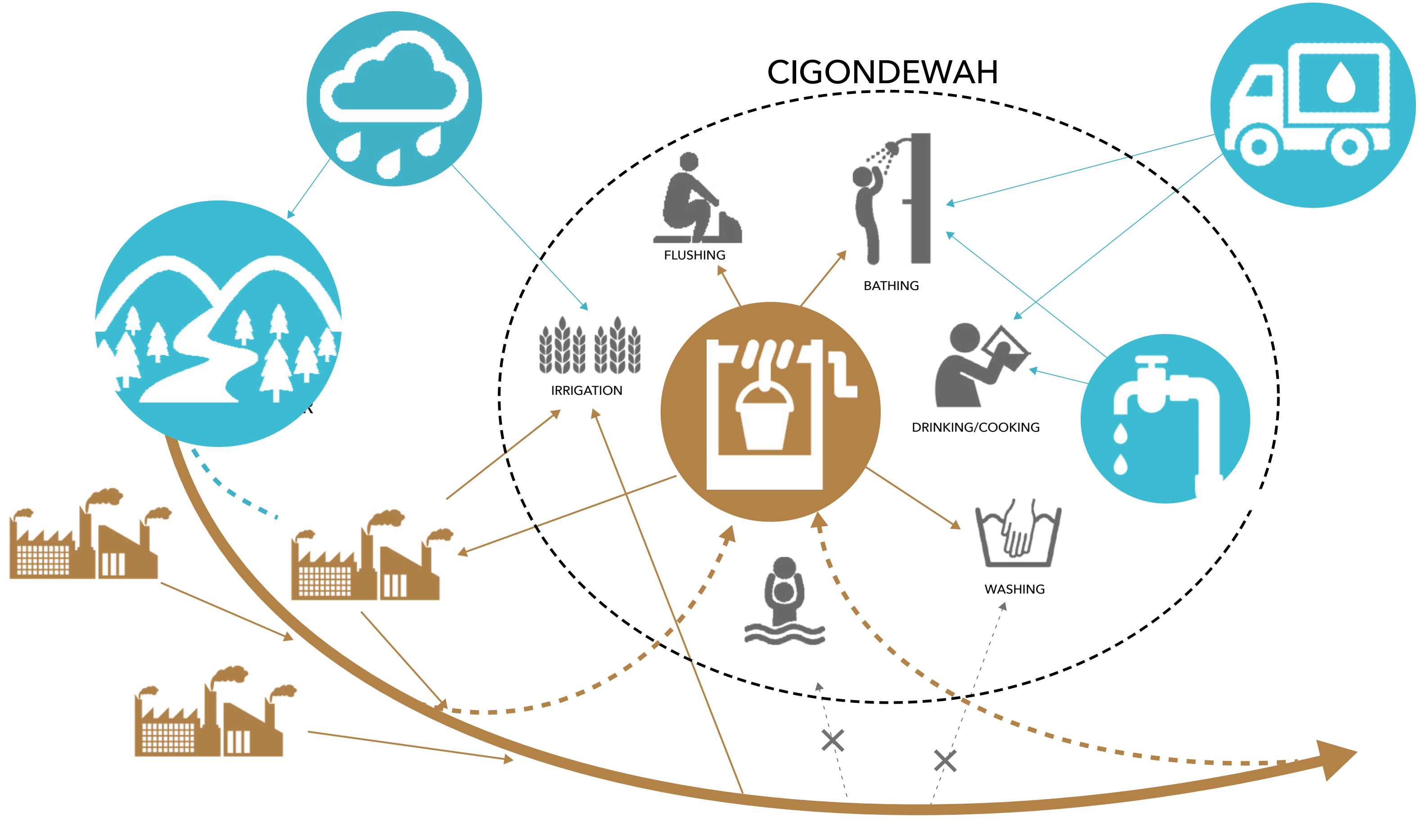
Domestic water is mainly sourced by three means: municipal water, ground water and tanked water from water treatment companies.

Groundwater is extracted by the use of wells in the Kampung. Even groundwater qualities vary from well to well. Cleaner water is used for washing and bathing, well dirtier water is used for flushing toilets. Sometimes when water quality in cleaner well also degrades, residents use their tool at hand, the wasted fabric, to filter the wate before use.

Hygienic water usually comes from municipal water supply pipeline. Due to unstable water pressure, inadequate infrastructures and cost paid monthly, not every household prefer this. An alternative resource is tanked water from water treatment companies, which is of the highest price but it guarantees quality, can be easily used and pay by amount actually used. No wonder that under such pre-urban, off-the-grid context in Cigondewah, where municipal water supply system need much development, tanked water is sometimes adopted by some families. A good thing is villagers acknowledge the insecurity of free water resources such as river water and well water. Bottled and packed water is preferred as drinking water. Even water from pipes will be boiled before drinking.

Meanwhile, river water, which ought to be the most abundant resource of water in Cigondewah, is no longer related closely to villagers' life, due to increasingly worsened solid waste deposition and water pollution which is noticeable even by naked eyes. Wasted fabrics are floating everywhere with the river flow. Dirty clothes can be seen hooked on plants along the banks and on infrastructures like electricity wires, drainage pipes, basically whatever comes close to the water surface. They stuck the waterway and drainage system sometimes, which contribute to frequent flood that getting worse each year according to villagers. The dyes and chemicals used in the upstream textile industrial process - lead, arsenic and mercury amongst them - are churned into the water, changing its colour and lending the area an acrid odor. Nearly half a million residents are directly ingesting water with lead concentrations that have tested at 25,000 times the recommended level . In short, the river once breeding the adjacent Kampungs is now considered as an unfavorable factor and thus being turned back to. The primitive but harmonious human-water inter-relationship is broken.

Figure 1.3 Photo compilation: water utilization
[Self photogragh]



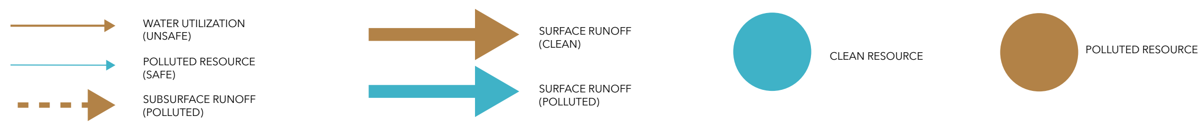


Figure 1.4 Water utilization map and possible pollution scope

[Self illustration]

1.3 WATER POLLUTION & UNDERLYING ECOLOGICAL THREATS

1.3.1 POLLUTION FROM TEXTILE INDUSTRIES

Textile industry is, without a doubt, the foremost creator of ecological threats Cigondewah is facing. Not only do factories discharge the most amount of pollutant along with waste water and sludge during processing, the polluted river triggers a chain reaction driving villagers and factories rely increasingly on groundwater, which could lead to even bigger threats in the future. In short, factory not acting as an eco-friendly role to surface runoff is the starting point from which everything goes wrong.

The concept of "eco-friendly" or "green" varies. However, whatever the definition, becoming green is important in that it means having made a commitment to protecting people and the planet; green or eco-friendly goods, services, and practices assure the use of environmentally-friendly materials, free from harmful chemicals, compounds, or energy waste, which do not deplete the environment during production and transportation.

About 25 % of the global production of chemicals is used in the textile industry globally. As many as 2000 different chemicals are used in textile processing, especially in textile wet processing, and many of these are known to be harmful to human (and animal) health. Some of these chemicals evaporate, some are dis- solved in treatment water which is discharged into the environment, and some are retained in the fabric. A list of the most commonly used chemicals in textile industries, and linked to human health problems, is listed in form 1.1.

Pollutant	Used in/ as	Threats
Nonylphenol (NPs)	Wash, dye	Reproductive toxicity, Bioconcentration
DEHP (di(2-ethylhexyl) phthalate)	Synthetic leather treatment	Reproductive toxicity
Brominated flame retardant (BFRs) phthalate)	Fire retardant	Reproductive toxicity, bioconcentration
Azo-dye	Dye	Carcinogenic
Tributyltin (TBT)	Antifungal	Affect immune and genital system bioconcentration unbiodegradable
Perfluorinated compounds (PFCs)	Waterproof antifouling	Affect liver and hormone system unbiodegradable bioconcentration
Perfluorinated compounds (PFCs)	Waterproof antifouling	Affect liver and hormone system unbiodegradable bioconcentration
Chlorobenzene	Solvent of dyes	Affect liver, Thyroid and central nervous system unbiodegradable bioconcentration
Trichloroethane (TCE)	Solvent washing fabric	Affect liver, kidney and central nervous system. Unbiodegradable
Pentachlorophenol (PCP)	Bactericide	Affect multiple organs
Short-chain chlorinated paraffins (SCCPs)	Fire retardant	Toxic for aquatic organisms, unbiodegradable bioconcentration
Heavy metals	Dyes	Undegradable bioconcentration high toxicity to multiple organs

Form 1.1 Hazardous chemicals related to fashion industries
[Self illustration]
[Resource: 8]

Among the pollutants, heavy metals have most relation to water and agriculture.
Heavy metals can be taken in by human body through food, water, or air, or by absorption through the skin, and has the ability to accumulate in internal organs, livers and kidneys for instance, and therefore impair their functions, especially when high concentration is reached. Some sorts of heavy metals are difficult to define the safety dose for chronic symptom can be caused by low dose, for example causing cancer, altering genes, affecting reproduction and harming hormone system. Though heavy metals also appear naturally in rocks, industrial utilization discharge them into ecosystem in such high density that damaging environment and hanging a sword above people's health.
Possible health problems caused by heavy metal pollutants related to textile industries are listed in form 1,2.

Metal/metalloid	Associated health hazard
Lead (Pb)	Damage to the brain, nervous system, and kidneys (causes in mild cases insomnia, restlessness, loss of appetite, and gastrointestinal problems)
Mercury (Hg)	Damage to the brain
Cadmium (Cd)	Disorders of the respiratory system, kidneys, and lungs
Chromium (Cr)	Skin and respiratory disorders, ulceration of skin and cancer of the respiratory tract on inhalation
Arsenic (As)	Skin cancer, hyper-pigmentation, kurtosis, and black foot disease

Form 1.2 Heavy metals related to fashion industries
[Resource: 18]

Heavy metal pollutants are released into ecosystem along with waste water from several procedures in textile industries, among which dyeing and finishing plants are the most exemplary. Heavy metal compounds can not break down into harmless ones, but can react to form new chemicals and transferred into other link within ecosystem, soil, aqua-life and human body for instance.

1.3.2 OTHER THREATS

The mapping of local utilization of water is illustrated in figure1.4. A significant trend can be seen is that the utilization of surface water is in decline because of the concern of pollution. Now the only main usage of river water is irrigating rice paddies. However, the security of crops produced by the polluted water is questionable. Bandung Basin produce 5% of Indonesia's rice. According to the interview of local farmer, rice produced is not consumed by local residents, instead, harvested rice will be sold to rice processing companies, from which it will be distribute to market all over the country. Such threat is clearly exceeding the area of the Kampung. Besides that, farmers in Kampung still work in a traditional way with their bare feet soaked in water and soil directly while Kampung kids use paddies as playground horsing around. The polluted water resource is obviously a considerable threat to their health. With the mistrust of river water, increasing demand for domestic water turn to groundwater. Even the water consuming textile industry now rely on ground water for its daily operation.

Based on the results of six GPS surveys conducted from February 2000 to August 2008, it was shown that several locations in the Bandung Basin have experienced land subsidence, with an average rate of about –7.6 cm/year and can go up to about –23 cm/year in certain locations. A hypothesis has been proposed by several studies that land subsidence observed in several locations in the Bandung Basin has been caused by excessive groundwater extraction, since it is found that there is a strong correlation between the rates of groundwater level lowering, with a correlation coefficient of up to about 0.92.

In the same study, significant subsidence in the textile industry area is detected, where very large volumes of groundwater are usually extracted. Extensive conversion of prime agricultural areas into residential and industrial areas, and also significant disturbance to the main ecological functions of the upland around Bandung Basin, also significantly disturb the groundwater recharging system in the basin; which in turn intensify subsidence problems there.

What's more, even if the ground water is now considered as the cleanest water people can get from nature but. Gradually pollutants in surface water will infiltrate into soil and finally reach ground water layer underneath. If we map the possible polluted resource and trace it down to the end of cycle, we will see no natural water resources is hygiene anymore. The only safe water resource will be municipal water supply and tanked water.

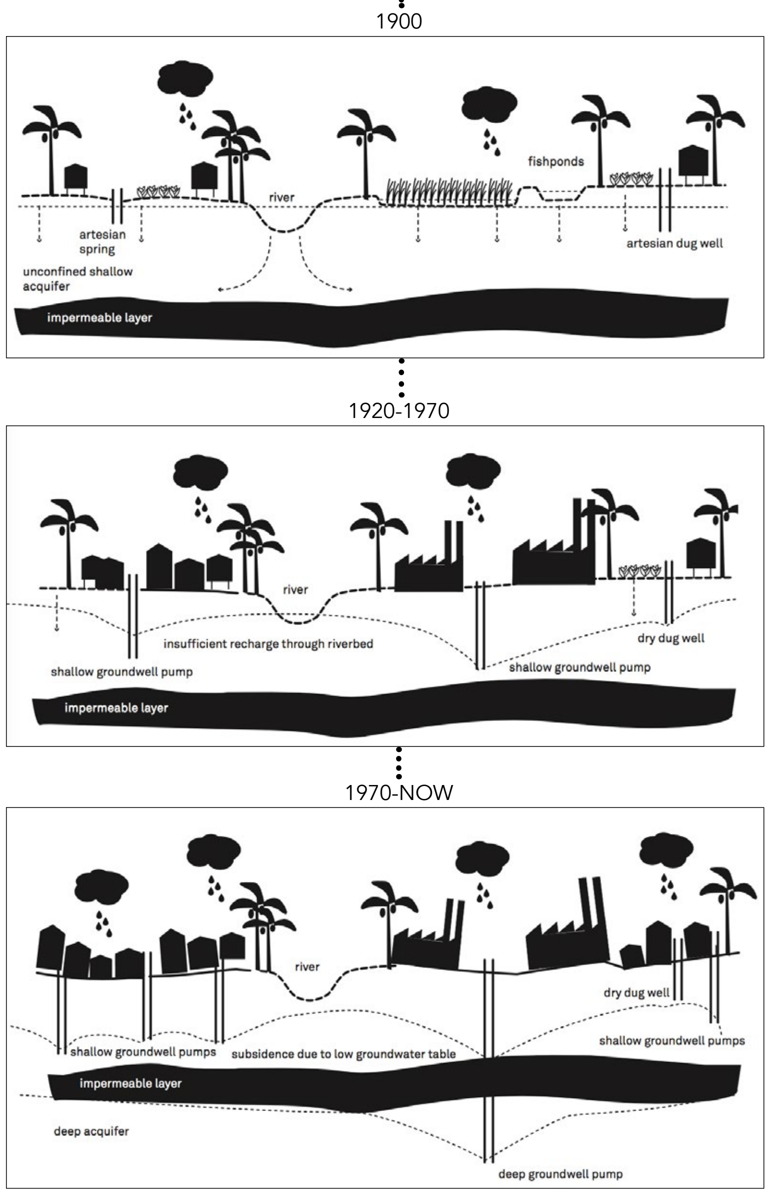


Figure 1.5 Industrialization and surface subsidence caused by groundwater extraction
[Resource: 15]

1.4 SOCIETAL PROBLEM

Ecological problems never exist alone. It always goes hand in hand with societal ones. Cigondewah is definitely not an exception, since pollution in water and soil is driven by human behavior and, in return, has great impact on villagers' daily life as well as local agriculture and industry.

First of all, the ownership of farmland in Cigondewah is not belong to farmers. Big capitals have buy the land, some of them belong to the factory next to the Kampung. People spend all days on the paddies are just tenant farmers who can only decide what to plant on the fields this year. They have little voice deciding land use in the Kampung.

Nowadays factories play a significant role in the Kampung. Data from 2007 shows that 42.5% workforce of Bandung City was employed in fashion industries . In interviews we found nearly every family have members working for fashion related industries, usually young generations. The population of agriculture is so heavily aged that most farmers in Cigondewah is in their 60s or even 70s. And more and more people find it a lot easier to construct dormitories to be rented to migrant workers than working as farmers.

Meanwhile, the industrialization process in Bandung has never stopped. In recent years population in Bandung city shows rapid growth of around 3.5% per year, and is projected to reach 4.1 million in 2031, which is 1.6 times of the number in 2015. The accumulative population pressure will add extra difficulties in public services and infrastructures which is already inadequate now.

It can be easily foreseen that in the close future, more factory plants will squeeze in and the very little farmland left will soon be bitten up. Actually, such consequences have already taken place in the Kampung next to Cigondewah RW12. From the satellite picture taken from 2003- 2015, large proportion of farmland is replaced by factory plants and high density residences. What this neighboring Kampung lost is not merely some fields. Its original spatial quality totally disappeared, along with its own identity as a self sustained village. Now it is subjected to industry and becomes part of the expending large urban pancake.

We certainly cannot blame villagers who gave up their own farmland because searching for most beneficial work is a human instinct. But are there better solutions to this?

Figure 1.6 Shrinking farmland
1 2003.8.21
2 2007.5.26
3 2012.5.26
4 2016.5.6

[Self illustration]


1
2
3
4

The problems in Cigondewah, although all generated from a single point namely the pollution made by textile industry, have developed into an intricate system. Such systematic problem need systematic solutions. Two points need to be noticed are:

1 Cigondewah is still a viable village populated by local residents with their entity and identity as a village need to be maintained
2 The industrialization process is the unstoppable trend, for industry makes great profit and contribute significantly to the rise of income for local people.

Apparently, an ecological restoration gesture is necessary in the given context, however, what is needed in Cigondewah is far more than that. People always search for higher income and better life. The reason why farmland plays less and less important role and end up being swallowed by factory area is simply that profit created by farming can hardly compare to industry, needless to say the heavy manual work acquired for maintaining the fields. To survive under the pressure of industrialization, farmland need to elevate its ability of profiting. Food crop plantation production in industry surrounded farmland, despite underlying safety threats, can hardly meet this requirement. In 2006, rice production per hectare is 4.618 tons in Indonesia, which means around 3.5 tons of white rice per hectare considering the output rate of rice processing, 75%-79%. Farm gate price of wet paddy in Indonesia is 3600-4500 Rp/kg (0.26-0.32 Euro/kg). Income gained by farmers varies from 16,624,800 Rp to 20,781,000 Rp (1183-1479Euro). A high value cash crop can be an alternative.

On the other hand, relation between industry and agriculture can be reconsidered. Nowadays agriculture and industry are two paralleled systems in Cigondewah with little beneficial interactions. Factories benefit from providing textile to fashion industry while farmers earn livings from selling food crop. With considerably lower benefit, agriculture lost its dominate position in the Kampung. There is no wonder that factories, as the winner in the competition, gradually take over farmland leaving less and less space for agriculture since it works in a universal survival of the fittest rule. What if agriculture integrate itself with local industry? Farmlands have always been feeding factories with raw materials. In textile industries, natural fiber for yarning, namely cotton, hemp, bamboo as well as animal resource such as wool and feathers, natural dyes can be produced on farmlands. Nowadays fashion industries work in such an international scale that each link within the system, raw materials provenance, yarning, spinning, sewing, accessorizing or finishing, is located all around the globe. Great distribution not only means long distance transport consuming large amount of energies, but also an exclusive relationship within the industry system from which geographically neighboring villages can hardly benefit. According to the new industry centers announced in 2013, a primary industrial chain including multiple industries in fashion is put on the agenda of future development in Bandung, however, farming is still an excluded link in this planned complementary system. In addition, water pollution makes food production an industry not trustworthy any more. Living space of farmlands is thus further suppressed. Imagine in a scenario where farmland act as the generator and resource of local industry, there will be no reasons for people chose factories over fields when determining their land use. The most

tangible approach preserving cornered farmland is not put farmland under conservatory or carrying out strict regulation prohibiting change of land use. Making farmland productive and profitable again is the key move.
Apart from restoring ecological environment, a change of position of farmlands is also necessary. "What is the relation between farmland and other social components?" "what change can farmland make concerning unfavorable living problem on site?" should be questions of same significance as "What is the most profitable crop?" and "What can be plant under existing soil and water conditions?"

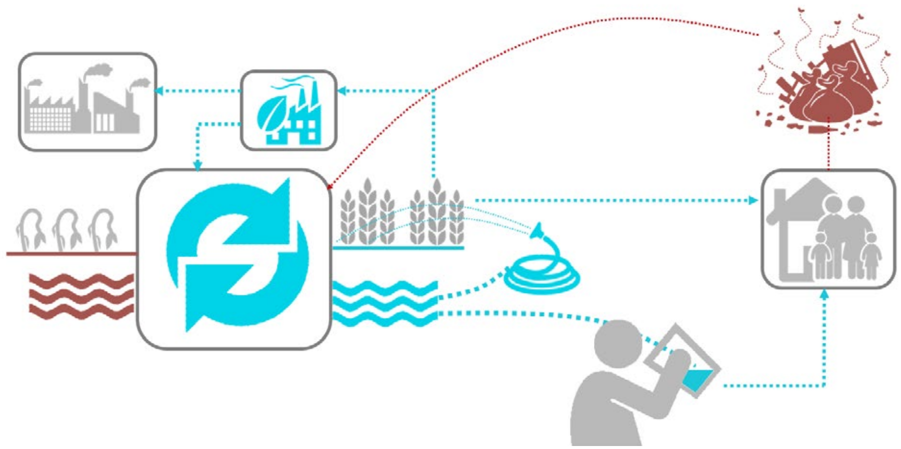
The alteration crop growing, without a doubt, will be a tough challenge. For decades, rice is the only main crop growing in Cigondewah. In interviews, farmers admitted that though they have freedom choosing which crop to grow, they simply plant the rice every year following long-standing traditions. Farmers' skills, field conditions, as well as connecting processing and sale channel has long been developed in a way suitable for rice instead of other crops. A single change in crops in the fields will certainly lead to a butterfly effect, in which whole agriculture related processing, wholesale and retailing system, material flow and benefit flow has to be reshaped to form a new inter-related system and achieve a new balance. Low profit during transformation period, when new social connections are being established, is also a predictable negative factor. What is needed is a convincing and tangible plan pointing out each step during the transitional period, and clarifying required resources and input, and finally an understandable scheme of development need to be announced. From this aspect, the capital land ownership acts a positive role. With a relatively unified ownership, a more strategic change in land use is possible to carry out. Considering Kampung as a potential material supply backyard, it is reasonable for factories to provide appropriate support helping local people out of tough transition period, for, in the long run, the new agriculture we are picturing will be a powerful support to further development for local industries.

In conclusion, three main gestures are the target of my design project:

1 filtering polluted water and soil with bio-base method,
2 making profit with productive farmland,
3 integrating with local industry and identities.

The first gesture is a physical necessity, considering existing water and soil pollution, if we still count on natural resources to provide healthy and beneficial product as well as life of higher quality. The latter two promise farmland stand the impact of industrialization. Making profit guarantee farmland a competitive position, when change of land use is being considered. Integrating makes the co-existence of agriculture and industry possible, more coherent and harmonious.

All decisions made, including crop selection, soil treatment, spatial design and so on, need to follow the three principles.



POSSIBLE SOLUSION

INTEGRATED BAMBOO INDUSTRIES

3.1 REASONS OF BAMBOO

An operable alternative crop for decaying farmland in Cigondewah as well as other pre-urban Kampung in Bandung is Bamboo. The reason will be given from three aspect: localness, eco-friendliness, and versatility.

3.1.1 A VERNACULAR PLANT

Bamboo population can be found in every island of Indonesia. Thus this indigenous plants suit perfectly in the climate and water soil condition in Indonesia. Local people have long history using bamboo for construction, waving and food(shoots).

Many valuable species of bamboo are growing in Indonesia, either native or introduced. Major utilization of bamboo including construction, pulping (for paper or textile), shoots (food), furniture and handcraft. Some of the superior species in Indonesia is listed below:

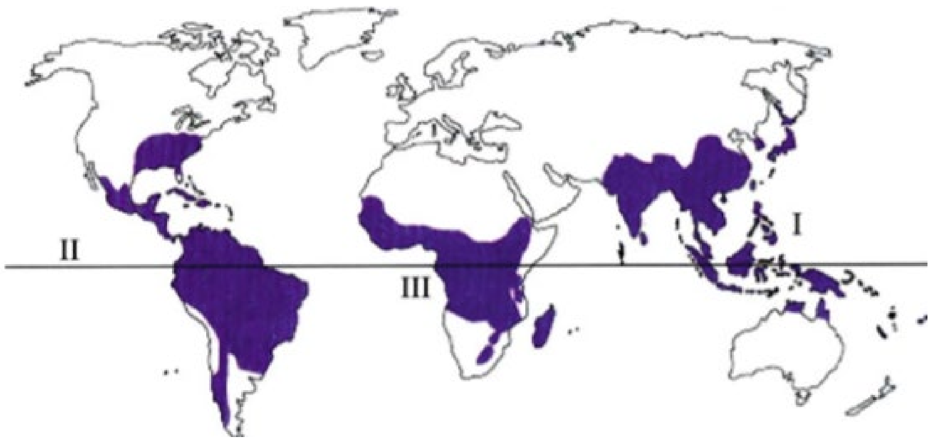


Figure 3.1 World bamboo distribution
[Resource: 18]

Species	Introduced or indigenous	Height	Usage
Bambusa arundinacea (B. bambos)	Introduced	30m	Handicraft Construction Pulp
Bambusa tulda	Introduced	20-30m	Handcraft furniture Construction pulp
Dendrocalamus asper	Introduced	20-30m	Construction shoots
Dendrocalamus giganteus	Introduced	25-60m	Construction shoots
Dendrocalamus latiflorus	Introduced	14-25m	Structure(medium) Furniture(Good) Handcraft Shoots (Good)
Gigantochloa apus	Indigenous	8-30m	Structure(medium) Furniture(medium-good) Handicraft
Gigantochloa levis	Indigenous	up to 30m	Structure Shoots(good) Furniture Paper
Melocanna baccifera (Grove Forming)	Introduced	10-20m	Roof Pulp Paper Rayon
Gigantochloa balui	Indigenous	10-12m	Structure Handicraft shoot
Gigantochloa hassarkliana	Indigenous	10m	Furniture Erosion control

Form 3.1 Valuable bamboo species in Indonesia
[Self illustration]
[Resource: 17]

3.1.2 ECOLOGICAL EFFECT OF BAMBOO

Bamboo's ecological benefits can be concluded in two main aspects: carbon sequestration and water and soil maintenance.

Carbon sequestration is the process involved in carbon capture and the long-term storage of atmospheric carbon dioxide. All plants can capture and store CO2 but with different efficiency, and bamboo is among the fastest. 1 hectare of Moso Bamboo forest under intensive management has the carbon sequestration of 12.75t, which can be converted to 46.75t carbon dioxide . Bamboo's outstanding abilities of carbon storage also illustrated in its fast growing character. In ideal conditions, some species can elongate its culms for over 1 meter within 24 hours. Such character makes bamboo a reliable resource of biomass.

A thing need to notice is that bamboo forest under human management has much better carbon sequestration ability than natural one. Old culms over 5 years old have little capacity of absorbing carbon dioxide. In order to maintain high carbon fixation rate, mature culms need to be removed from the clumps annually, which in turn make bamboo forest an alternative resource of timber.

Bamboo forest has outstanding rainfall interception ability. According to the research conducted by many Chinese scholar, total interception capacity ranges from 13.47% to 63.58% according to different precipitation, with an average of 25%, which is in general

Figure 3.2 Bamboo root system
[Resource:http://www.shweeashbamboo.com/bamboo%20care%20and%20maintenance.htm]

Figure 3.3 Bamboo's root system and reproduction
[Resource:http://www.bambooaustralia.com.au/bamboo-running-species/]

higher than other forest species. High interception assuring less direct rainfall hitting the soil. Such phenomenon originates from bamboo's evergreeness, high density clumps and exuberance of foliage.

On the other hand, bamboo forests' intricate underground system, constituted by its underground stem and root, improves soil structure and thus increase soil infiltration capacity. Abundant fallen leaves, quickly exceeding 1cm thick after 3 to 5 years, significantly slow down surface runway. Dry fallen leaves also improve soil water retention ability to a large extent. Usually dry bamboo leaves can absorb water 1.6-4 times their own weight . In some bamboo forest in southern China, fallen leaves within 1 hectare, with the thickness of 1.13 cm, are able to hold water from 4.9 to 20.4 ton, 9.9 on average .

Reticulated root system of Bamboo… capillary tubes of bamboo root 0-60 cm below ground have the effective water-holding capacity of 312.73mm, higher than Cunninghamia lanceolata plantation and natural broad leaved forest. Soil conservation ability of bamboo is 1.5 times of Pinus massoniana, and its ability of absorbing rainfall is 1.3 times of cedar . All these properties make bamboo an outstanding phytoremediation tool rescuing soil under the threat of water erosion.

In Cigondewah where flood is a frequent disaster, bamboo plantation can affectively reduce water and soil loss.

3.1.2 VERSATILITY OF BAMBOO

There are countless utilizations of bamboo around the world. In this paper, I will discuss the following ones which are related to the chance and challenges that Cigondewah is facing:

1 Bamboo Plantation
2 Bamboo Fiber
3 Bamboo charcoal and bamboo derived activated carbon
4 Bamboo base biogas

Among them, bamboo fiber is a high add value product for fashion industry. Bamboo charcoal and bamboo derived activated carbon is the key weapon purifying polluted water especially for toxic chemicals from factories. Bamboo based biogas generators can make full use of less valued part of bamboo, the leaves, and can also help digesting other biomass which is difficult to use in other way such as field weed and household waste. Bamboo plantation not only supplies material for each sectors, but also benefit ecological environment in Kampung.

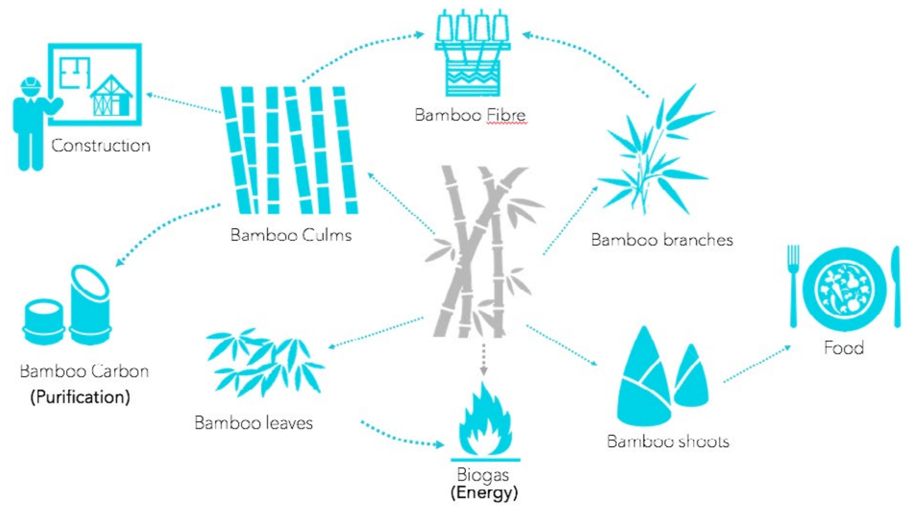


Figure 3.4 Bamboo's versatility
[Self illustration]

3.2 BAMBOO PLANTATION

Bamboo is seldom widely planted as profitable crop because it grows so easily in natural environment and the natural resource is enormous, which also result in its low price as raw material. However, with high add value bamboo based products being utilized, and its ecological value being recognized worldwide, artificial plantation attracts increasing attention.

3.2.1 MANAGEMENT AND YIELD

In order to achieve the expected fast growth, high quality and maximum yield, certain species should be selected that have adaptability or can adapt quickly and bring economic benefits and are suitable for particular environmental conditions, soils and topography.

Bamboo stands can be categorised into five end-use types: timber stand (including timber-and- shoot stands), shoot stand, pulp stand, ornamental stand and water/soil conservation stand. The species involved and the management system will vary with the intended end use.

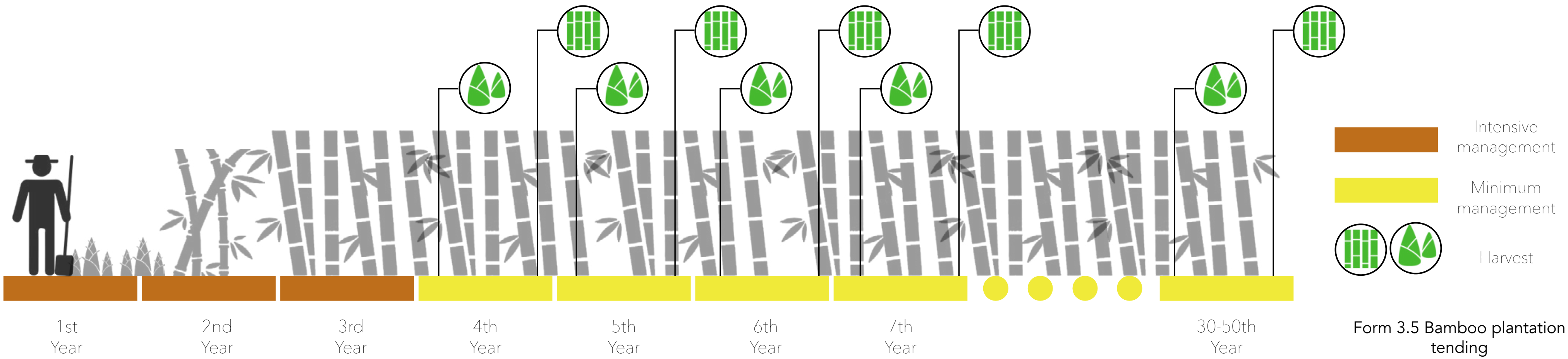
The end product of some species in Indonesia, such as B. bambos, B. tulda, D. giganteus, is 3–4-year-old culms. Some species can be grown for both culm timber and edible shoots, thus leading to the term 'timber–shoot stand' or 'multipurpose stand'.

Although bamboos mature within a few years of planting, they should be managed continuously to obtain the maximum yield. The recommended stand density is 700 clumps per hectare, each clump containing 10–20 culms at 1–3 years of age. The annual yield of culm timber generally ranges from 3 to 10 t, sometimes reaching 15–33 t/ha.

Bamboo need minimum human care. Intensive management is acquired in first few years of the plantation. After 3 years, most of the operations is done 1-2 times a year, which is much easier than rice paddies. Usually bamboo forest has life length of 30-40 years. Additionally, strong disease resistance and viability of bamboo decrease pesticide and fertilizer dose compared to other crops. Thus less hazardous chemicals will be involved, as well as manual labor. Specific tending operations are listed in form 3.2.

Tending operation	Time/ frequencey
1 irrigation	early stages of bamboos' life
2 drainage	when flood happen
3 fencing	during the first three years
4 weeding	1-2 times per year
5 vacancy filling	when clump die
6 losening soil	once a year
7 application of fertilizer	multiple times a year

Form 3.2 Bamboo plantation tending
[Resource: 17]



Form 3.5 Bamboo plantation tending
[Self illustration]

3.2.2 BYPRODUCT: BAMBOO SHOOTS

bamboo shoots are the by-product during bamboo plantation. Bamboo shoots are the young bamboo plant. If not harvested, bamboo shoots will grow into a full size bamboo plant after 3 to 4 months. Bamboo shoots usually break ground after the rainy season and are harvested after reaching 20–30 cm height. During artificial plantation, in order to maintain plant density, redundant bamboo shoots will be cut off. Annual yield of shoot stand can be 10-30 t.

Bamboos are not only poor people's wood but also rich people's delicacy. Fresh bamboo shoots are sweet and crisp, along with a characteristic flavor of bamboo shoots called egomi or egumi in Japanese, which, according to investigation, irritates the root of the tongue. Bamboo shoots are rich in dietary fiber, amino acid, protein and low in fat. Unique flavor and nutritious valuemake bamboo shoot welcomed not only in Asia, its hometown, but also in other parts of the world. Every year US imports 30,000 tons of canned bamboo shoots from Taiwan, Thailand, and China.

Other By products namely leaves and branches can be used in other sectors of the integrated system.

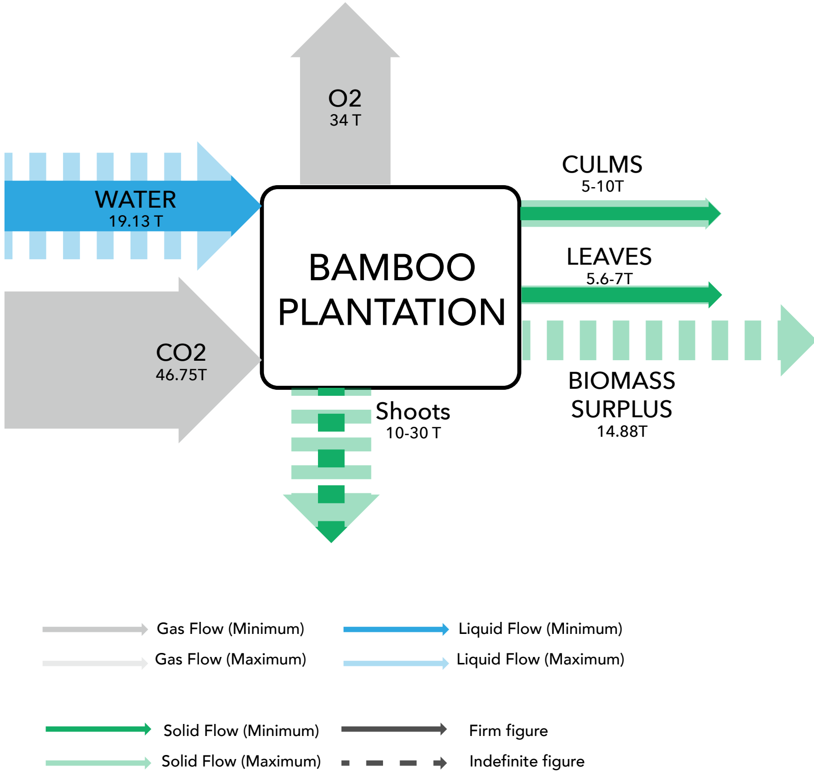


Figure 3.6 Bamboo plantation flow map
1 hectare 1 year
[Self illustration]

Note: 1 Water amount is calculated based on chemical equition of photosynthesis, actual amount will be much bigger.

2 Shoots are harvest and trade fresh, and contain large proportion of water, so the data appears to be quite big.

3 Biomass surplus is contained in part of bamboo that is not harvested: young culms, leaves, rhizome, root, etc.

3.3 BAMBOO FIBER

3.3.1 PERFECT TROPICAL TEXTILE

Bamboo has always been a widely used raw material for clothing. In Asia, bamboo strips were woven together to form shoes or hats, which is still common nowadays. In western countries, bamboos were used as structural components in corsets or bustles, similar to whalebone and metal wires. but due to the stiffness, the utilization of bamboo as textile material is quite limited.

With development of related technologies, bamboo fiber is brought under spotlight becoming one of the most intensively used new nature-based material for clothing.

People's preference of bamboo fiber rooted from its superior fabric properties. The most admired property of bamboo fiber is good hygroscopicity, which comes from its irregular section. Along the length of the fiber covered with many pores various in size. The hallow structure makes sure the fabric absorbing large quantities of water instantly with high air permeability, which result in moisture absorbing and quick drying property. Besides, bamboo fiber also has high bacteriostatic rate, 71% within 24 hours, and good uvioresistant ability, thanks to microstructure and chemical substance, namely chlorophyll and Sodium copper chlorophyllin, which are safe and effective ultraviolet absorber. Thereby, bamboo fiber textile has good potential market in hot and humid environment. In China, bed sheets made of bamboo fiber is an expensive yet widely welcomed product in summer.

3.3.2 PRODUCTION PROCESS

Having so many satisfactory properties, bamboo textile also draws some criticism for not being as natural and sustainable as labeled, especially when we take manufacture process of bamboo fiber into consideration. Manufacturer as well as retailer keep asserting that bamboo fiber came from plants without any fertilizer and pesticide used in its plantation, and thus is ecofriendly and biodegradable. What they hide is that, technically, most of commercial bamboo fiber product is made of synthetic fiber with natural ingredient, instead of true natural fiber.

Chemical composition of bamboo is mainly cellulose, Hemicellulose and Lignin with a small amount of ash and other substances like polysaccharides, waxes, resins, tannins and proteins. First two constituents are the chemical substance of bamboo fiber. To produce natural bamboo fiber, other constituents, most of which is glue-like lignin, need to be removed. However, the fiber gained is too short to be spun into yarn. Viscose process is introduced to solve this problem. A typical manufacture process is shown in Figure 3.7. End product, regenerated bamboo fiber, is silky, strong and elegant but just like any other regenerated fiber, involves toxic chemicals and harmful byproducts. With chemicals modifying fiber morphology, the superior properties of bamboo fiber are partly lost after treatment.

Natural bamboo fiber made by 100% mechanical methods or with biobased material is catching increasing attention. A typical production process is illustrated in Figure 3.8

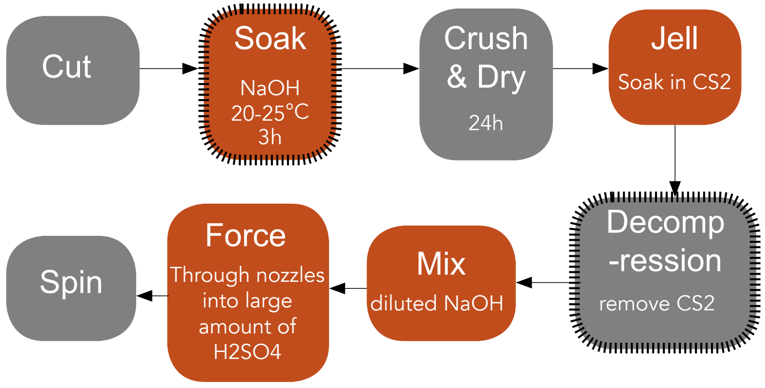


Figure 3.7 Bamboo Regenerated fiber production process
[Self illustration]

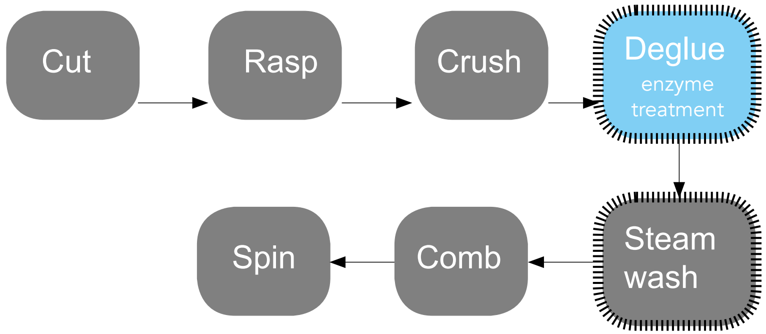
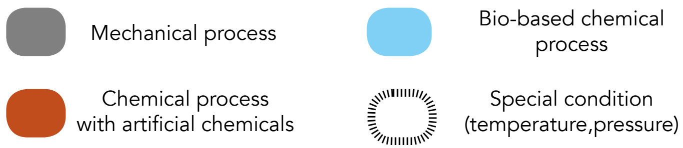


Figure 3.8 Natural bamboo fiber production process
[Self illustration]



The most essential step is enzyme treatment. The more thoroughly it digests, the thinner and shorter the fiber will be. Hence, the de-glue process need to be stopped at an incomplete state, so that left glue will stick singular fiber together forming stronger and longer fiber bundle. However, end product will be slightly rough and stiff. Such dilemma is the main problem that researchers in related industry are studying right now. With abundant sources of raw material, relatively low cost; and unique performance of bamboo fiber it is only a matter of time to develop green and pure bamboo textiles.

Xuesong, a fiber company in Hunan, China, has developed an original bamboo fiber textile product, of which the linear density and length are close to the performance of linen fiber . Swiss brand LITRAX also has developed natural bamboo fiber that offers a green alternative for manufacturers. The manufacturing process includes a series of precisely timed alternate steam-washing and enzyme treatment cycles.

3.3.3 MATERIAL, YIELD AND BY PRODUCTS

Ideal raw material for bamboo fiber is mature culm after at least 3-4 years' growth. Young culms and branches can also be used, but with lower conversion rate because of low cellulose content. 1t of bamboo culm is estimated to produce 200-250kg original bamboo fiber using eco-friendly methods.

Temperature control and steam-wash procedure acquires energy and water input. However, specific quantity needed varies a lot according to different methods. Effluent produced is harmless to environment and can be discharged after simple treatment.

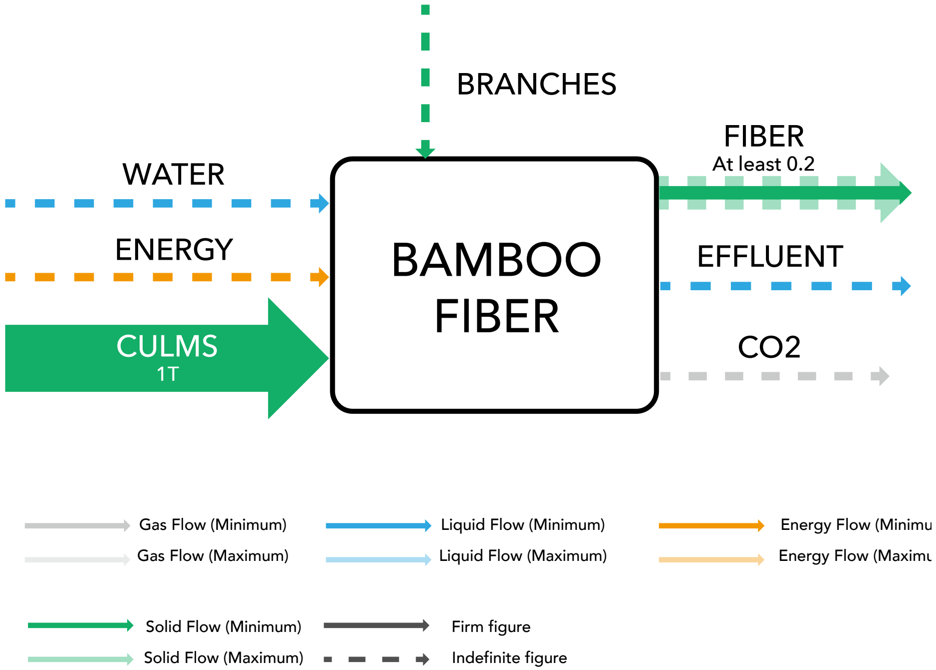


Figure 3.9 Bamboo fiber flow map
1t material input
[Self illustration]

Note: 1 The amount of water, energy involved vary a lot due to different process

2 CO2 emission is decided by energy sources introduced.

3.4 BAMBOO CHARCOAL

3.4.1 ABSORPTION ABILITY

In the past, bamboo charcoal was mainly used as fuel like other types of charcoal derived from firewood. However, some other functions of charcoal, namely, adsorbing and reducing function have been used from the ancient times to purify water, preserve objects and adjust humidity of the living environment. in addition, at present the bamboo charcoal is also utilized as a semiconductor and a bioreactor.

Bamboo charcoal's ability of absorption comes from its porous structure and high surface area. Within Raw bamboo material distribute countless minute capillary bundles transporting water and nutrient all over the plant. After carbonization, this unique anatomy structure contributes to a higher surface area of bamboo charcoal compare to other types of charcoal. Each gram of bamboo charcoal has a surface area of 300 square meters, thanks to the tiny hollows close set with diameter range from 0.25 to 0.4 mm. In China and Japan, bamboo charcoal is widely used in improving quality of drinking water, absorbing unfavorable odor.

To achieve better performance in absorption, an activating process can be introduced. Activated carbon derived from bamboo charcoal has much bigger surface area, 1200 square meters per gram. Researches have found out bamboo derived activated carbon has better absorption capacity than activated carbon mad from wood or coal.

Bamboo charcoal and bamboo derived active carbon has long been used in waste water treatment because of Its ability of absorbing large range of pollutants, especially those related to textile industries. Series of researches have been done illustrating superior ability of removing various pollutants from aqueous solution.

Pollutant	Effective or not	Removal	Capacity	Source
Nonylphenol (NPs)	Yes	94%	1.43mg/g	[6]
DEHP (di(2-ethylhexyl) phthalate)	Yes	over 70%		[20]
Brominated flame retardant (BFRs) phthalate)	Yes			[21]
Azo-dye	Yes	98%		[22]
Tributyltin (TBT)	Yes	99.2%	5mg/g	[23]
Perfluorinated compounds (PFCs)	Yes	60-90%		[3]
Perfluorinated compounds (PFCs)	Yes	60-90%		[9]
Chlorobenzene	Yes	over 90%	59.76mg/g	[24]
Trichloroethane (TCE)	Yes		28mg/g	[16]
Pentachlorophenol (PCP)	Yes		188.68mg/g	[4]
Short-chain chlorinated paraffins (SCCPs)	Not found	Not found	Not found	
Heavy metals	Yes	60-80%(arsenic)		[12]

Form 3.3 Removal effect of hazardous chemicals by activated carbon
[self illustration]

3.4.2 PRODUCTION PROCESS

Producing process of bamboo charcoal, of which carbonization under high temperature is the main principal, is relatively low-tech. However, to maximize quality of end products, the control of temperature and time is very crucial. The whole process can be finished either in a traditional kiln built in bricks, or in a mechanical electrical oven. No matter what kind of kiln is used, a standard bamboo charcoal manufacture process can be divided into five steps:

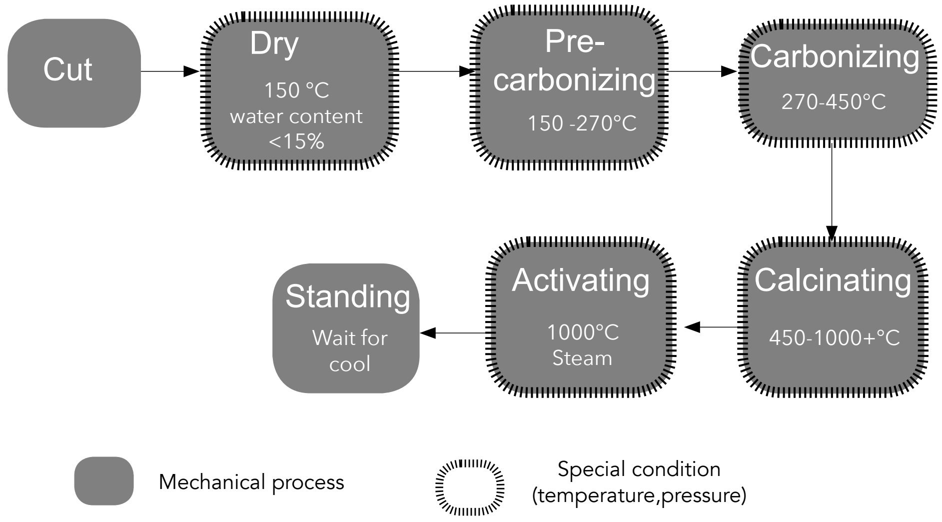


Figure 3.10 Bamboo activated carbon production process
Self illustration

According to different water content, material dimension, bamboo species and target product, technical standard of temperature and time control varies. Approximately, the whole process requires 20 days to finish in traditional kiln. If an electrical kiln with more flexible temperature control method is applied, the procedure can be shortened.

To activate charcoal into activated carbon, various techniques can be adopted, either chemical or physical. Chemical method of activation means chemical additives, usually zinc chloride or Potassium hydroxide, are applied to raw material and carbonization and activation phase are carried out simultaneously. Chemical methods, though easier to control reaction process and more time efficient, involves large amount of hazardous chemicals which means underlying pollution. A method with little harmful chemicals involved is to use high temperature steam. A Chinese company has developed an activation method in traditional kiln. After the calcinating process, raise the internal temperature to 900 degrees centigrade till blue flame can be observed around charcoal, and maintain for 30 minutes. After that, steam is injected into the kiln gradually, until blue flame disappear. And then speed up the injection, letting thick fog filling the kiln. Last step, close the injection door and chimney, leaving the inner kiln environment void of oxygen and continue the standing process letting charcoal cool down gradually. This method is tested to enlarge surface area of bamboo charcoal from 192-360 to 700-900 m2/g. technologies in this topic have made active carbon manufacturing possible in rural and pre-industrial regions.

3.4.3 MATERIAL AND RESOURCES

Raw materials for making bamboo charcoal has a wide range. Usually, bamboo culms growing for more than 3 years are qualified to make charcoal, since with age comes high carbon content in the plant, the chemical substance of bamboo charcoal. Besides, mature bamboo stems have more developed micro tube system, which contribute to bigger surface area after carbonization and better absorption capacity. Researchers also claimed that recycled bamboo material from old furniture and architectural components can also be used to manufacture bamboo charcoal . Additionally, sawdust and leftover particles from bamboo processing are another applicable material for powdered purification charcoal. Bamboo constructions have long been criticized for short lifespan. If bamboo waste has better usage than merely firewood, the valuable lifespan of bamboo material will be further lengthened.

As is introduced, the manufacture of bamboo charcoal and active carbon requires large amount of energy, in other words fuel. Thus resource of fuel in the production can be the most vital standard when evaluating the sustainability of this industry. In the scenario of traditional kiln, firewood is still one of the main source of fuel till now. Reports have claimed that to produce 1t bamboo charcoal requires 2-3 tons of firewood. Fire wood has low heat value, and high possibility of incomplete combustion, and its combustion product contains lot of smoke. If a cleaner fuel with higher heat value is introduced, the manufacture of bamboo charcoal and activated carbon will definitely be a more competitive product in the field of purification.

3.4.4 BY-PRODUCTS

Along with charcoal production, bamboo vinegar and bamboo ash are by-products. The escaping smoke condenses in the vents of the oven and drips into a receptacle. The dark brown condensate smells smoky and separates into a light yellow layer (bamboo vinegar) and a dark bottom layer (bamboo tar).

Vinegar is applied to improve alkali soil. It is also widely used in the area of medical products for skin infections and as an antimicrobial.

At the end of the charcoal making process, about 2– 4 % bamboo ash remains, depending upon the species of bamboo and the carbonization method used. The ash contains minerals such as silica, calcium, potassium, magnesium, sodium, iron, and manganese. They serve agriculture by protecting plants, acidifying the soil, and as fertilizer.

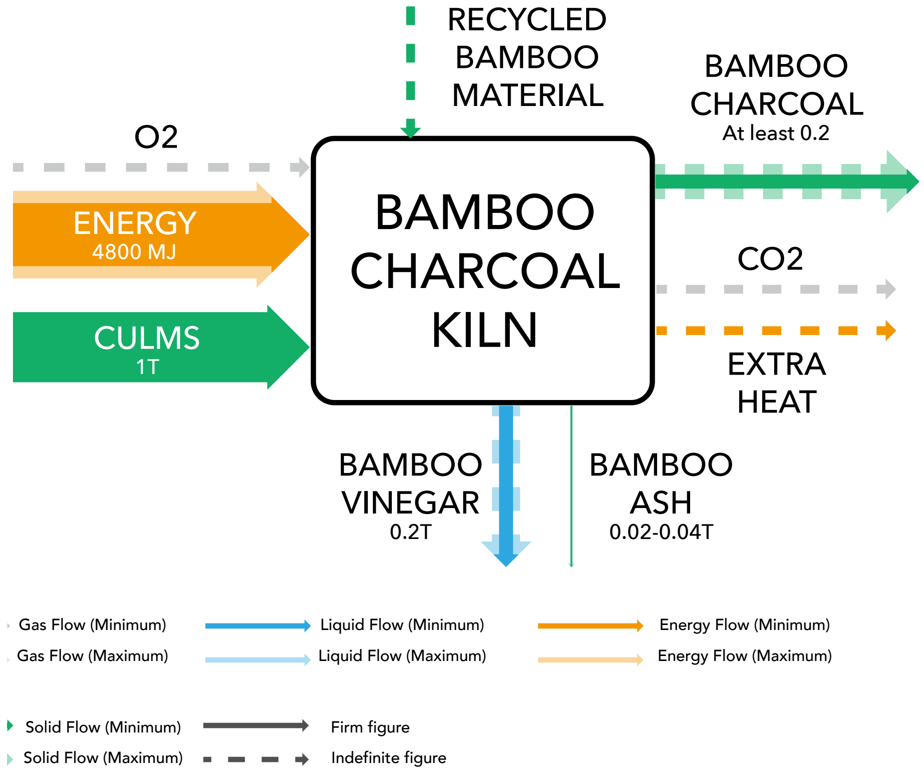


Figure 3.12 Bamboo activated carbon flow map
[Self illustration]

Figure 3.11 Raw material for bamboo charcoal
[Self illustration]

3.5 BAMBOO LEAVES BASED BIOGAS

In rural and pre-urbanized Kampungs in Indonesia, energy has always been a big problem. Local people has to rely on bottled liquefied gas for daily life. With large amount of people emerging in and insufficient infrastructure under today's circumstances, energy supply is already in shortage, not to mention feeding the energy-greedy industries such as bamboo charcoal and bamboo fiber. Alternative source of fuel need to be found. Luckily, the portentous solution lies in bamboo field as well.

3.5.1 BIOGAS: AN AFFORDABLE CLEAN FUEL

Biogas typically refers to a mixture of different gases produced by the breakdown of organic matter in the absence of oxygen. The precise constituents may vary due to the difference of organic matters used for generating. Usually biogas is a mixture of methane (up to 70% of the total gaseous product) and carbon dioxide with small quantities of other gases such as hydrogen sulfide. Methane, the desired component of biogas, is a colorless, blue burning gas used for cooking, heating, and lighting.

There are different models to assess the energy content of different energy sources, which includes water boiling test, controlled cooking test and kitchen performance test. The energy content of 1.0 m3 of purified biogas is equal to 1.1 L of gasoline, 1.7 L of bioethanol, or 0.97 m3 of natural gas.

Average proportion of methane in biogas is around 60%, which means the heat value of biogas is 30 mj/kg approximately, considering that heat value of methane is 50.07mj/kg. Compared to other common energy resource in rural areas, dry firewood(12mj/kg), charcoal(27mj/kg) and coal(29.2mj/kg) respectively, biogas has significantly higher heat potential than firewood, almost in line with charcoal and coal. However, heat value is measured when the material is completely combusted. In most cases biogas is most likely to be burn completely among the options listed. When it comes to possible harmful byproduct from burning and energy required for producing the fuels, biogas shows even more obvious advantages, needless to say it is an almost free resource.

3.5.2 MATERIAL AND YIELD

Main product of bamboo plantation is bamboo culms for they accumulate most of the biomass. Bamboo branches sometimes can also be used to build fences, make pulp or extract cellulose. Bamboo leaves are somehow waste in the system of industries and yet to be utilized.

Life of Bamboo leaf is about 9-18 months. Old leaves fall off along with rain and wind. Recent researches have proved that bamboo leaves have great potential in producing biogas. Some Indonesia grow bamboo species, namely M. baccifera, G. andamanica, B. tulda and D. giganteus, have annual leaf fall amount vary from 5.6 to 7 tons per hectare. Every gram of fresh bamboo leaves can produce 83ml biogas. If all leaf fall is used to produce biogas, the yield will be around 493m3.

Reports have revealed that carbon sequestration capacity of bamboo is questionable for large amount of methane is released during its life cycle. Collecting and utilizing the unfavorable methane will also be an addition to bamboo's superior ecological restoration effects.

Meanwhile, agriculture and domestic waste are also common and productive material for biogas generation. According to research, 1 kg organic waste can produce 0.085m3 methane. In Cigondewah where approximately 771 kg of waste is producing everyday, 65.5 m3 methane can be generated each day. In less urbanized areas where municipal services such as garbage dumping are not sufficient, biogas generator can play the part digesting organic wastes and upcycle them into clean, efficient and renewable fuel, which eases the tensions between human and ecological environment from two aspects.

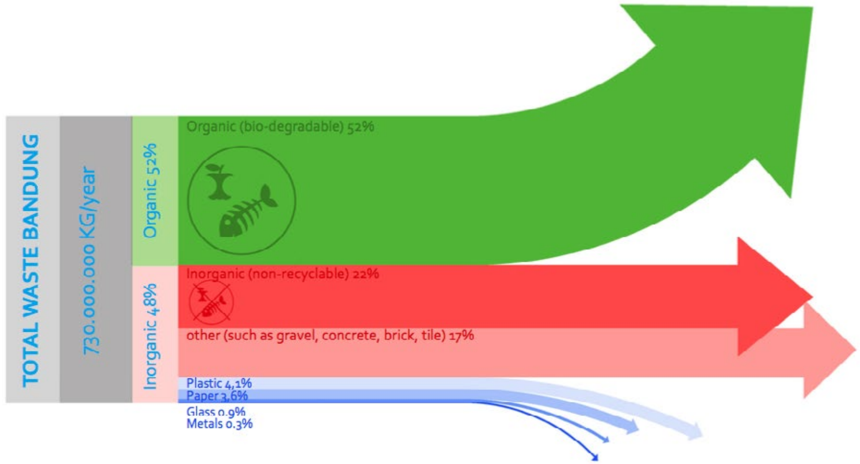


Figure 3.13 Household waste generated in Bandung per day [Resource: 8]

biogas is an important alternative fuel especially in rural area, for its high heat value, clean burning and low technology needed for building a generator. Compared to biodiesel and bioethanol, biogas producing can be afforded and operated in any conditions, and is not monopolistic.

The main body of biogas generator consists of four parts: inlet, digestate outlet, gas outlet and digesting chamber. Design of biogas generators varies according to different specific needs.

PVC, PE, Neoprene, bricks, concrete and even steel are all optional material for biogas generators. PVC and PE generators are light in weight, and easily to be made portable, but with short lifespan. Neoprene ones have better adaptability to weather change but are expensive and not sufficient in gas pressure. Bricks and concrete ones are everlasting and cheap to maintain. However, it is not portable and not easy to clean for it is buried underground. Steel ones can produce gas in a constant flow and is leak prof, but corrosion sometimes happen.

3.5.4 BY-PRODUCT RESIDUE

The digestate left over from the digester is rich in nitrogen, phosphorus, and potassium, and can be used as a fertilizer. Digestate increased the potato cultivation by 27.5% and forage by 1.5% compared to no added fertilizer. Due to the anaerobic digestion of organic matter, these nutrient concentrations were easily taken up by plants. The effluent can be directly used as a fertilizer in farming. The dried effluent could also be used as an adsorbent to remove lead from industrial wastewater.

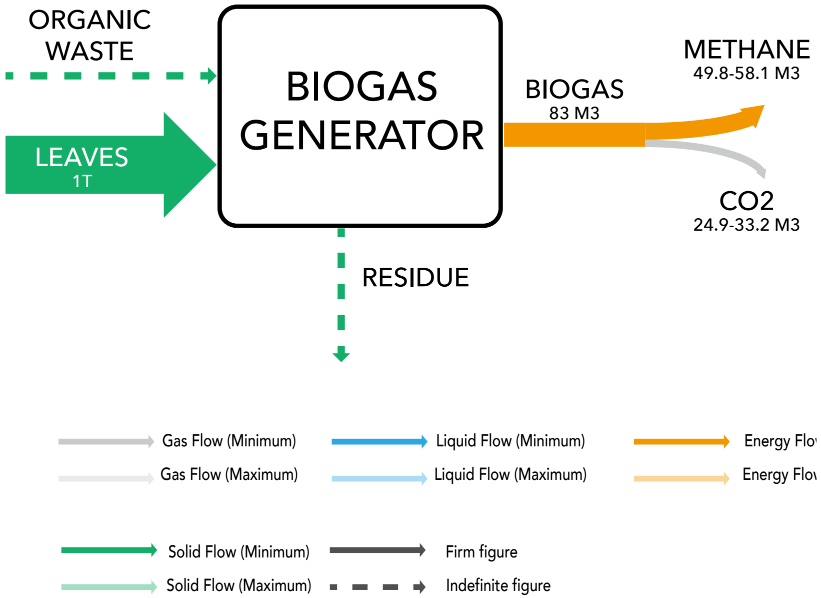


Figure 3.13 Bamboo leaves biogas flow map
[Self illustration]

4.1 MATERIAL FLOW MAP

Study of flow allows people to think about problems not as individuals but as intertwining system. Byproduct or even waste from one link can be a precious resource of another link. By establish an inter-related flow system, components within the system take advantage of each others' drawbacks and thus only a small kick start is needed to let the system regenerate itself.

As is introduced before, bamboo plantation, bamboo fiber, bamboo charcoal, bamboo leaves biogas are four industries related to the same raw material, and each of them will have positive impact on Cigondewah if applied.

Bamboo charcoal industry produce high performance purification material for factory waste polluted water. Bamboo fiber industry act a positive role in the further development of local textile industry in the long run and makes great profit. Bamboo leaves biogas generating produce clean and affordable energy for households and factories. Bamboo plantation, which is the root of all industries mentioned, makes full use of the polluted farmland while making it more profitable, so that farmland become an active and involving factor during the development and will less likely be swallowed by factories.

Meanwhile, among them embedded a matter cycling flow. Bamboo plantation is the seed of the whole system producing raw material for all related industries, culms for bamboo charcoal, culms and branches for bamboo fiber, leaves for generating biogas. Biogas from bamboo leaves can be used as fuel producing the energy consuming bamboo charcoal and complete the activation process.

Extra heat form carbonization process can be used to produce bamboo fiber for example generate steams for multiple steam wash steps. Various organic wastes can go to biogas generators to increase the yield. Digestate will fertilize bamboo fields. Carbon dioxide emission from factories can be absorbed by bamboo forest planted up close. the system is highly self-sustained and wastes are upcycled and reused to the largest extent.

Besides, the inter-related industry system also has positive effect to ecological and social environment in pre-urbanized Kampung like Cigondewah. Bamboo charcoal and bamboo fiber is two major product of the industry system. Bamboo charcoal purifies polluted water and soil and bamboo fiber is the key product connecting farmland to dominating textile industries while making considerable profit. Charcoal kilns also upcycle bamboo waste from local housings. Bamboo leaves biogas generator can be the digester of organic domestic wastes, which prevent excessive solid waste from further invading soil and water. Bamboo plantation will help maintain soil under the frequent flood. By products like bamboo shoots, bamboo vinegar and bamboo ash are also good addition to community life.

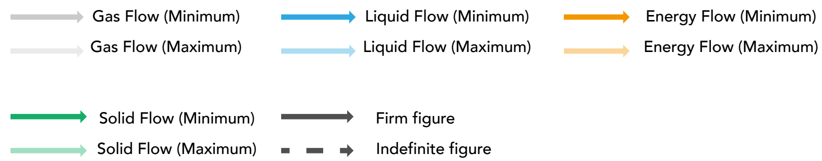
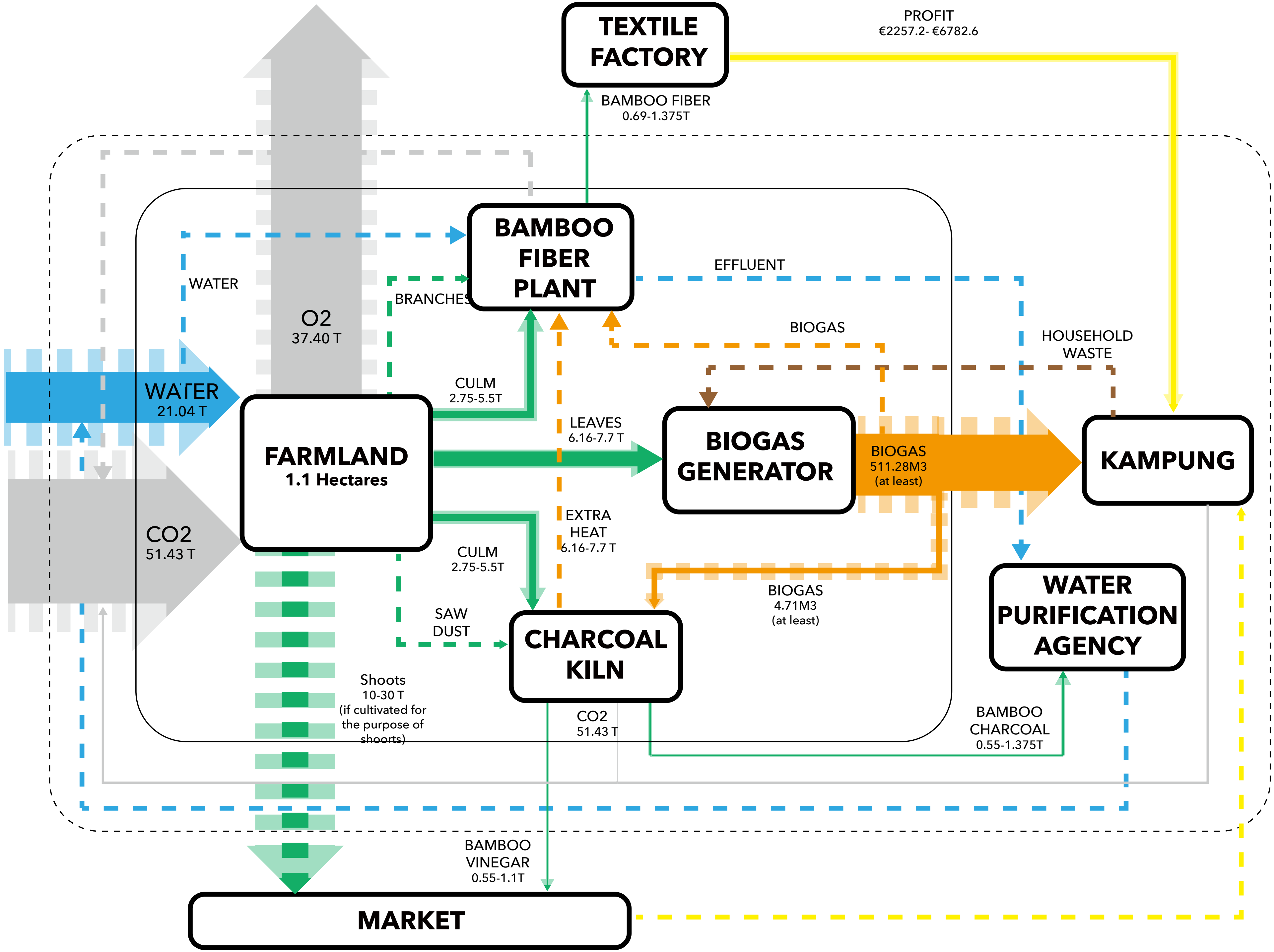


Figure 4.1 New systematic flow map
[Self illustration]


TEXTILE FACTORY
PROFIT
€2257.2- €6782.6
BAMBOO FIBER
0.69-1.375T
BAMBOO FIBER PLANT
WATER
BRANCHES
EFFLUENT
O2
37.40 T
BIOGAS
HOUSEHOLD WASTE
WATER
21.04 T
CULM
2.75-5.5T
LEAVES
6.16-7.7 T
BIOGAS GENERATOR
BIOGAS
511.28M3
(at least)
KAMPUNG
FARMLAND
1.1 Hectares
CO2
51.43 T
EXTRA HEAT
6.16-7.7 T
CULM
2.75-5.5T
BIOGAS
4.71M3
(at least)
WATER PURIFICATION AGENCY
SAW DUST
CHARCOAL KILN
Shoots
10-30 T
(if cultivated for the purpose of shoorts)
CO2
51.43 T
BAMBOO CHARCOAL
0.55-1.375T
BAMBOO VINEGAR
0.55-1.1T
MARKET

4.2 BENEFIT ANALYSIS

To be a successful industry model, not only sustainability is important, a good profit need to be achieved as well. In the given context where a systematic agriculture and industry alteration is being considered, a high expectation of profit will greatly promote the evolvement.

Within the new bio-based industry system, bamboo fiber is the main product for profit. Here I compare the commercial value of end product of three bio-base farming/industry models:

1 Rice paddy
2 Bamboo plantation
3 Bamboo plantation + bamboo fiber industr

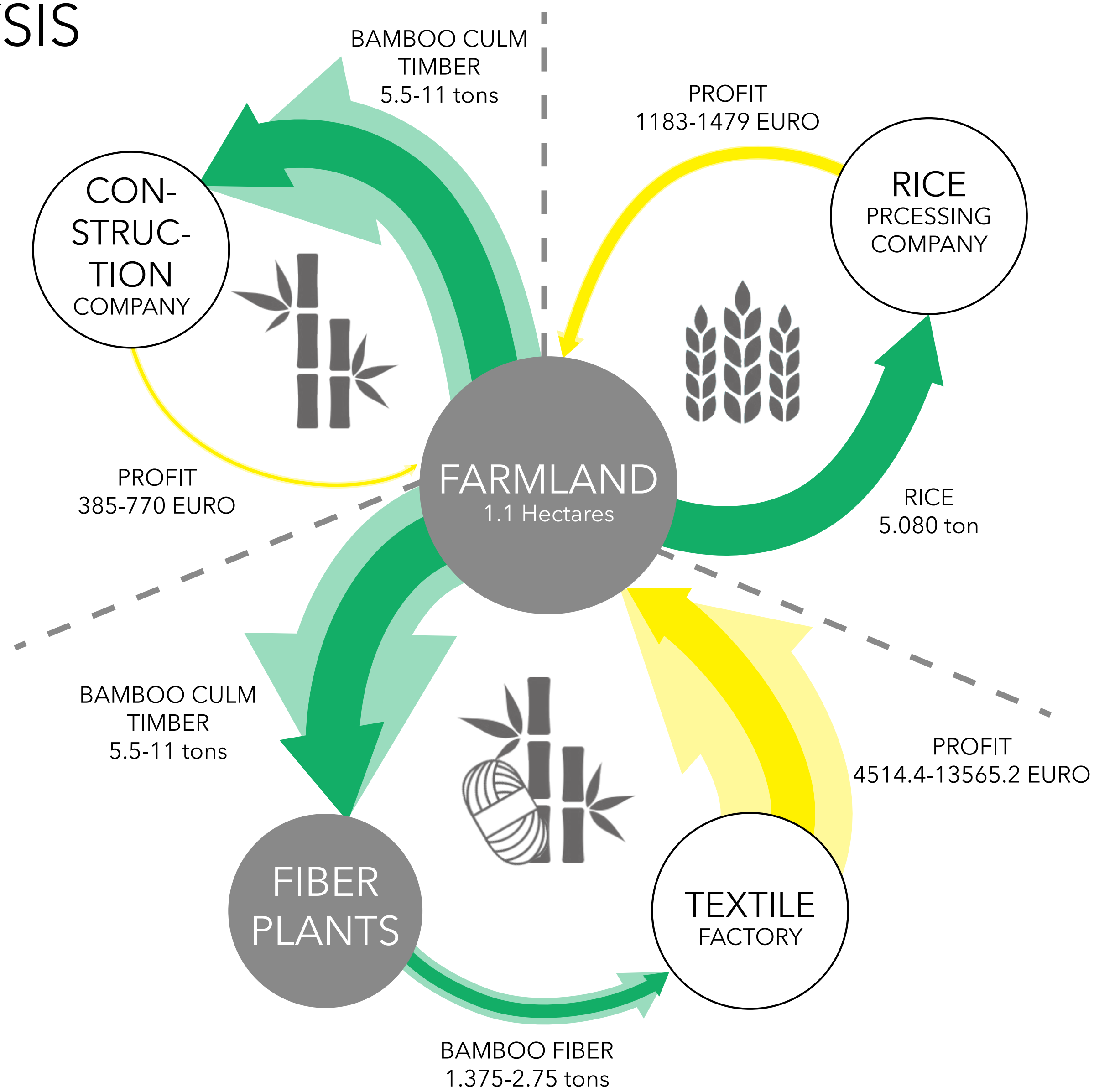


Figure 4.2 Comparison of 3 farmland utilization model
[Self illustration]

Solid Flow (Minimum)
Solid Flow (Maximum)

4.3 INSIGHTS

1 The hypothetical model is highly self sustained within the farmland-workshop sphere. Little extra material and energy input is needed.

2 With this agriculture-industry model, Kampung residents will get several considerable benefits, such as place to disposal domestic waste, large amount of free biogas and bamboo charcoal to purify drinking water, other than higher economic profit compared to rice paddy.

3 Bamboo plantation itself cannot provide good income, for bamboo as a raw material is very cheap. However, with a link of fiber extraction added, same amount of bamboo harvest will create much bigger value. Even in worst years, fiber from one fourth of the bamboo yield can be comparable to total rice yield in terms of selling price.

4 Though this model is still profitable, annual production of charcoal and fiber is relatively low compared to industrialized manufacture. This consequence due to limited area of farmland for bamboo plantation.

There are two strategies to solve this problem. Firstly, increase the input of raw bamboo material by purchasing from other plantation fields or recycling bamboo waste. Bamboo is a cheap material. The high profit rate in the model comes from high add value. Broadening raw material resource will certainly lead to higher production as well as profit.

Secondly, the program of this farmland-workshop can be reconsidered. Instead of being a manufacturing unit, it can also take more responsibility in research field. Bamboo is still a hot research topic with unexploited potentiality. Though less profit will be made, a research institution will act as a generator of integrated bamboo industries, searching for ways to realize the goal of pre-urban Kampung sustainable development in a larger and more influential scale.

4.4 SPATIAL PROSPECT

In order to realize this vision, a new agriculture-based factory scenario need to be configured in the pre-urbanized Kampung in Indonesia. Three spatial elements are necessary in this system: a constructed wetland for purifying irrigation water, several field for bamboo plantation and industrial plants for processing bamboo.

Constructed wetland
Constructed wetland is often used as the site for phytoremediation. Application of bamboo charcoal will enhance the purification effects. Water was treated while flowing through the wetland, providing affordable clean water for irrigation and daily use like washing, flushing and recreating. Making the purification procedure visible and approachable for local people brings more feels of responsibility and understanding to them.

Bamboo field
the bamboo plantation will occupy majority of the space assuring enough harvest of bamboo. Along with constructed wetland, field can be the playground of villagers. With totally different morphology as plant compared to rice, bamboo will bring new and unique spatial quality to Kampung. High and low species of bamboo, if managed properly, will create various yet rhythmic public spaces.

Industrial Plants
The industrial plants contain multiple sections: pre-processing, bamboo cutting, fiber extraction, charcoal kiln, and biogas generation. in order to achieve the goal of the new flow map where extra energy is reused and product and by-product of each section works in favor of another section, the spatial layout of plants need to be designed in a way energy and material transportation can be easily realized. Meanwhile, the ability of construction on site need to be considered. Even if many low-tech processing is introduced, within the industrial system, some parts need quite high standard spatial quality, for example temperature and humidity control, high cleanliness. If local construction skill can not meet with spatial requirement, a plug-in system can be introduced. Space framework and supplementary spaces can be built on site with vernacular low-tech techniques while space with high requirements can be prefabricated integrated cores which can be transported to various locations and implanted easily on site.

SPATIAL REFERENCE

This workshop is owned by Mr Budi Faisal, architecture professor in ITB known for bamboo integrating design. The place, located 40 minutes' drive to the north of Bandung City, is on a hilly lawn surrounded by trees and bamboos. Two warehouse housing treatment of bamboo material and storage and an experimental bamboo pavilion scattered freely in the environment. 5 minutes walk from here lie Mr. Faisal's private residence and a rural Muslim school built in bamboo.

This example provides great insight in space needed for bamboo industry and how bamboo industry (construction) co-exists peacefully with dwellers. However, this workshop relies completely on imported bamboo material despite abundant bamboo just growing on hillside around it. And this workshop is more experimental rather than productive. A more realistic and profitable model need to be intervened in Cigondewah.

This small village in Korea is famous for charcoal industry, and now tourism. The charcoal kilns here not only work as a showcase of local industry, remaining heat after charcoal production is used for Sauna for vacationer.

Two different type of industry, tourism and charcoal, which seem totally irrelevant, is interweaved together creating new public space and operation mode while still keep productiveness of the traditional kiln. The reuse of abundant heat is also a highlight.

CONCLUSION

Volating textile industry, without a doubt, trigger the chain reaction of serious ecological and societal problem in Cigondewah. Realizing surface water pollution only scrach the surface of the problem. Over extraction of groundwater, toxicant accumulation in soil, decay of farmland, lost of Kampung identity are all inter-related constituting an intricate dilemma.

The position of integrated bamboo industries is simply making farmland productive again. Bamboo will provide multiple products curing the problematic Kampung from many aspect, while make considerable profit. Bamboo plantation maintain soil from frequent flood, and is a much easier agriculture type to manage. Bamboo fiber is the main profitable product, which also link farmland with textile industry. With agriculture and industry cooperating with each other, factory and farmland will have the motivation to co-exist. Bamboo charcoal have the ability to purify industrial polluted water, and therefore shift the demand of groundwater to surface water again.Biogas generator provide energy for both industry and household, making full use of unfavorable biomass.

This prospective system is highly self sustained. Once runed properly, it requires minimum material and energy input. Additionally, carbon sequestration ability and energy production ability are excessive so that they can benefit ecological environment and Kampung The profitability is significantly higher than rice planting and bamboo planting without further processing. The only problem is limited area of farmland, which calls for inter-Kampung cooperation, combination of natural and artificial plantation, or a different farmland function.

In conclusion, the integrated bamboo industries system is a feasible solusion to the dilemma of pre-urban Kampung in Indonesia. A sustainable development scheme can be expected.

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