

Chapter 2

Natural Resources with Potential for Health Applications

If one simply drives through the rural areas or observes the rituals of one of India's dozens of harvest festivals, it is obvious that agriculture plays a pivotal role in Indian life. India is the second largest user of arable land in the world (after the United States) and agriculture accounts for approximately 16 % of India's GDP.¹ It is also important to note that despite the rising populations of urban hubs like Mumbai and New Delhi, more than three of every five Indians is dependent upon agriculture for his/her livelihood.² Silk farming, also known as sericulture, is also a major operation in India, employing approximately 750,000 people.³

Hence, this chapter will introduce nine natural resources in India, all of which are major factors in agriculture or sericulture. Each of these resources has also demonstrated potential for biomaterial and therapeutic applications, an area that will be explored further in [Chap. 3](#).

Bamboo

One of the world's fastest-growing plants, bamboo is a versatile renewable resource with applications ranging from construction materials to culinary ingredients.

Bamboo, depicted in [Fig. 2.1](#), is the everyday name for perennial, ornamental grasses of the family *Gramineae* that can be subdivided into five general with about 280 different species. Most bamboo development can be found in Asia's monsoon regions, but bamboo is also quite prevalent in the Americas and Africa. Bamboo plants typically appear as straight, upright stems emerging from rhizomes

¹ US Department of Agriculture (2011).

² Soundari (2011).

³ Central Silk Board, Bangalore (2011).



Fig. 2.1 Bamboo stalks (*left*) and Bananas growing on a tree (*right*) [from Wikimedia Commons Users annieo76 and Pisang Rebus/Saba (Sap Caio), respectively]

and topped by horizontal branches. Most of these grasses are woody, but some are herbaceous or climbing. The largest types of bamboo can grow to be a stunning 120 ft in height and 1 foot in diameter. Bamboo seeds and shoots are often used as food while leaves can be used for livestock fodder. The stems are highly versatile and can be used to create bridges, cooking vessels, furniture, paper pulp, weapons, and other items.⁴ Particularly in India and China, bamboo has also been used for medicinal purposes.⁵

Covering nearly 9 million hectares of land, Indian bamboo accounts for 36 % of the world's bamboo.⁶ The country produces approximately 3 million tonnes of bamboo each year and has had much success and high yields in exports. In fact, the bamboo industry has demonstrated such potential that the country has plans to use the industry to increase rural employment and livelihoods by creating several million new jobs and lifting associated families out of poverty.⁷

Banana

The banana plant is a large, tropical flowering plant of the family *Musaceae*, commonly found in South and Southeast Asia as well as the Americas.⁸ One of the most common banana types, *Musa sapientum*, is thought to have originated in Asia and is considered one of the earliest cultivated fruits. In a banana plant, a pseudostem made up of concentric leaves rises from the rhizome. At the center of these leaves, an inflorescence stalk develops on which fruits later grow, as shown in Fig. 2.1. This seedless, edible fruits grow in bunches and typically mature within

⁴ Strausbaugh and Core (2008).

⁵ Farrelly (1984).

⁶ Rawat and Khanduri (1999).

⁷ NABARD (2007).

⁸ Lentfer and Boyd (2012).

75–150 days while growing to a length of approximately 6–8 in.⁹ The fruits are easy to consume, low in sodium, and rich in calcium and potassium.¹⁰ Although the fruit is commonly used for culinary purposes, the other parts of the banana plant can be used for such diverse functions as musical instruments or disposable dishware.

As of 2008, global banana production averaged at around 100 million bunches per year. The majority of global banana production takes place in the Western Hemisphere—in countries like Ecuador, Guatemala, and Honduras—and approximately three-fifths of bananas worldwide are ultimately consumed in the United States (see Footnote 9). India accounted for approximately 27 % of world banana production as of 2010 (see Footnote 10).

Coconut

Another common crop in India is coconut, also known as *Cocos nucifera*. The coconut is a large palm plant of the family *Areacaceae*, grown throughout tropical regions primarily for its fruit and fiber. The ovoid coconut fruit is typically 10 in. or greater in length and obtusely triangular in cross-section. A fibrous outer husk covers a spherical nut that consists of fleshy, oil- and protein-rich meat surrounded by a bony shell. Dried coconut meat, also called copra, is frequently sold for culinary uses, while the oil is often used for margarine, soap, or industrial purposes.¹¹ Ground coconut meat can also yield coconut milk, a common culinary ingredient. Coconut water is a popular drink taken from young coconuts that is rich in mineral ions, particularly potassium.¹² Some remaining parts of the coconut fruit can be used for animal feed. Coconut husks are used to produce coir fiber, which is made into ropes, matting, planting material, and upholstery filling (see Footnote 11).

Coconut is largely grown in Asia and Oceania, though it is also cultivated in the Americas.¹³ In 2010, India alone produced 10,824,100 tonnes of coconut, making it the largest coconut producer in the world.^{14,15} The crop contributes Rs. 70 billion to India's GDP every year.¹⁶ As depicted in Fig. 2.2, coconut is an extremely versatile crop, used for everything from beauty products (such as coconut oil applied to the hair) to potting compost (like coir). Coconut plants can also be used for building material, thatching, apparel, dishware, baskets, and other purposes (see Footnote 11). Since every bit of the coconut can be used, the plant

⁹ Schroeder and Dimitman (2008).

¹⁰ Mohapatra et al. (2010).

¹¹ MacDaniels and Chiarappa (2008).

¹² Yong et al. (2009).

¹³ Ibid

¹⁴ FAOSTAT (2012).

¹⁵ National Horticulture Board of India (2010).

¹⁶ Markrose (2012).



Fig. 2.2 Different forms and uses of coconut. From *left* coconuts on a tree, hut made with thatched coconut leaves, coir fiber (from Wikimedia Commons Users Iaminfo, Sengai Podhuvan, and Fotokannan, respectively)

is sometimes called the “Tree of Life”. During World War II and the Vietnam War, coconut water was even used as a substitute for intra-venous solutions when the latter was in short supply.¹⁷

Jackfruit

Jackfruit (species name *Artocarpus heterophyllus*) is a plant commonly found in regions of South and Southeast Asia, though it can also be found in places like Brazil where it is considered an invasive species. Archeological evidence indicates that jackfruit—a member of the *Moraceae* family—was cultivated in India over 3,000 years ago.¹⁸ Jackfruit, which is related to the breadfruit, is primarily grown for its fruit and sturdy wood. When fully mature, jackfruit plants are typically 50–70 ft in height with stiff, glossy, green leaves between 6 and 8 in. in length. Their fruits, illustrated in Fig. 2.3, can weigh up to 40 pounds and grow to be about 2 ft long.¹⁹ Therefore, they are considered the largest tree-borne fruits in the world.²⁰

The unripe fruit, greenish in color, can be cooked as a vegetable while the brown ripened fruit is typically consumed fresh and distinguished by its “sweetly acid but insipid” pulp (see Footnote 19). The fruit is often used as a food or for herbal remedies, while the rest of the plant can be used for medical purposes, for construction, or to create musical instruments. In addition, the jackfruit plant can be used to provide shade for other crops or to yield an orange-hued dye which is often used to color the garments of Buddhist priests.²¹

¹⁷ Library of Congress (2010).

¹⁸ Jain et al. (2011).

¹⁹ Encyclopaedia Britannica (2012).

²⁰ Valavi et al. (2011).

²¹ Elevitch and Manner (2006).



Fig. 2.3 Jackfruits on a tree (*left*) and jute drying in the sun (*right*) (from Wikimedia Commons Users Ahoerstemeier and Auyon, respectively)

Jute

Jute is a vegetable fiber product of the family *Tiliaceae* often used to make coarse cloth, geotextiles, sacks, or twine.²² Most of the world's largest jute producers are in Asia, with Bangladesh, China, India, and Myanmar contributing the lion's share.²³ However, jute is quite common in tropical Africa as well.²⁴

Jute can be divided into two categories: White (*Corchorus capsularis*) and Tossa (*Corchorus olitorius*). The former generally has smaller, straight leaves that are dark green in color with deep serrations, while the latter typically has larger, drooping leaves of a yellow-green hue.²⁵ The plants are typically slender, half-shrubby annuals that reach 8–12 ft in height. Harvested stems are usually retted in pools of water to rot out softer tissue. Then the stems are beaten on the surface of the water to loosen the jute fiber strands. These fibers are then collected, dried in the sun (see Fig. 2.3), and prepared for use. Although jute fibers can weaken substantially in the presence of moisture, jute is used quite commonly for everyday purposes that can involve exposure to moisture, such as crop transportation (see Footnote 22).

India is the world's largest producer of raw jute and jute products and 4 million Indian families are involved in the jute cultivation process.²⁶ In 2010, India

²² Nelson and Summers (2008).

²³ International Jute Study Group (2003a).

²⁴ Oboh et al. (2009).

²⁵ Indian Council of Agricultural Research (2010).

²⁶ National Multi-Commodity Exchange of India (2012).



Fig. 2.4 Rice field, *Bombyx mori* Larvae, and *Bombyx mori* Cocoons (left to right) (from Wikimedia Commons Users Miya, Małgorzata Miłaszewska, and Katpatuka, respectively)

produced over 1.7 million tonnes of jute (see Footnote 14). Annual worldwide production of jute and allied fibers is approximately 3 million tonnes.²⁷

Rice

Oryza sativa, which is commonly referred to as rice, is a tremendously important cereal crop that serves as the staple food for more than half of the world's population.²⁸ In some Asian countries, rice is a more crucial carbohydrate source than wheat, with yearly per capita rice consumption reaching levels of up to 50 times that of the United States. Rice is thought to have originated around 7 millennia ago in areas of present-day China and India, though it is a common crop throughout the Americas, Africa, Asia, and Oceania today.²⁹ India itself produced over 120 million tonnes of rice paddy in 2010 (see Footnote 14).

Rice is unique in that it can grow in very wet environments that many other crops would not tolerate (see Footnote 28). This is shown in Fig. 2.4, where rice is growing in a field submerged in water. The rice plant itself is typically between 2 and 6 ft in height, and new shoots will grow given sufficient space and soil fertility. These annual plants can take 80–200 days to mature. A rice crop can be harvested by hand or using large combines, similar to what is often used for wheat (see Footnote 29).

More than 95 % of the global rice crop is used as a human food source. The rice kernel consists of four parts: hull/husk, seedcoat/bran, embryo/germ, and endosperm (see Footnote 29). Rice is extremely rich in complex carbohydrates—an excellent energy source—although many nutrients and minerals are lost during the milling and polishing process that removes the outer rice husk and bran to turn

²⁷ International Jute Study Group (2003b).

²⁸ International Rice Research Institute (2012).

²⁹ Rutger et al. (2008).

brown rice into white rice (see Footnote 28). Rice can also be used to produce alcoholic beverages, livestock feed, and fuel sources. Rice straw can be used for thatching, weaving ropes or bags, or making baskets, hats, mats, and paper (see Footnote 29).

Silk

Although it can be produced from various sources, silk generally refers to the glossy fiber derived from silkworm larvae. Silkworms have been raised specifically for silk production purposes for at least 5 millennia in a process termed sericulture. The *Bombyx mori*, one of the most important and common silkworms in the world, spins a peanut-shaped cocoon during the second stage of its life cycle as a means of protection and to enable its transition to a pupa. The *Bombyx mori* larvae and cocoons are illustrated in Fig. 2.4. The silkworm secretes a protein-based silk film and usually finishes its cocoon within 3 days, at which point its life cycle can be terminated to allow for the silk to be harvested and unwound. This silk is typically composed of 95 % protein, of which about four-fifths is fibroin and one-fifth is sericin. The fiber is a double-filament of fibroin held together by the gummy sericin.³⁰

As the world's largest silk producer after China, India accounted for nearly 15% of the 140,051 metric tonnes that comprise the world's total raw silk production in 2010. It is also the only country to produce all four types of silk: mulberry, tasar, eri, and muga. Silk consumption in India itself is around 29,300 metric tonnes per year, but there is high export demand as well, particularly to regions such as the US and Europe (see Footnote 3). The US is the world's greatest importer and consumer of silk (see Footnote 30). Nearly three-quarters of a million people are employed in sericulture in India, many of whom are classified as “disadvantaged” or women (see Footnote 3).

Soy

Glycine max, also known as the soybean, is a legume that has been grown in Asia for over 3,000 years and is currently produced largely in Argentina, Brazil, China, India, and the United States.³¹ India alone produced nearly 10 million tonnes of soybean in 2010 (see Footnote 14).

The annual soybean plant can take 90–180 days to reach maturity, at which point it is typically between 25 and 50 in. in height. Two unifoliate leaves develop above

³⁰ Potter (2008).

³¹ Soyatech (2012).



Fig. 2.5 Soybeans on plant, tamarind pods and components, and tamarind fruits on a tree (*left to right*) (from Wikimedia Commons Users Scott Bauer, Carschten, and B.navez, respectively)

the cotyledon while all other leaves are typically trifoliate. Depending on space available, a plant may have a few branches (which emerge from the main stem) with just a few seeds or have many branches with a thousand or so seeds. Soybean plants also have white or purplish flowers, and much of the plant is covered with thin brown or gray hairs. There are thousands of varieties of soybean, but nearly all soybean pods contain one to four seeds with black, brown, green, or yellow seed coats, as shown in Fig. 2.5. The seeds are considered the most important part of the plant, and contain approximately 40 % protein and 20 % oil on a dry-weight basis.³² Genetically modified soybeans have been commercially grown since 1996 and are now dominant in most major producing countries (see Footnote 31).

Soy processing generally converts soybeans into oil, meal, or protein products. The three major processing steps are oil extraction, oil refining, and protein processing (see Footnote 32). About 85 % of the soybeans produced in the world are processed into soybean meal and oil. Nearly all of the soybean meal is further processed into animal feed and fertilizer, while a smaller fraction is used for soy flour and proteins. About 95 % of the oil fraction is used as edible oil in items like salad dressing or mayonnaise, with the rest going to industrial products like biodiesels, soaps, or varnishes (see Footnote 31).

Tamarind

Although the tamarind, of family *Leguminosae*, is considered native to tropical Africa, it may also be indigenous to India. Today, it is widely grown elsewhere in Asia and in Mexico as well.³³ The *Tamarindus indica* is an evergreen tree that can grow to be nearly 80 ft in height and over 10 ft in girth. The plant grows pale yellow or pink flowers and podded fruit. The subcylindrical pod is generally 4–7 in. in length and about 1.5 in. in width with a velvety brown cover, as depicted

³² Fehr et al. (2008).

³³ California Rare Fruit Growers, Inc. (1996).

in Fig. 2.5. The pod's shell is brittle, but inside are 3–10 hard seeds about 0.6 in. in length, covered in a sticky, edible pulp.

Tamarind fruits have one of the highest levels of carbohydrate (41.1–61.4 g/100 g) and protein (2–3 g/100 g) of any known fruit.³⁴ These podded fruit are primarily used for medicinal or culinary purposes, though other parts of the plant have different uses. For example, tamarind oil can be used for varnish and tamarind wood is used to create everything from canoes to printing blocks.³⁵

India is Asia's largest sour tamarind producer.³⁶ The country exported 37,000 metric tonnes of tamarind from 2001 to 2002.³⁷

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³⁴ El-Siddig et al. (2006).

³⁵ Bhadoriya et al. (2010).

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