2. Background

2.1 The Cotton Crop

Cotton, the world's principal natural fiber is the most valuable and preferred fiber that has the unique nature of usage as fiber as well as food. A cellulosic fiber, cotton accounts for about 40 percent of all textile usage and more than half of all the fibers used in clothing and household furnishings (UNCTAD, 2009). Besides traditional uses, cotton is also used in industrial fabrics as well as in medical and hygienic applications. The by-products derived from cottonseed and stalks are usable in soap manufacturing, industrial products, firewood, paper and high protein animal feed supplements. Additionally cotton provides edible oil for human consumption which accounts for approximately 8 percent of vegetable oil consumption in the world (EJF, 2007; Valderrama, 2009).

The cotton plant belongs to genus *Gossypium* and family *Malvacae*, that comprises approximately 1500 species including the flowering shrub Hibiscus and Okra. Though the plant grows up to 10 meters high in the wild, it is domesticated to range of 1 to 2 meters under commercial cultivation to facilitate picking. By nature, the cotton plant is a perennial tree (lasting about 10 years), but under extensive cultivation it is grown as a annual shrub. Of about 50 species in the world, only four species of cotton are widely cultivated; *Gossypium hirsutum*, *Gossypium barbadense*, *Gossypium arboreum* and *Gossypium herbaceum*. *Gossypium hirsutum*, the Mexico originated upland cotton whose fibers range from 2 to 3 centimeters in length is the commonly cultivated species covering more than 90 percent of the world fiber production. *Gossypium barbadense*, the long staple cotton of Peruvian origin occupies

a small area of less than 5 percent and has fiber length of up to 5 centimeters. The other two species *Gossypium arboreum* (which originated in the Indo-Pakistan subcontinent) and *Gossypium herbaceum* (from Southern Africa) are the Asiatic cotton species that are grown in restricted areas of Asia and Africa. These are diploid species and are incompatible with upland and long staple cotton which are self pollinating allotetraploids. There are no identified non-cotton wild relatives with which upland and long staple cotton will outcross. The commercial seeds that are sold globally are varieties rather than hybrids with India being an exception, where majority of cotton cultivated is hybrid (Alam, 2004; Khadi *et al*. 2007).

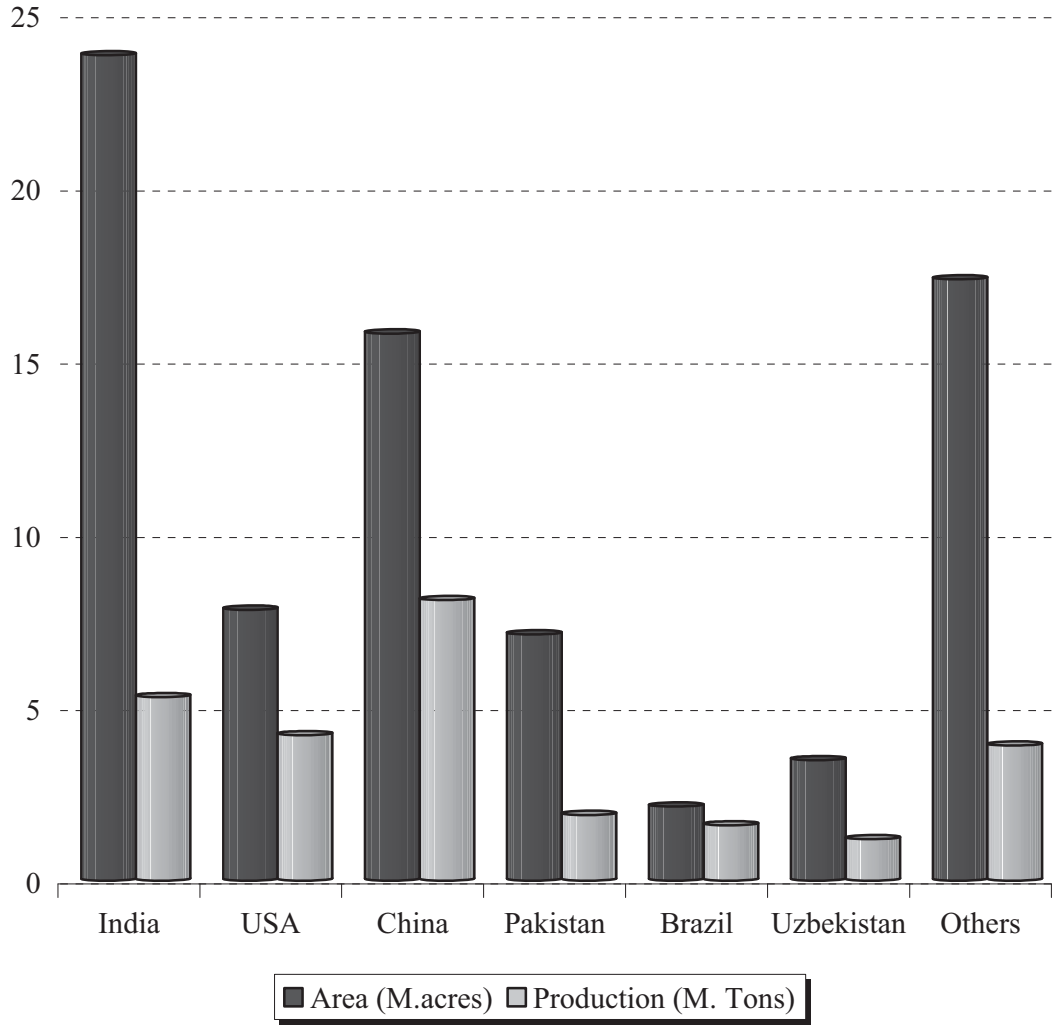
Cotton plant is native to hotter regions of tropical and sub-tropical countries. It is a sun-loving plant highly vulnerable to freezing temperatures. Cotton prefers a heavy loam soil and is grown on sandy to clay range of soils. It is known to produce one of the highest quantities of dry matter per liter of water and is regarded as one of the efficient water utilization crop. The season length of cotton varies from 14 to 250 days that differs in the Northern and Southern hemisphere. The cotton flower has five large petals (snowy, white, white-creamy or even rose in color), which soon fall off, leaving capsules or fruit known as the "cotton bolls". The cotton boll contains approximately 10 cotton seeds that are surrounded by fibers (lint) which grows from the coats of the seed. The capsule bursts open upon maturity, revealing the seeds and masses of white/creamy and downy fibers. The cotton lint is the primary commercial product that generates income for cotton producers and lint yield is approximately one-third by weight of seed cotton. The lint is separated from the seed during processing. Besides being a major natural fiber crop, cotton also provides edible oil and seed by-products which is used as source of food, feed and oil for humans and animals. Cotton seed is refined before it is fit for human consumption to remove

Gossypol (a polyphenol) which is toxic to humans and monogastric animals (UNCTAD, 2009).

2.2 Economic Importance of Cotton

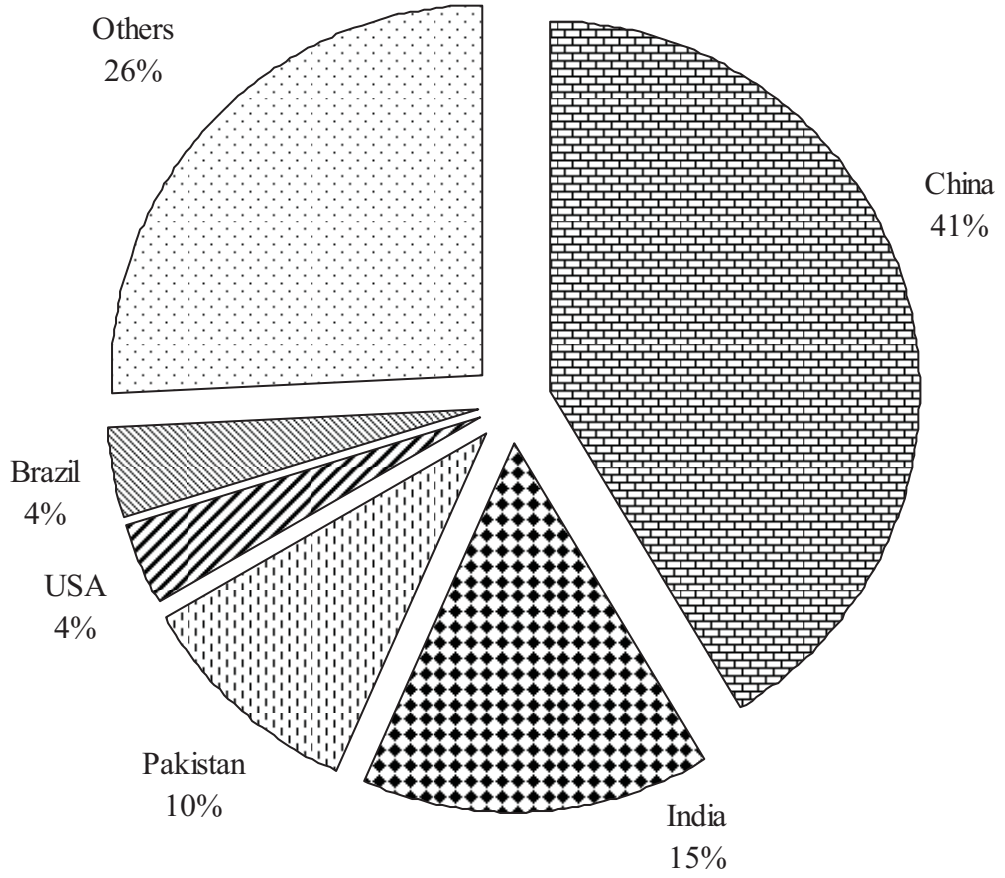
Cotton is known to be cultivated in more than 100 countries but according to statistics from International Cotton Advisory Committee (ICAC) it is cultivated in around 65 countries (ICAC, 2009). It is estimated that the crop is planted on about 2.5 percent of the world's arable land, making it one of the most significant in terms of land use after food grains and soybeans. The number of cotton farmers' are estimated at around 20 million worldwide where small farmers from developing countries of Asia, Africa and Latin America account for 97 percent (19.3 million). In 2007 cotton was cultivated in 90 countries of which 52 were developing countries, 21 of which were indexed as the least developed countries (LDCs) by the United Nations (UNCTAD, 2009). The main cotton producing countries are China, India, USA and Pakistan, accounting for three quarters of world output. Figure 2-1 shows the major cotton producing economies of the world. These main cotton producing economies also account for a large part of processing. According to ICAC, China, USA, India and Pakistan accounted for more than 55 percent of global cotton processing over the period from 1989 to 2008 (UNCTAD, 2009) (figure 2-2). With respect to acreage, average cotton holding is about 5 acres consisting more than 90 percent in developing countries while it is larger in Latin America (20 acres) and it is around 475 acres and 825 acres in the US and Australia respectively (ICAC, 2002).

Figure 2-1: Major cotton producers in the world in 2007-08



Source: ICAC, 2009

Figure 2-2: World share of cotton processing in 2007-08



Source: ICAC, 2009

More than 350 million people are engaged worldwide in cotton sector under various activities including family labor, hired-on farm labor and workers in ancillary services such as transportation, ginning, baling and storage (Valderrama, 2009). With respect to number of farmers, China and India alone represent 15.5 million cotton farmers (77%) globally. Cotton continues to play an important role in the developing world as a major source of revenue. It plays a major role in the economic development of Africa with 35 of the 53 African countries produce cotton and 22 of them being exporters. More than 20 million tons of raw cotton is produced annually of which 30 percent is traded as raw material. Trade in cotton related products

represents almost half of the total $ 115 billion trade in textiles and the $ 133 billion trade in clothing (ICAC, 2002). The total value of the world cotton production is estimated at around $ 40 billions per annum (Guitchounts, 2008). World cotton area is estimated at 31.3 million hectares and production forecasted at 23.7 million tons in 2008-09 (ICAC, 2009; CWS, 2008).

2.3 Insect Pests of Cotton

Insect pests of cotton have gained economic importance due to significant production losses and quality degradation they cause. Around 1326 different species of insects are known to affect the cotton crop, but only few are economically important. The major insect pests of cotton belong to the caterpillar group (Lepidoptera) with 88 percent of the global cotton area equivalent to 72.5 million acres has infestations at medium to high levels (James, 2002). Major lepidopteran insect pests are pink bollworm (*Pectinophora gossypiella*), American bollworm (*Helicoverpa armigera*), spiny bollworm (*Earias* spp.) cutworms (*Agrotis* spp.), bollworm (*Helicoverpa zea*), Egyptian cotton leaf worm (*Spodoptera literoralis*), tobacco budworm (*Heliothis virescens*) and Australian budworm (*Helicoverpa punctigera*). Of these the American bollworm is known for a 90 percent incidence present in most of countries followed by pink bollworm (82% incidence) and other bollworms. These pests are known to cause severe damage and crop losses globally. These lepidopteran arthropod pests feed on various crops and migrate from one crop to another (CICR, 2007).

Insect pests are major constraint to production and the principal cause of yield losses. High infestations of these insect pests can lead to very heavy losses and hence biological, cultural and chemical controls with insecticides have been used to attempt control. Estimates indicate that the yield losses due to insect infections would amount

to almost 15% of world annual production (UNCTAD, 2009). Potential losses due to cotton insect pests could range from 35 to 41 percent in the absence of any control measures. But the actual loses despite control measures are estimated to range from 7 to 24 percent (James, 2002). Crop losses depend on the level of infestation varying by country, crop variety and by year. The highest actual losses are recorded in Africa in the range of 20 percent followed by Asia at about 13 percent. Large proportion of cotton being cultivated in tropical developing countries where insect infestations and crop losses are higher compared with high insecticide sprays. With a gross loss in the range of 15 percent globally, the value of crop losses due to cotton insect pests based on a $ 20 billion production in 2000-01 was $ 3 billion plus $ 1.7 billion for insecticide for a total cost of approximately $ 5 billion (James, 2002).

2.4 Global Insecticide Usage on Cotton

Due to heavy insect incidence, cotton crop has become the largest insecticide consumer (Matthews and Tunstall, 1994). Despite occupying only 2.5 percent of global cropland, cotton uses approximately 25 percent of world's insecticides – more than any other single crop and more than 10 percent of the pesticides. More than $ 1.7 billion is being spent on insecticides globally to control insect pests of cotton. Globally cotton crop is known to consume US $ 2 billion of agrochemicals every year, US $ 819 million of which are toxic enough to be classified as hazardous by the World Health Organization (WHO). Of this a staggering US$ 112 million is spent on aldicarb – the world's second biggest selling cotton pesticide, and one of the most toxic chemicals in global agriculture. Other hazardous pesticides used in large volumes include parathion, methamidophos and alphacypermethrin which are categorized as highly hazardous by the WHO (EJF, 2007).