BAMBOO RESOURCE AND ITS ROLE IN ECOLOGICAL SECURITY

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Introduction

Bamboo is the world's largest grass and already known for its thematic uses like construction work, furniture, utensils, fibre and paper. There are 75 genera of bamboo with over 1,200 species (Sharma, 1980). Bamboo is mostly distributed in tropical and subtropical zones between 46° North and 47° South latitude in Asia, Africa and America. It is estimated that bamboo occupies over 1% of the tropical and subtropical forest area of the world covering over 22 mha area. Over 80% of the total area covered by bamboo is located in Asia (Bystriakova et al., 2003), 10% in Africa and 10% in America (INBAR, 2003). About 30% of bamboo may be classified as forest plantations vs 3.8% of wood plantations. According to the FAO/INBAR global thematic study, over 63% of bamboo resources are privately owned with 36% owned by governmental entities. In comparison 80% of all world forests are on public lands (INBAR, 2004).

The most widely known features of bamboo are its fast growth, adaptability, resilience and substantial biomass production. Bamboo is a versatile and multifaceted non-timber plant. In the last 15-20 years, it has emerged as a valuable wood substitute. Virtually every product which is now produced from wood, can be effectively produced from bamboo including panels, boards, flooring, roofing, pulp and paper, fabrics and cloth, charcoal, oil, gas and even vegetables.

Bamboo is one of the most important non-timber forest products. It is also an important support for the economy of developing countries and well being of people living there. A huge advantage is that bamboo can be used on the scale of the farmer and his family, as well as on industrial scale. About 1.5 billion people depend on bamboo for their daily lives. Over 20 million tons of bamboo are collected and utilized annually (Scurlock, 2000). Those in rural areas and the poor are the prime harvesters of bamboo, widely known as a “poor man’s timber”. Global bamboo trade is estimated to be between 1.5 to 2.5 billion USD (Lobovikov, et al., 2006). Although it occupies only 1-3% of the total tropical and sub-tropical forest area, including trees outside forest lands, bamboo contributes
between 4-7% of the total tropical and subtropical timber trade.

With modern processing techniques, many of which are still quite new, bamboo can be transformed to many eco-friendly products that may compete directly with wood products in price and performance. Bamboo often surpasses wood in the diversity of products produced.

**Bamboo and Ecological Security**

Exploding population growth, elevation of living standards, industrialization man-made pollution and other developmental activities are placing a greater stress upon the natural environment. Rapid loss of forests is contributing to global warming and flooding in many parts of the world. Carbon dioxide emissions are at historic highs and rising. The emergence of huge new global trading economies and the attendant transportation and manufacturing booms has quickly put the entire world at almost no return point in many categories of natural resources, especially, air and water. Development of bamboo resources and industries worldwide may promote economic and environmental growth, mitigate deforestation and illegal logging, prevent soil degradation and restore degraded lands.

Bamboo is a hugely environment-friendly resource. Typical hardwood trees take between 30-50 years to regenerate to their full mass. Also there is less oxygen produced, less consumption of carbon dioxide and more soil runoff where those trees were harvested. All of these have a negative effect on the environment. Bamboo however, is the fastest growing plant on the planet, with some species having been recorded to grow over 1.2 M in just 24 hours (El Bassam, 2002). Bamboo can be continuously re-harvested every 3 years with no damage to the surrounding environment. Regular harvesting is actually of benefit to the health of the bamboo plant. Also, during its regeneration, root system of bamboo remains intact preventing massive soil erosion where it is utilised. The anti-erosion properties are key to the bamboo's reputation as a useful soil conservation tool. Effective erosion control creates an effective watershed, stitching the soil together along fragile river banks, deforested areas and in places prone to earthquakes and mud slides.

Bamboo is the best practical atmospheric carbon sequestering biomass and could theoretically, be the fastest and least expensive way to offset CO₂ emissions and water pollution, while new systems of energy and conservation are being developed. It is widely believed that if bamboo is planted on a mass basis the effects of global warming could be reduced in as little as just 6 years with a renewable source of food, building materials and erosion prevention.

**Erosion Controller and Windbreak**

Bamboo has been used for centuries for windbreaks and erosion control. Unlike most trees proper harvesting does not kill the bamboo plant so topsoil is held in place. During its growth, it contributes to the improvement of the environment. It act as
an effective erosion control agent; it’s net-like root system create an effective mechanism for watershed protection, stitching the soil together along fragile riverbanks, deforested areas, and in places prone to earthquakes and mudslides. The root system of bamboo is ideal for soil stabilization-preventing erosion and landslides, protecting riverbanks and preventing floods. Its unique ground colonizing, horizontally spreading growth habit makes plantation expand in area automatically unlike trees, which have to be individually planted. Because of their wide-spreading root system, uniquely shaped leaves, and dense litter on the forest floor, the sum of stem flow rate and canopy intercept of bamboo is 25% which means that bamboo greatly reduces rain runoff, preventing massive soil erosion and keeping as much up to twice water in the watershed (Morris, 2004). Its leaves and branches serve as buffers against torrential rainfall; roots help retain topsoil, slow down the flow of flood waters and reduce siltation of rivers. It is incredibly flexible that it will bend in strong winds, but it rarely breaks. For the human environment bamboo provides shade, wind break, acoustical barriers and aesthetic beauty. Bamboo is the fastest growing canopy for the regreening of degraded lands.

**Soil Rehabilitator**

About 17% of the world’s total cultivated land is degraded; of which 62% is moderately to severely damaged. Rehabilitating this land will require policy and ground level efforts and bamboo can make a significant contribution in this context. Its growth characteristics and requirements help the environment both above the ground in terms of carbon sequestration, as well as below the ground in terms of soil rehabilitation. Bamboo can also grow well in poor soils, under low rainfall and moisture conditions. There have been a number of projects in recent years that utilize bamboo to reclaim degraded lands and wastelands. What needs to be done for the future, however, is to develop standardized information and techniques that can enable bamboo to be used on a much larger scale. This will require estimation of total reclaimable area across countries, matching of most appropriate species to various types of damaged site and development of new technologies to increase the efficacy of rehabilitation plantations, while making the short-term economics attractive to landholders.

**Wastewater Utilizer**

The Bamboo Forest is an ecological wastewater utilization system that essentially grows away, waste, producing a marketable crop in the process. Comprised of a subsurface evaporation-transpiration bed planted with bamboo and other rapid-growing, non-invasive plants, the system is engineered to provide an aerobic rhizosphere in which damaging polluting components are transformed into plant nutrients (Zhou Ben et al., 2005).

**Rainforest Protector**

Bamboo is an efficient forest cover. It naturally qualifies as an alternative to other
trees not only for reforestation but also for aorestation. Each and every newly-planted tree requires long-term monitoring and protection. It takes 20-30 years for a tree to grow. And even secondary wood forests are continuously threatened by small-time loggers and hillside communities. On the other hand, bamboo needs only 2-3 years to grow and generates a crop every year. With a 10-30% annual increase in biomass versus 2-5% for trees, bamboo creates greater yields of raw material for use. One clump can produce 200 poles in 3-5 years. Using bamboo as timber substitute can save the rainforests (Mohmod et al., 2003). Bamboo is a much better alternative to traditional softwood reforestation. It is the fastest growing reforestation medium and requires virtually no management. It is also self-propagating. A single bamboo stalk soon becomes a multiple-stalk bamboo stand in less than a year. Because logging is now practically prohibited, the supply of wood has become scarce. There is, therefore, a need to rapidly increase the areas planted to bamboo. Given the opportunity bamboo can take the tremendous pressure off on our precious forests and reduce the environmental damage brought on by cutting them.

**Phytoremediator**

The properties of the bamboo make it ideally positioned for phytoremediation of pollution, reclamation sewage and waste water and environmental clean up as a whole. The nutrients from manure and faecal matter discharged into and around water sources are especially troublesome to the environment. When nitrogen, phosphates, potash, etc. are released indiscriminately into the environment, they nurture all type of unwanted plant life, especially algae. An algal bloom is an immediate danger signal for all indigenous plant and animal life. Fortunately bamboo thrives on these nutrients and takes them up in abundance. Bamboo's unique ability to reclaim nitrogen from raw sewage water makes it an ideal candidate to both filter and treat water sources all over the world. It is also known to be a valuable ecological resource for soil and water conservation and restoration of degraded lands. In addition, bamboo is also effective in reducing non-organic pollutants and since plants are largely made of water and carbon, bamboo captures and holds large amounts of carbon dioxide which also held balance the carbon cycle.

**Bio-energy Generator**

Bamboo has got huge potential to bring revolution as a bio-energy resource. With over 5000 applications, this should be considered as the best amongst other known biomass resources. As a bio-energy resource it can meet both thermal as well as electrical energy requirements and thereby can give energy security to the rural people. From the time immemorial there has been heavy dependence on biomass resources for meeting thermal energy requirements. As such, the forest biomass was indiscriminately extracted from natural vegetation without giving much thought on its conservation. And the result has been huge depletion in forest cover. In some areas the situation is so bad that poor villagers need to
purchase fuel wood or walk miles to collect the fuel wood.

Bamboo can produce greater biomass than a hardwood forest species of comparable size. Still now, conventional fossil fuels like coal, oil, etc. have been mostly used but their shrinking source, limited storage and polluting nature have forced to look for alternatives. The situation is deteriorating in most of the developing countries. Bamboo has got potential to tide over this problem and ensure energy security. Utilization of renewable Bamboo biomass as fuel can save vast natural forest resources and fossil fuels. This would allow retention of carbon already sequestered in forests and in fossil fuels. The availability of sufficient quantity of economically affordably biomass resource on sustainable basis has been the concern in most of the areas (Riaño et al., 2002). Some of the varieties of bamboo grow so fast that their cultivation can be considered as short rotation forestry. It can be harvested in 3-5 years versus 10-20 years for most softwood (El Bassam, 2002). It can be processed for thematic uses and the unused part can be used for power generation along with other energy purposes.

Time has come to explore usage of Bamboo biomass as a renewable energy resource. But, it is not something newly explored; it is already tested but needs huge awareness build-up among the common people considering its importance as a biomass energy resource and environment protector. All the energy generation options based on bamboo have potential to alleviate poverty by linking with various income earning options.

**Carbon Sequester**

The burning of vast quantities of fossil fuels, large-scale devastation of tropical forest and land-use change have resulted in a gradual increase of atmospheric Greenhouse gas concentration which, in turn, have led to global warming. Carbon dioxide and other trace gases in atmosphere have a strong absorbency on infrared radiation, which absorb long-wave radiation from the earth and emit part of long-wave radiation to the earth, thus causing the warming of the earth’s surface and globe climate. Since the beginning of the industrial revolution, atmospheric concentrations of carbon dioxide have increased nearly 30%, methane concentrations have more than doubled, and nitrous oxide concentrations have risen by about 15% (Karl and Trenberth, 2003). These increases have enhanced the heat-trapping capability of the earth’s atmosphere. According to the National Academy of Sciences, the Earth’s surface temperature has risen by about 0.3-0.6°C in the past century (Beerling and Berner, 2005), with accelerated warming during the past two decades. There is new and stronger evidence that most of the warming over the last 50 years is attributable to human activities that have altered the chemical composition of the atmosphere through the build up of greenhouse gases.

Bamboo, being high biomass producer has advantages over wood as a carbon stock. It acts as a net carbon sink, producing 35%
more oxygen than equivalent stands of trees (Isagi et al., 1993). However, less is known about bamboo as a carbon sink. Unlike woody crops bamboo offers the possibility of annual selective harvesting and removal of about 15-20% of the total stock without damaging the environment and stock productivity (Baral and Guha, 2004). The annual biomass and carbon sink per hectare of many bamboo species are comparative to wood tree crops, such as eucalyptus or teak. Some bamboo even sequester up to 12 tons of carbon dioxide from air per hectare of plantation (Isagi et al., 1993). The unique growing capacity makes bamboo a valuable sink for carbon storage. Below ground bamboo biomass makes up 25-50% of the total stock. Carbon content comprises usually about 50% of the total biomass.

Available studies conclude that bamboo biomass and carbon production may be 7-30% higher compared to the fast growing wood species. The rotation cycle of bamboo should be considered when comparing it to woody crops. Bamboo is harvested annually and continues to produce new culms throughout its life. Every five years the carbon sequestered on one hectare will be the same and this productivity of bamboo will not be reflected in living biomass. After 30-40 years (at the age of teak or eucalyptus harvesting) the bamboo's biomass will still be as high as it was at 5-8 years old. If continuing sequestration in durable products is added to the total carbon sequestration figure, the productivity of bamboo should enable it to reach and exceed long term sequestration levels of the best tree species for carbon sequestration.

Bamboo can easily compete with the most effective wood species in terms of carbon sequestration capacities, but unlike wood species, it is not yet a part of CDM promoted through Kyoto Protocol that entered into force in 2005. The current study, implemented jointly with FAO, aims to identify opportunities for bamboo within the CDM in conjunction with its role as a resource for poverty reduction.

**Bamboo Products as CO₂ Sink**

Over 90% of bamboo carbon can be sequestered in durable products such as boards, panels, floors, furniture, buildings, cloth, paper and activated charcoal. These products have a very long life span and may retain carbon for several decades (Van der Lugt et al., 2003). The cement industry is under tremendous pressure to improve its carbon dioxide balance. The massive production has been partly reduced and marginally offset with reforestation programmes, but the overall balance remains unfavourable. The search for natural fibres, which sequester carbon dioxide, was considered a practical option (Janssen, 1981). Researchers identified bamboo-specific fungi that would eliminate all sugars after crushing the bamboo. This process saves water and offers a good quality fibre with no residual sugars. The blending of 50% cement with 50% bamboo fibres reverses the carbon dioxide balance. Since the cement board has an expected life of 30 years, the fast growing species like *Bambusa vulgaris* offers a unique opportunity for the construction industry to adhere to the Kyoto Protocol. *Phyllostachys pubescens*, one of the largest bamboo species
with a leptomorph root system has total above-ground biomass one of the highest among the world's bamboo communities. Annual soil respiration has been found to be 52.3 tons CO₂ per ha (Isagi et al., 1997). Gross production and carbon cycling in *Phyllostachys bambusoides* stand has been determined in Kyoto Prefecture and a compartment model showing the carbon stock and cycling within the ecosystem has been developed (Isagi, 1994).

The use of bamboo fibre has a positive effect on the carbon balance. Since there are some 1,300 species of bamboo and the material is abundant and easy to grow, the use of bamboo fibre offers numerous benefits (Purushotham, 1963; Masani et al., 1977). Bamboo industry through reforestations not only can improve farmers livelihood but it can also improve the quality of air we breathe and prevent our environment from deterioration.

**Carbon Trading and Credits**

Interest in carbon trading under the Clean Development Mechanism (CDM) of the Kyoto Protocol has blossomed since 2004. Bamboo can meet current requirements for CDM forestry projects such as forest definition, socio-economic and environmental criteria for sustainability, cost benefit analysis, CO₂ models, monitoring methodology and accounting. Many different types of CDM projects could be developed using bamboo, ranging from ecological conservation to cottage and large scale industrial projects. Bamboo can play a significant role in linking climate change mitigation to sustainable economic development in the developing world. Carbon credits may trigger creation of otherwise marginal bamboo plantations for processing jobs and wealth generation.

**CDM Forestry and Bamboo**

Bamboo is the rational because, as it can provide a package of desirable benefits that are not rivalled by tree species. Many varieties of Bamboo sequester amounts of carbon comparable to or superior to other favoured CDM tree crops. Furthermore, they are capable of storing that amount of carbon in a very short period, so that maximum carbon revenues can be attained in a very short time and the payback period on the investment can be reached within the first five-year trading period. The only comparable tree crop in terms of quick growth is the eucalyptus.

Modern bamboo management produces high-yielding, renewable resources that do not require chemical fertilizers and do not deplete the soil. The rhizome system of roots has even been shown to have water and soil erosion capacities superior to many tree species. Further, many bamboo species are endangered or associated with endangered species, so, forest, with endangered bamboo species, would be an important contribution to biodiversity preservation.

Bamboo is a versatile product that can be processed into finished or semi-finished products in home in many cases. It is easier to process than timber because of its light weight; and it can be grown on marginal land near or around houses as well as in large stands. As new industries develop for
bamboo, communities that invest in modern processing for building materials, furniture, fabrics, food or fuel, have the opportunity to benefit from capturing high returns on finished products. Bamboo processing can also be very efficient, with up to 90 per cent of the biomass utilized at harvest, from the leaves to the rhizomes (Van der Lught et al., 2006). Many bamboo projects have already been shown to have impressive poverty alleviation results.

The upfront investment for establishing a bamboo forest or plantation should be lower than for tree crops. As unprocessed bamboo is still valued less than wood, the propagation materials should also be cheaper than for favoured tree species. Considering that CDM Forestry Projects should benefit poor communities and considering the very high transaction costs involved with registration, this factor could be crucial for getting CDM forestry off the ground.

An Ideal Plantation Crop of Endless Opportunities

Bamboo plantation is highly suitable for the clean-cut forestlands, degraded lands and non-agricultural lands. There are some 1500 bamboo species in the world and can grow from sea level to 4000 m on every continent but the poles. This diversity makes bamboo adaptable to many environments. Bamboo tolerates extremes of precipitation and annual rainfall. Bamboo can be grown in soil damaged by overgrazing and poor agricultural techniques. With a tensile strength superior to mild steel and a weight to strength ratio better than graphite, bamboo is the strongest contender among other known biomass species on earth for its propagation. Bamboo is not only an ideal economic investment that can be utilized in many different manners but also has enormous potential for alleviating many environmental problems facing the world today. In addition, its well known applications, bamboo products are now extensively used in modern construction works like wall paneling, roofing, flooring, etc. and briquettes for fuel, rebar for reinforced concrete beams and numerous other industrial products (Vander Lught and Otten, 2007). Current research points to bamboo’s potential in a number of medicinal uses. Bamboo shoots provide nutrition for millions of people worldwide. In Japan, the antioxidant properties of pulverized bamboo skin can prevent bacterial growth, and it is used as a natural food preservative. Bamboo litters make fodder for animals and food for fish. Bamboo leaves are normally utilized as fodder during scarcity.

Bamboo can be grown almost anywhere in both good and poor soil conditions. Marginalized lands including degraded/wasteland can be brought back into production and their soil can be improved over time with the cultivation of bamboo. At the same time, bamboo creates a harvestable cash crop for local farmers.

Conclusion

The world, as a whole and developing countries, in particular, are facing a serious
problem of depletion in the natural resource base. The livelihoods of rural people are particularly vulnerable to depletion of soil and water resources, as millions of hectares of productive land become unproductive because of topsoil loss from erosion. Erosion of riverbanks exacerbated by the scouring power sediment-laden streams and hilly regions causes thousands more hectares to be lost annually. Moreover, global warming from excesses of atmospheric carbon will present a very serious problem for developing countries in years to come. There is a pressing need for the development sector to find ways to address these problems.

Besides recovering wastelands and degraded lands, the appropriate use of bamboo can mitigate the impact of unsustainable agricultural practices and deforestation on the soil. This is important in riverine and hilly areas, which are particularly vulnerable to water and wind erosion. As with land rehabilitation, large-scale soil conservation efforts must be based on research into appropriate technique and standardization of processes. Bamboo provides a viable economic alternative to forest exploitation and conservation, so that forest can be protected for their biodiversity and their diverse other benefits. On account of better strength properties of bamboo wood its entry into the wood market as the new environment friendly wood of the 21\textsuperscript{st} century can help save tropical forest via timber substitutes.

Control of greenhouse gas emission has become a socio-politically charged issue around the world needs development of novel means of removing carbon from the atmosphere. Bamboo as a carbon sequestration agent can play a major role in offsetting the continued emissions of carbon dioxide into the environment. As companies and governments look for ways to balance their carbon producing activities with carbon absorbing projects, bamboo would be an ideal species for such carbon credits. Recent studies suggest that well-managed bamboo plantations could mitigate carbon dioxide from the atmosphere more effectively than any other species. In addition, bamboo’s uniquely rapid growth and its multiple uses would ensure the economic as well as ecological value of these plantations.

SUMMARY

Rapid and alarming deterioration in natural environment has become a matter of great concern for the entire globe. Exploding population, industrialization, man-made pollution, loss of forests, etc. are responsible for this disastrous ecological scenario. Carbon dioxide emissions are at historic highs and rising. Bamboo is emerged as a way out to effectively combat these problems. Development of bamboo resources and industries worldwide may promote economic and environmental growth, mitigate deforestation, prevent soil degradation, restore degraded lands and provide cleaner environment addressing the livelihood and poverty alleviation issues at the same time. The paper describes role of bamboo in controlling soil erosion, water conservation, land rehabilitation and carbon sequestration.

*Key words:* Bamboo, Environmental degradation, Climate Change, Carbon sequestration.


