Bamboo resources for new usage in Japan

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Abstract

Bamboo forests in Japan tend to be neglected at present due to a shift in usage from bamboo to other materials. As a result, many such are no longer managed and have crept onto surrounding land intended for other uses. In the last few decades bamboo groves have come to be recognized as invaders from a biodiversity viewpoint due to unchecked growth of the Moso bamboo (one of Japan's main species), which was introduced to Japan about 400 years ago. During the decade from1995 to 2005Moso bamboo was recognized in Japan as a dangerous species in terms of biodiversity, and efforts have been made to eliminate forests where it grows. In the last ten years or so, bamboo has regained recognition as an important resource and has become more widely used again for energy and material purposes. Some local governments are also successfully using bamboo resources in new industrial applications.

Introduction

Japan's bamboo industry has a very long history. At archaeological sites dating back around 2000 years, earthenwarerelics showing the use of woven dwarf bamboo culms have been found. Bamboo resources alsoplay a very important role in daily life today, and bamboo shoots form part of people's diets. Bamboo haslong been used in such ways in most countries to which it is indigenous.

However, modern life styles have relegated bamboo resources to a back-seat role in Japan (Shibata 2003). By way of example, most of baskets that were previously made from bamboo are now made of plastic. Many daily uses for bamboo have fallen by the wayside in this manner, and boiled bamboo shoots as a food are now largely imported rather than being produced domestically(Shibata 2001, Japan Forestry Agency) (Fig. 1, Fig. 2). As a result, large areas of bamboo forests in Japan have fallen into neglect, and unmanaged bamboo groves have crept onto surrounding land intended for other uses (Shibata 2001, Japan Forestry Agency) (Fig. 3). Ultimately, this causes ecosystem deterioration.

On the end of 20th century, many neglected bamboo forests mostly consisting of Mosobamboo in Japan were regarded as undesirable vegetation that should be wiped out due toMoso bamboo's status

as a non-native species that was introduced from China around400 years ago. A lack of knowledge in Japan regarding the difference between Moso bamboo and other bamboo species has not changed even in the last decade that the efforts to re-popularize the use of bamboo in material and energy roles.

This paper outlines developments in the use of bamboo resource over the last few decades, and also highlights efforts to promote new usage, new methods and new concepts for effective bamboo resource application in Japan.

Present Situation of Bamboo Usage in Japan

Japan has a long history of bamboo usage as evidenced by bamboo's appearance in ancient literature detailing its use to make combs and by the popularity of bamboo shoots as food (Shibata 2003). People in Japan have traditionally used naturally growing bamboo of the *Phyllostachys* and other species as well as the *Sasa*, *Pleioblastus* and *Sasamorpha* dwarf species. Such usage has been handed down to the present day in the form of traditional products whose creation requiresskillful techniques (Fig. 4). Some of the many historical uses of bamboo in Japan are outlined below.

1. Sacred plants
   Under the influence of Chinese culture, bamboo came to be regarded as a highly sacred plant. Bamboo culms and/or branches are used as god lodging parts for religious services andas tools for religious ceremonies.

2. Materials for primary industry
   Bamboo culms are very useful as a material for their lightness, which makes them ideal for use as poles and similar in agriculture, aquaculture and other primary industries.

3. Materials for woven products
   Some bamboo species have the favorable characteristicsof being easy to split, which makes them useful for the manufacture of woven baskets, sieves, blinds and the like. Bamboo resources, especially *Phyllostachys bambusoides* and *P. nigra* var. *henonis*, have traditionally been used to make woven products in Japan.

4. Materials for tools used in the tea ceremony and*ikebana* (Japanese art of flower arrangement):
   These typicalJapanese cultural activitieswould not have been established without bamboo. The *Chasen* (tea whisk) in particular would have been impossible to produce without the characteristics of bamboo culms.

5. Materials for musical instruments
   Traditional Japanese instruments include a variety of flutes and some castanets made of bamboo.

6. Materials for traditional and everyday application
   Even today bamboo is used in certain applications where alternative materials do not have the necessary characteristics. These include the manufacture of precise rulers, knitting needles, and rubbing pads.

7. Materials for food and wrapping
   Bamboo shoots are very important as a vegetables, and suitable well for fermentationand drying. Bamboo leaves and culm sheaths have traditionally been used as wrapping materials because they help to keep raw food fresh.

8. Materials for modern application
   It is well known that the bamboo filamentsfacilitated Thomas Edison's invention of the light bulb around 135 years ago. The use of bamboo in the construction of reinforced-concrete buildings as the alternative to steel was also introduced in Japan around 70 years ago during World War II. This technique is still regarded as an important today.

9. Horticultural usage
   In Japan, bamboo is regarded as an important material in gardening. It is seen as a sacred plant due to the influence of Chinese culture, and bamboo plantations are often observed in Japanese gardens. Bamboo's characteristics of temperate climate zone preference and long rhizomes make itideal for growth even in tight spaces. The large number of species also gives rise to various sizes (from 15cm to 20m tall) and horticultural characteristics (culm shape, leaf variegation, culm color etc.), which adds to its versatility (Yoshikawa and Shibata 1987).

Some of these bamboo applications are still alive and well in Japan, othershave been lostdue to changes of Japanese lifestyles.

New Trials to Promote the Use of Bamboo Resources

In Japan, most traditional uses for bamboo have declined in recent decades due to lifestyle changes and a shift to fossil materials (Shibata 2003). As a result, there is much less demand for bamboo today, and bamboo forests have fallen into neglect (Motoe *et al.* 2006) (Fig. 3, Fig. 5). In addition, Moso bamboo has come to be regarded as an invader species due to its non-native status in spite of its convenience as a material (Abe and Shibata 2009). When the 21st century began, the value of bamboo resources was underestimated and less need was seen for bamboo forests. Numerous local

have been developed plans to eliminate such neglected forests.

After these transitions, the importance ofusing bamboo once again became recognized based on re-evaluation of the material as a resource. Now bamboo forests in some parts of Japan areagain regarded as a source of new materials not only for their merits as resources but also forJapan's environment and its particular biodiversity (Shibata 2014). Bamboo is considered particularly useful in the roles outlined below.

1. Woody materials resources
   As bamboo differs from common timber in itsculm structure, lamination techniques must be applied to process the material for use in construction. In Japan,laminated bamboo timber produced for its antibacterial and deodorantproperties is used as flooring for kitchens and other parts of houses prone to water exposure.Split bamboois also used for the construction of wind-resistant greenhouses.

2. Charcoal resources
   Bamboo charcoal is regarded as high-quality, versatile materials. Its high density of very fine poles creates high absorbency, making it suitable for a variety of applications including underfloor humidity control anddeodorization. Bamboo charcoal powder is also extensively usedin soil improvement, cosmetics, audio equipment and other areas, and asan energy resource in industry. Some even believe it has significant healing effects. Efforts are currently under way to reduce the cost of bamboo active charcoal for use in water purification.

3. Fiber resources
   Bamboo fiber is known for its high quality, with usages depending on its fineness. Coarse fiber is used for purposes such as making compost and road pavement materials, while fine fiber from bamboo culms and sheaths is regarded as a superior material for the production of traditional Japanese paper (*Washi*). Bamboo culms are today usedindustrially for pulp in Japan, while fine fiber is also used for clothes, food, industrial product reinforcement and a variety of other purposes. Techniques to produce fine bamboo fiber areconstantly being developed,and efforts haverecently been made toward its use on a nanoparticle level. Such technological development is promising for the potential use of bamboo in the production of bio-plastics and bio-glass.

4. Extract resources
   Bamboo leaves and culm sheaths have long been known for their antibacterial properties, and have environmentally been used to wrap a variety of food types. Such usagecontinues today for traditional foods like sushi and Japanese cakes. Bamboo leaves are also used in Japan to make

tea, alcoholand other beverages. As the green surface part of bamboo culm is considered to have a stronger antibacterial effect, it is sold today as a high quality product. Extracts from bamboo culm surfaces and leaves are also used for medicines, cosmetics and other purposes.

5. Energy resources
   Bamboo charcoal has traditionally been used as an energy resource in Japan. Despite producing more heat than common timber charcoal, bamboo charcoal is under-evaluated in Japan due to a lack of domestic standard. The use of woody resources in pellet form as an energy source is currently being reviewed in Japan, and bamboo can be regarded as a similar material. In industrialapplication, combined combustion of bamboo chips at electric power plants and the use of bamboo chips for bio-gas power generation has beenimplemented. Under the auspices of the Japanese Government, a trial involving the use of bamboo resources for bio-ethanol production is also ongoing. At present, technology to produce very fine bamboo powder has been developed, but methods of implementation are still being considered.

6. Environmental capital resources
   Although bamboo forests account for less than one percent of Japan's forest area, they are seen as important in the resolution of global warming issues. They are recognized as helping to maintain favorable environmental conditions and supporting specific biodiversity. Plans are in place in many parts of Japan to evaluate these properties toward environmental capital resumption in bamboo forest management (Abe and Shibata 2009).

The various efforts outlined above are important in the re-evaluation of bamboo forests in Japan, where work is under way to re-introduce the use of bamboo forests resources. The outcomes of these efforts are expected to contribute to the future success of the endeavor.

Efforts toward System Development for New Bamboo Resources Usage

The Japanese Government is currently investigating effective bamboo resource harvesting systems. Many local governments and private companies are also making efforts in various related areas including management systems for bamboo forest resources, harvesting systems, methods of registering bamboo management conditions, ways of processing bamboo materials, and development of harvesting and processing machines.

In the last decade or so, the Japanese Government has also been working on the development of new applications for biomass and the construction of social systems (Ministry of Agriculture, Forestry

and Fishery, Japan). 318 local governments decided to participate in this nationwide effort before the end of April of 2011 and more than 20 of them implemented plans to use bamboo resources as major materials.

As an initial step in clarifying the local situation of bamboo resources, Mifune Town in southern Japan's Kumamoto Prefecture introduce a bamboo forest registration system involving map information for effective resource management. As part of these efforts, aset of maps and inventory introduction to determine the most suitable resource distribution for individual consumers was planned. The project remains ongoing due to a delay in plant construction for new energy production.

Kochi Prefecture's Haruno Town (nowintegrated into Kochi City) began a project to promote effective bamboo resourceapplication about 12 years ago with the aims of reviving local resource usage and stimulating the town's economy. Town officialsresearched bamboo resources and nourished the technical experts of bamboo cutting and bamboo processing. In Haruno Town, bamboo floorboards were produced and bamboo resources came to be used effectively. However, the project has now been discontinued due to financing issues.

Miyazu City in Kyoto Prefecture planned a project for cascade use of bamboo resources and started the initiative in 2005.The project's ultimate goal is to enable the production of bio-methanol and the management of a plant factory of vegetables using electricity generated from bamboo biomass-gas power. To support the completion of a bio-methanol production plant for the project, city officials are currently raising funds by selling bamboo chips and powder made from green bamboo culm surfaces as a high-value extract resource. The city is also collaborating with forestry experts to develop a new bamboo harvesting system based on the use of cable yarding (Fig. 6).

Major Japanese paper manufacture Chuetsu Pulp & Paper Co., Ltd.began producing bamboo paper in 1998 at its Sendai factory in Kagoshima Prefecture. This factory uses only domestic bamboo resources and collects large quantities of bamboo from wide areas of the southern Kyusyu Islands. Its bamboo paper is viewed in Japan as an environmentally friendly product.

The central government also continue efforts to develop new harvesting machines and related methods based on research at the Forestry and Forest Products Research Institute. The new ideas that result from such work are gradually introduced to society. Similar efforts are also conducted by private companies toward the development of techniques to produce bamboo fibers, fine bamboo powders and other products.

Theme: Ecology and Environmental Concerns

Conclusion: Requirement of Profitability High Farmers' Incomes

The high cost of Japanese labor necessitates the development of effective harvesting system and the use of bamboo resourcesto manufacture products with high added value. Efforts to secure profitability are important in creating high incomesof bamboo farmers; otherwise,farmers will not be motivated to maintain bamboo forests because bamboo as a material fetches very low prices.

Companies planning to use domestic bamboo resources as a material on a commercial basis seek to purchase the resource as cheaply as possible. As the current unit price of bamboo culm is 3 – 5 JPY (2.5 – 4.2 cents in USD) per kilogram, farmers earn around 60 – 175 JPY (0.51 – 1.48 USD) per culm. Well-managed Moso bamboo forests yield around 1,000 culms per hectareannually, producing a yearly farming income of only 500 – 1500 USD per hectare. This income is very low for Japan.

To maintainbamboo farmers' motivation and ensure that bamboo forests are well-managed, farming incomes need to be ten times their current level. Accordingly, there is a need to consider ways of increasing unit prices in order to secure high profitability. One important solution to this is known as cascade resource use, as seen in efforts by Miyazu City. This municipality plans cascade use of bamboo and the development of an effective bamboo harvesting system to reduce harvesting labor costs (Miyoshi and Shibata unpublished). In the process of cascade resource use, the green bamboo culm surface is first shaved to obtain green powder. This powder is highly valuable in the production of bamboo extracts and sells for a good price, thereby boosting profitability. The remaining bamboo is processed to produce chips that are sold at low prices for compost materials and other applications. However, bamboo chips will in future be used as a material for methanol production. Miyazu City aims to increase farming incomes to at least 500 – 700 JPY (4 – 6 USD) per culm.

The priority in rebuildingJapan's depressed bamboo industryis to ensure stable farming incomes. Recognition of farmers' motivation inthe management of bamboo forests will result in well-managed forests, favorable environmental conditions and superior biodiversity in the future. This is one of Japan's most important and urgent tasks today.

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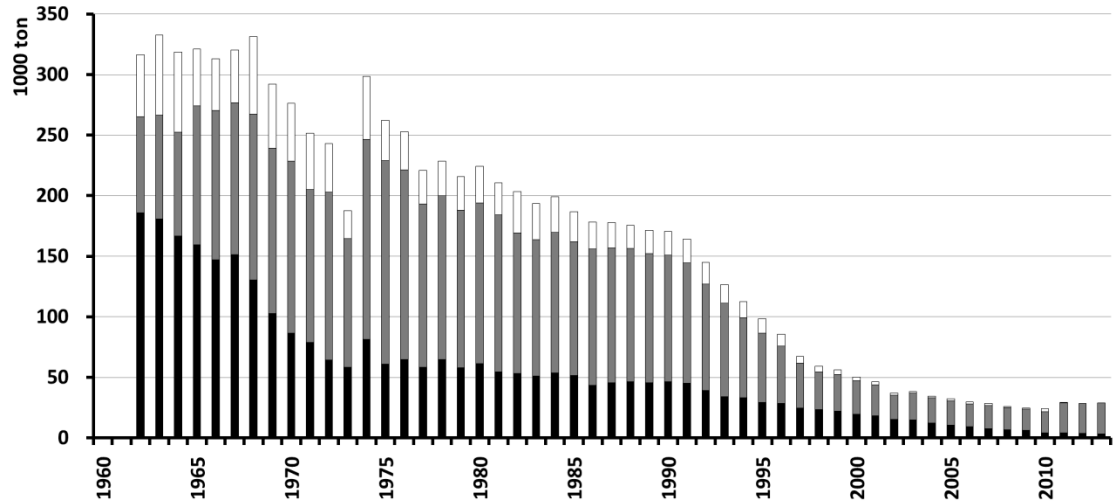
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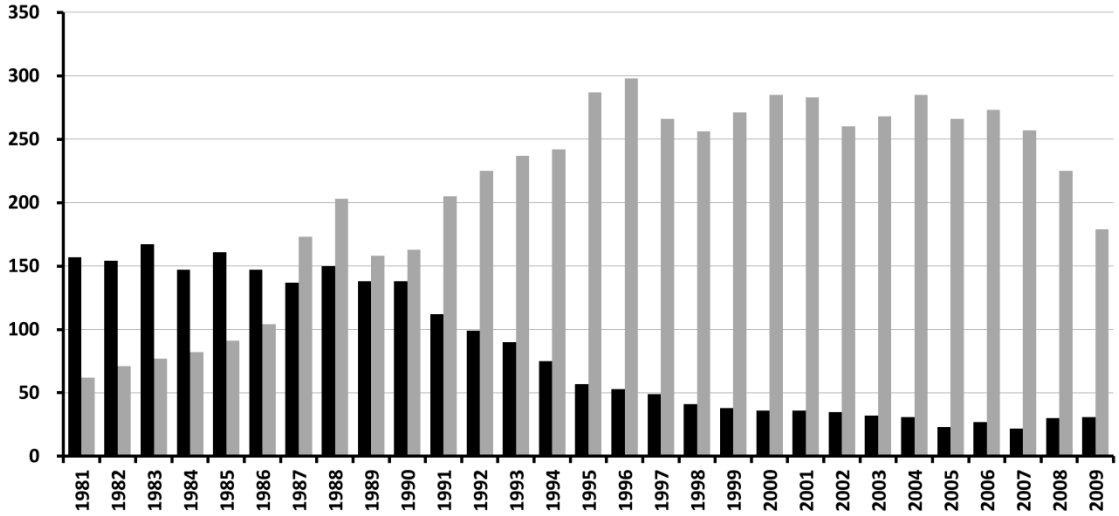
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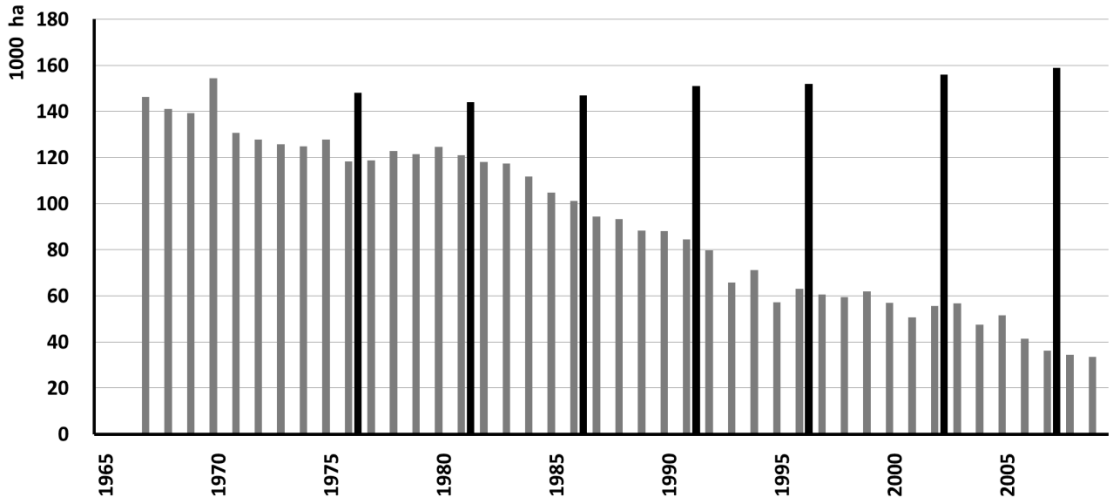
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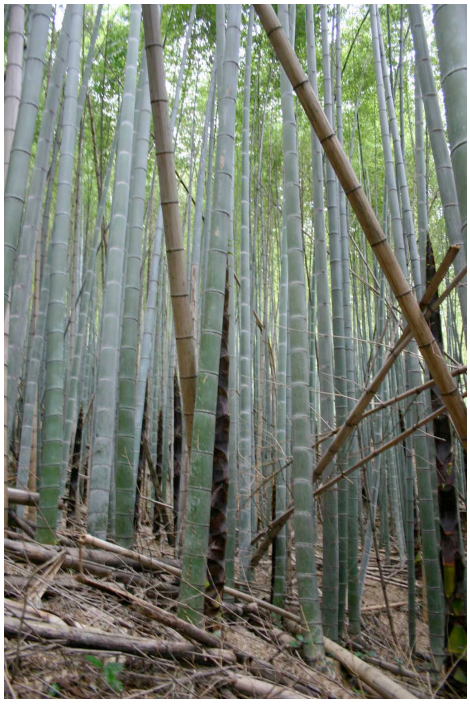

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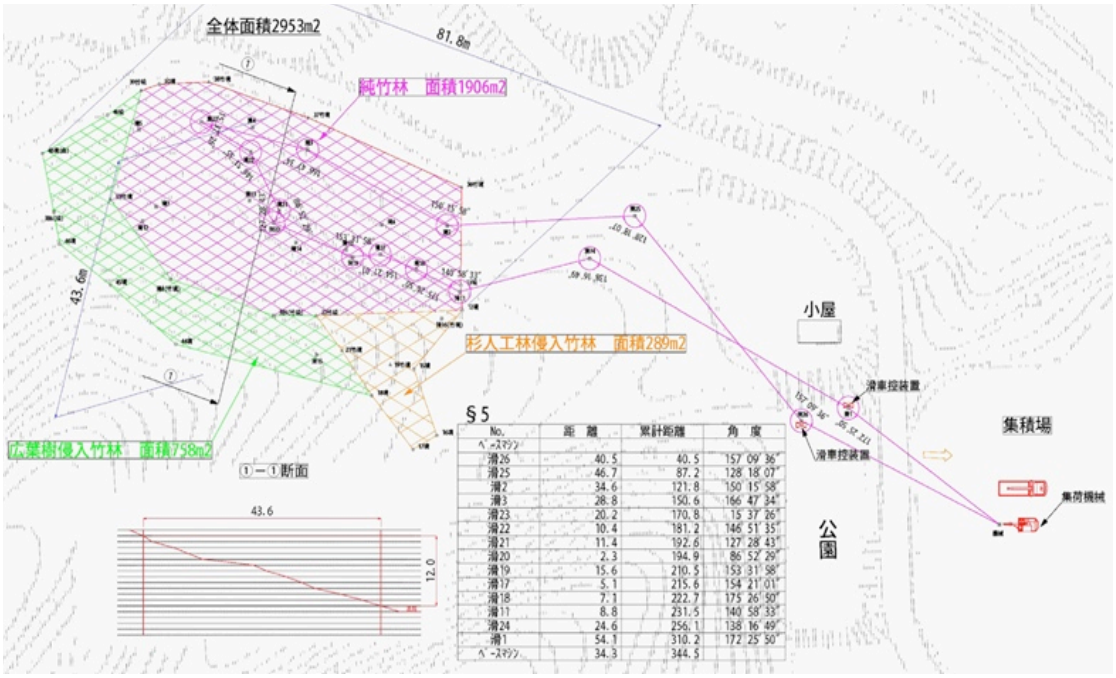

Fig. 6

Theme: Ecology and Environmental Concerns