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Research on the Utilization and Development of Bamboo Resources through Problem Analysis and Assessment

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Abstract. Bamboo is a very important resource plant that determines the function and health of terrestrial ecosystems, and the safety and well-being of human society. However, current use and consumption of bamboo resources has created some serious problems that will inevitably impede sustainable development of bamboo resources. The present study focuses on four major issues that are closely related to the usage and development of bamboo resources, including overexploitation, low utilization efficiency, the shortage of bamboo raw material, and environmental issues that arise out of the development of bamboo industry. Based on an analysis on such major problems associated with the utilization and development of bamboo resources, several strategies were proposed to help improve the protection and utilization efficiency of bamboo resources, including the collecting and harvesting of bamboo resources following scientific guidelines, the enhancement of the utilization efficiency, especially multiple use of bamboo resources, the maintenance of high production and genetic diversity of bamboo resources, and the realization of an eco-friendly development of bamboo industry.

1. Introduction

Plant resources represent the foundations for human societies [1]. Since ancient times, plant resources have been used to support human existence and development, and the collection and utilization of plant resources have played a key role in promoting human civilization and economic development. Ancient humans collected wild plants as important food sources, and used wood fuel for cooking and heating. Nowadays we are more relying on plant resources, as they serve as raw materials for food, medicine, dyes, textiles, clothing, furniture, energy and industrial products, and human utilization of plant resources has stepped into a new phase thanks to rapid advances in science and technology. With the world's population continue to grow, accompanied by social, cultural and economic development, the demand for plant resources will surely increase.

As a unique plant resource, bamboo has received a lot of attention. Through a review of the literature on the theme of bamboo resources, and a reflection on the status quo and existing problems of the development of bamboo industry, the present study first introduces some basic facts about bamboo, including its biological, ecological, social and economic importance, then focuses on discussing four major issues that are closely related to the usage and development of bamboo resources, including overexploitation, low utilization efficiency, the shortage of bamboo raw material, and environmental



issues that arise out of the development of bamboo industry. We then point out some future directions for effective protection and sustainable development of precious bamboo resources.

2. The importance of bamboo

Among diverse plant species worldwide, bamboo is a very important natural resource. Bamboo belongs to a group of perennial grasses in the grass family Poaceae, and is well known for its adaptability with a short development life cycle and exceptionally quick growth [2]. Bamboo species can adapt to a wide variety of ecosystems and climatic conditions. For example, they can be found in diverse environment, including moist deciduous, semi-evergreen, tropical, subtropical and temperate areas, although tropical and subtropical regions usually support high levels of bamboo diversity. Globally speaking, there are approximately 1500 bamboo species under 87 genera [3]. However, bamboo resources are distributed unequally across continents. They could be found in all continents except for Antarctica and Europe, and bamboo resources are especially rich in Asia, with approximately 900 bamboo species under 65 genera [4]. For example, China has the highest bamboo biodiversity in the world, followed by Japan and India.

Unlike hardwood trees, bamboo could regrow after harvesting, which means it can be harvested every single year for the life of the plant. As one of the most important non-wood forest resources, bamboo represents an ideal wood substitute, and could effectively minimize timber demand pressure on forest wood production. In China, for example, the government has kept promoting the use of bamboo resources since the implementation of natural forest protection policy for the purpose of forest conservation. As a result, natural forests have been protected effectively, and a bamboo-based industry is developing promisingly [5]. Bamboo is also widely used for multiple purposes, such as the essential materials for construction and decoration purpose, furniture, flooring, textiles, fiber, food, utensils and music instruments, due to its quality and versatility. It is said that bamboo can not only replace wood, but also substitute plastics, steel, cement and composite materials in structural and product applications [6]. For people from remote mountainous areas with limited off farm income opportunities, bamboo plays an especially important role in sustaining their livelihood, and this holds true across continents [6, 7]. For example, local communities build their houses using bamboo, decorate room with bamboo furniture, collect and eat bamboo roots to obtain a sufficient supply of dietary fiber and vitamins, and make handcrafted bamboo products and sell them to other communities or available markets.

Bamboo also has significant environmental benefits. Its soil-grabbing roots could help prevent soil erosion and maintain soil stability. Also, its roots could leach heavy metals from the soil, and efficiently draw water closer to the surface due to its strong water absorption capability. As a result, environment that is inhospitable to other plants could be modified and improved, although this important role of ecological engineering by bamboo is often less understood or appreciated. During its growth, bamboo could also take up high amounts of nitrogen from the soil and carbon dioxide from the air, which, undoubtedly, would help alleviate water and air pollution problems. Obviously, promoting the development of bamboo resources not only enhances community livelihood, but also improves environmental quality and increases ecosystem functioning. Meanwhile, bamboo is of high aesthetic value, and serves as a very important component in landscape architecture and garden design due to its beautiful morphological shape and high ornamental appeal. The Chinese love bamboo, and bamboo culture has been rooted in their culture over generations. To the Chinese people, bamboo is a symbol of virtue, and reflects people's souls and emotions. It is not surprising that in China, a large number of artistic works have been made with bamboo as the central theme.

3. The problems of utilizing bamboo resources

3.1. Overexploitation of bamboo resources

Although bamboo offers significant advantages to low-income rural communities, overexploitation of bamboo by local residents impose a serious hurdle to its regeneration. In some undeveloped

mountainous areas, local residents over-harvest bamboo resources due to shortage of knowledge in sustainable development. As a result, bamboo diversity and productivity is seriously compromised.

3.2. Low utilization efficiency of bamboo resources

Low utilization efficiency of bamboo resources is a common problem widely found during the manufacturing process of bamboo products. For example, bamboo leaves, roots, powder and cutting pieces are often not fully utilized. Instead, they are simply treated as useless solid wastes. Another serious problem lies in that many bamboo manufacturers are small-scale enterprises, and they produce conventional products that are similar to one another. Also, most of these products are primary products without adding more value. Therefore, these products often lack competitiveness in consumer markets. Moreover, such manufacturing of bamboo products represents an irresponsible and inefficient way of using precious bamboo resources.

3.3. The shortage of bamboo raw material

Although large-scale commercialization of bamboo products is an emerging trend all over the world, as demand soars, the shortage of bamboo resources will be a limitation to the development of bamboo industry. Also, rapid population growth, agricultural land expansion and large-scale deforestation all put great pressure on the available land for bamboo planting. Even large areas are specifically devoted to growing bamboo, these lands would take over land traditionally used for other purposes, and thus have negative effects on biodiversity and the ecological balance of local environments. Also, current bamboo plantation practices often lack suitable methods to ensure bamboo quality and productivity. For example, bamboo plantations can lead to increased susceptibility to pests and diseases, as well as soil degradation and a loss of biodiversity. Also, the lack of information regarding bamboo survival and performance under different environmental conditions could jeopardize the outcome of bamboo plantations.

3.4. Environmental issues associated with the development of bamboo industry

Although bamboo is a natural and ecologically friendly material, serious environmental issues could emerge during the process when bamboo products are manufactured. For example, the enterprises that produce bamboo-based flooring, filament and panels also generate solid, liquid and gaseous wastes, which would then impose negative impacts on the surrounding environment. Also, although bamboo shoot represents an exceptional delicacy, the production of canned bamboo shoots involves the addition of salt and other food additives, and the treatment of pollutant from this processing, namely, a large amount of high salinity wastewater, is a very difficult task.

4. Future directions

It is important for rural communities to realize that sustainable use of bamboo resources is the only way for them to receive the maximum benefits from bamboo resources. By contrast, overexploitation and overharvesting bamboo resources would cause short-term gains but long-term losses. Therefore, the harvesting of bamboo resources should followed scientific guidelines. For example, the maximum number of bamboo poles to be harvested from each harvesting site per year should be determined in order to ensure the adequate regeneration of bamboo resources. Meanwhile, bamboo suitable for cutting should be at least 2-3 years old, and young bamboo poles that are less than 1 year old need to be left intact. Moreover, it is advised to not cut the whole clump. Rather, one or two poles should always be retained within a cluster. Also, it is especially important to create and develop educational programmes for rural communities, so that they could use bamboo resources in a scientific and sustainable manner.

We stress the importance of enhancing the utilization efficiency of bamboo resources. On the one hand, small-scale enterprises could be merged to increase enterprise size and production capacities, accompanied by enhanced machinery and equipment supply. On the other hand, by developing new manufacturing technologies or adapting to marketing trends, bamboo manufacturers should focus on developing high value-added bamboo products in order to gain a competitive advantage in the marketplace. For example, bamboo leaves are often considered as some form of solid wastes in

conventional bamboo processing factories. However, scientific evidence repeatedly shows that bamboo leaves are of high medicinal and economic values. Flavonoids extracted from bamboo leaves show significant anti-inflammatory and antioxidant activities, and have been successfully used as health products and food additives, such as bamboo leaf tea, antioxidants and polysaccharide [8]. Actually, the example of bamboo leaf flavonoids manifests that multiple use of bamboo resources should be encouraged to enhance their utilization efficiency. In addition to bamboo leaves, the long fibers of bamboo make it a good papermaking raw material. Especially, bamboo fibers have natural anti-bacteria, anti-bacteria and anti-ultraviolet characteristics, which make them superior to other fiber materials. As a promising alternative energy source, bamboo charcoal is more porous than regular wood charcoal, which significantly increases its absorption effectiveness of moisture, nutrients and metals. Also, bamboo charcoal can be used in many different ways, whether added into food, used to make cosmetics or generate electricity. Obviously, the best way to improve the utilization efficiency of bamboo resources is to recognize and promote their multiple usage, and pay special attention to the value added at every stage of the production process.

For the sustainable development of bamboo industry, the sufficient supply of raw bamboo materials must be guaranteed. Although large-scale bamboo plantations could be a straight solution, land availability often makes this approach difficult to practice in reality. However, large-scale bamboo production is still possible by applying tissue culture techniques, and tissue culture techniques along with conventional methods could be combined to enhance the production of raw bamboo materials. Also, the cultivation and management of bamboo production under scientific guidance is essential. For example, suitable bamboo species with favorable traits, such as high productivity and fast growth, should be particularly selected through the screening process, and optimal environmental conditions for their best performance should be studied in detail. Also, it is important to maintain bamboo diversity at both species and genetic level, as this is essential for the health and sustainability of bamboo resources. To serve this goal, building successful partnerships between academia and industry is necessary.

Environmental issues associated with the development of bamboo industry need to be well addressed. First, wastewater and other forms of waste need to be treated and recycled to a sufficiently acceptable level (e.g., the national or local discharge/emission standards should be met), rather than being released directly into the environment. In practice, it means that all of the bamboo-processing enterprises should submit the application of pollutant emission permits to the local environmental protection bureaus/departments on a yearly basis. Only enterprises that meet regulation requirements are could get an approval for production operations. Otherwise, they are suspended or revoked as a consequence of violating environmental rules. For enterprises, they should purchase high-tech equipment to replace the old ones in order to meet legal emission standards, while for local environmental protection bureaus/departments, they should enhance their monitoring and auditing capacities, and make great efforts to strengthen enforcement of environmental rules.

Overall, the reasonable development of bamboo resources is a win-win solution as it could help alleviate rural poverty, protect environment and enhance ecosystem functioning. However, to achieve an eco-friendly development of bamboo industry, some priorities should be identified and corresponding steps should be taken, including but not limited to the sustainable development, efficient utilization and scientific cultivation of bamboo resources, and strict management of bamboo manufacturers to minimize their environmental footprint.

5. Conclusion

Bamboo represents an important resource plant with tremendous economic, ecological and environmental benefits, such as improving rural livelihood, saving forest trees and mitigating environmental problems. However, current use and consumption of bamboo resources by human society is unsustainable, which inevitably puts increased pressure on bamboo. Based on an analysis on existing problems associated with the utilization and development of bamboo resources, several strategies were proposed to help improve the protection and utilization efficiency of bamboo resources, including the collecting and harvesting of bamboo resources following scientific guidelines, the enhancement of the

utilization efficiency, especially multiple use of bamboo resources, the maintenance of high production and genetic diversity of bamboo resources, and the realization of an eco-friendly development of bamboo industry.

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