SUSTAINABLE COTTON PRODUCTION

An Achievable Goal in the Aral Sea Area?

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Preface

This report aims to fill knowledge gaps in our understanding of cotton production, industry and trade and to update information on the environmental catastrophe of the Aral Sea in Central Asia. The vanishing Aral Sea, which by 2007 had decreased to 10% of the size it was at the beginning of the 1960s, has become a symbol of poor environmental management. Not only that, the Aral Sea is a perfect example of how all of society and nature is affected, socially, culturally, economically, and environmentally. Overall, it shows that sustainability of cotton production needs to have environmental management as the main focus and that nature's self-healing properties is not sufficient for repairing a man-induced distortion of the water resources when the size of the projects cover several 100 000 ha.

For the historical description of the Aral Sea catastrophe we are greatly indebted to Bo Libert, who in 1995 wrote a book on Soviet agriculture that explains many of the shortcomings of the Soviet agricultural practices in general, and with quite a few interesting references to the Aral Sea Area. Other useful sources can be found at the end of this report and through the website www.aralsjon.nu.

Together with Gudrun Sjödén Design AB we have decided to produce this report for use as reference material for people interested in extending their knowledge. The sources of information contained in the report are largely scientific, but in some cases materials published on NGO websites and in the news media are also cited. We advise the reader to always check for updates of the facts in cases where we refer to specific websites. Summaries and extracts from this report may also be reproduced by Gudrun Sjödén Design AB and Svenska Aralsjösällskapet in shorter or more accessible versions.

The authors of this report have a twofold interest in the subject. We are both active members of the Swedish Aral Sea Society (Svenska Aralsjösällskapet), Ingrid as chairperson and Gunilla as vice-chairperson. We are also professionals with expertise in agriculture and development studies (Ingrid) and physical geography, water management and international water policy (Gunilla). Both of us have doctorates, Ingrid from the Swedish University of Agricultural Science and Gunilla from Uppsala University, Sweden.

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One of the illustrations in this publication, the map of The Aral Sea Basin, is reprinted from an article by Rolle et al. (2006) with kind permission from Tachido Uda, Secretary General of the International Lake Environmental Committee. We appreciate their generosity.

Dr Mary McAfee Graham has done the linguistic revision of the manuscript. Björn Guterstam has provided all photos in the report.

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Short Summary

Cotton forms the basis for about 40% of world textile production. It is an annual crop with a high demand for water and high temperatures throughout the almost six-month long growing season. Besides these climatic demands, it also requires specific soil conditions, crop and water management, crop protection chemicals and labour for harvesting. Human resources could be replaced by high technology machinery and irrigation equipment, but high energy inputs and efficient management skills are still necessary for this crop, which is much more complex than other agricultural crops. Cotton can only be grown at a competitive price in industrialised countries when production is highly mechanised. Low-cost labour means that countries such as China, India, Pakistan and Uzbekistan are major producers of cotton.

The rapidly disappearing Aral Sea in Central Asia is an example of the consequences of conventional cotton production in low income countries. More than 90% of what used to be the world's fourth largest water body has disappeared due to water mismanagement over the years, including diversion of the water for irrigation of cotton and other crops such as rice and for hydropower installations. The area that the Aral Sea used to occupy is now mainly a saline desert that is the source of toxic airborne pollutants. These poisonous chemicals and soil particles affect the health of local people, especially mothers and young children. The area's surface water has been salinized and people in the downstream areas of Uzbekistan have very little drinking water. The countries in the Aral Sea basin (Uzbekistan, Tajikistan, Kazakhstan, Kyrgyzstan, Turkmenistan and Afghanistan) compete for the water feeding into the former Aral Sea via the rivers Amu Darya and Syr Darya. The leaders of these countries have had great difficulties in agreeing on fair allocation and utilisation of the water resources. Today the Northern parts of the former Aral Sea are slowly recovering as a result of political interventions – hopefully a positive turn-around for at least a small part of the region.

What can be done? Organic cotton grown without fertilisers and pesticides would be a more environmentally friendly option with fewer adverse side-effects on health and biodiversity – but would it be feasible? Organic cotton still needs irrigation, and the costs of production and the land requirement are both at least 50% higher. In addition, the soils and waters are already heavily polluted – the future is certainly bleak!

One conclusion is that cotton production needs to be decreased on a global scale. This could be achieved by replacing cotton with synthetic fibres or by reusing cotton fibres from recycled materials – and by a change in global consumption patterns!

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1. Why cotton is an important crop

Cotton is the most important source of fibre in the world. Although synthetic fibres have long been commercially available and are much cheaper today than they used to be, cotton continues to be the preferred textile fibre for many consumers. This is mainly due to its excellent comfort properties and comparatively inexpensive cost. Cotton is also durable, it can be washed repeatedly and it feels good against the skin, especially when outdoor temperatures are high.

With increasing standards of living, consumption of clothing has increased in all industrialised countries and in countries with rapidly expanding economies (e.g. Korea, China, India, Vietnam, etc.). It has become increasingly important to follow fashion, and fashion styles change from year to year. In 2006, Sweden had a per capita clothing consumption (people from 0-79 years old) valued at SEK 3483 per year (about 360 Euros), with Swedish women consuming twice as much in terms of clothing expenditure as Swedish men (Holmberg 2007, p. 19). About half of Swedish clothing consumption is produced from cotton textiles (Zeander, 2002).

Cotton is the basis for about 40% of the world's fibre textile production, but cotton seed can also be pressed to give seed oil (used in cooking, production of margarine, soap, paints and lubricants). The seed cake remaining after oil removal is a by-product that is rich in protein and is considered very good feed for cattle.

Where is cotton grown and why?

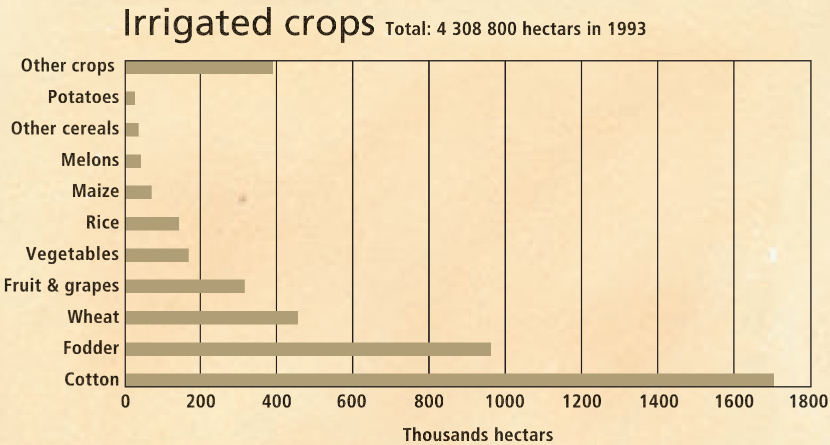
Cotton has mainly been grown in subtropical and temperate climates for at least 5000 years, but it can also still be found as a wild plant in tropical areas. It belongs to the genus Gossypium, of which there are several species and many varieties. Cotton places high demands on its growing site and this determines where large-scale cotton production can be found today.

The main factors determining the location of large-scale cotton production are production history/tradition, climate, soil, water, manpower costs and availability of manpower, world market price, legal issues including land and water rights, subsidies to farmers/producers, knowledge, and technological efficiency.

Today, the most important producers of cotton are the People's Republic of China, USA, India, Pakistan, Brazil, Uzbekistan, Turkey, and in Africa mainly Francophone West Africa and Tanzania. The cotton belts of these countries lie in areas with temperatures above +15°C during a minimum of 160 days (Lee, 1984). Furthermore, water must be available either as rainfall or as surface water/groundwater that can be used for irrigation. This means that cotton is often grown in delta areas or close to large rivers. The main reason why some countries (e.g. India, Brazil, Peoples' Republic of China) have increased their share of cotton production in recent years (since 2002) is probably due to their low cost of labour. Irrigation and other agricultural practices and especially cotton harvesting are very labour-intensive in low mechanised agriculture.

It is highly interesting that the USA has maintained a relatively high percentage of world cotton production (4%) in spite of its high labour costs. This is mainly due to the high subsidies given to the ~25 000 cotton producers by the US government, a fact which is also said to have great impact on world market prices. Section 3 discusses in detail how and European Union subsidies affect cotton production, globally and locally.

The significance of water demand, agricultural policies, available labour, cost of other inputs and the subsidies in industrialised countries are discussed further as a case study in Section 9, using the Aral Sea area and in particular Uzbekistan as an example.



Irrigated crops in Uzbekistan 1995. Source: FAO, AQUASTAT (1995).

2. Economic importance of cotton

In the 2004/05 season, 26 million metric tonnes of cotton were produced in 85 countries, Ukraine being the furthest north and Argentina the furthest south. The total acreage of cotton in the world is 36 billion hectares, approximately 2.5% of the global agricultural area (WWF, 2005).

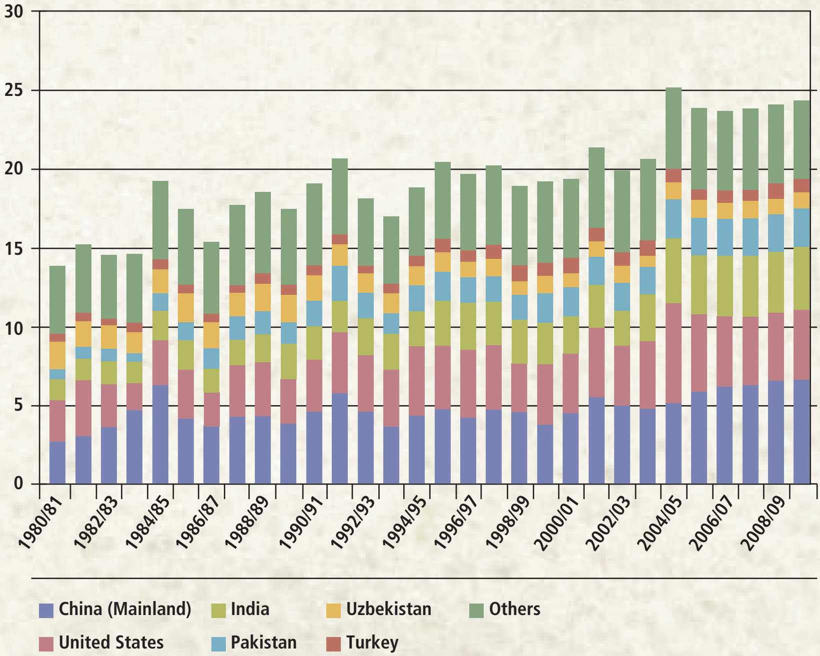
Since early 1950s, world consumption of cotton has increased manifold, and it is expected that with the economic growth in China, India, Pakistan and other fast growing states in Asia, there will be an even higher demand for this fibre in the future. These countries are simultaneous producers, manufacturers and end-users. However, the main end-users of cotton textiles can be found in Europe and North America.

The world market price of cotton decreased steadily in recent decades, by one-third from the mid-1970s to 2005 (FAO, 2006, ANNEX 1, TABLE 1). During the first decade of the 2000 century, however, prices have remained fairly stable and are now slowly rising. With higher oil prices, the cost of synthetic fibres is likely to increase relative to that of cotton and thus increase demand for the latter. However, with very high oil prices, irrigation and soil management will be more costly, as will pesticides and fertilisers, and thus we will probably see increasing cotton prices.

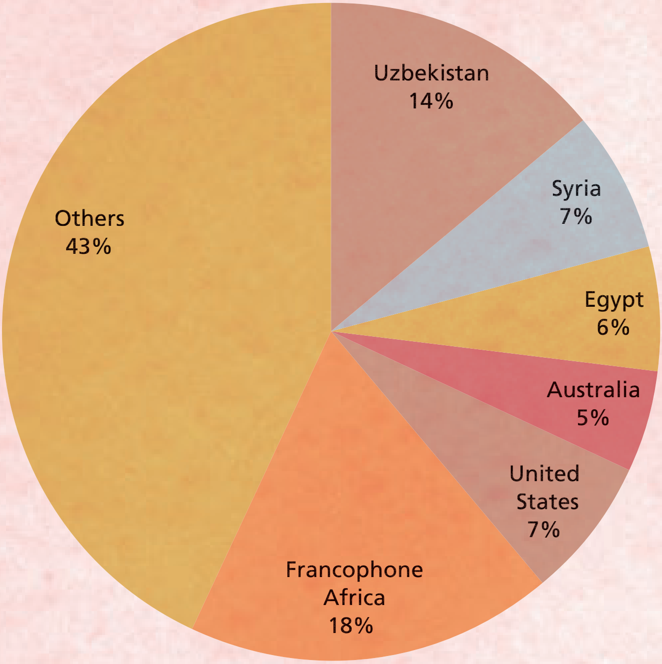
Food prices and biofuel prices are currently increasing for reasons similar to those listed above for cotton. In the future, there will be increasing competition for agricultural land between fibre crops, food crops, energy crops and other type of crops.

For some countries, cotton is a very important source of income, sometimes constituting substantial parts of GNI (Gross National Income). This is especially true in some low income countries, for instance in West African countries such as Mali and Burkina Faso, and in Uzbekistan, Central Asia.

Cotton production (million tonnes), by main countries, 1980/81 - 2009/10



World Cotton Production. Source: UNCTAD Secretariat, based on International Cotton Advisory Committee (ICAC) statistics.



Breakdown of EU imports (UE15), by country of origin

Source: UNCTAD Secretariat 2008, based on International Cotton Advisory Committee (ICAC) statistics.

3. Role of the international cotton market

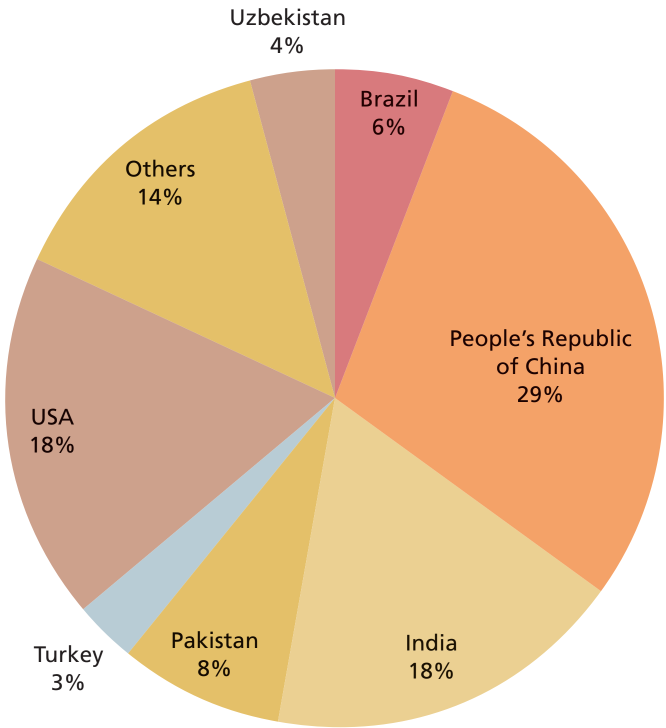
US agricultural policy and the EU Common Agricultural Policy (CAP) both involve subsidisation of cotton production using a range of different measures, coupled and decoupled, including favourable loans. According to Baffes (2004, TABLE 3) and Gillson et al. (2004, TABLES 7, 8 and 12) cotton production in southern USA, and also in Greece and Spain, is about 10-30% higher than if the subsidies were not in place. However, these calculations based on different types of modelling have been challenged by other researchers, who argue that the subsidies to cotton farmers have much less effect – or perhaps none – on market prices (Pan et al., 2006).

Import duties have recently been lifted from cotton textiles in Europe and the USA, which means that less expensive cotton clothes are being bought by Europeans and Americans. Two pie charts show the main global cotton producers and consumers/importers (importers being both manufacturers and end-users). In a case brought by Brazil, a WTO dispute panel found in 2004 that $3.2 billion in annual cotton subsidies and $1.6 billion in export credits paid by the USA on cotton and other commodities went against international trade rules (Oxfam, 2008). However, subsidies to cotton producers are still in place. At the WTO Doha meetings, one of the important issues has been to put pressure on the USA, EU and other industrialised markets to decrease subsidies and other ways of artificially supporting their cotton production. A declaration by the WTO Sixth Ministerial Conference (WTO, 2005) called for elimination of export subsidies for cotton in developed countries. In addition, a substantial reduction in their cotton production subsidies was demanded.

Cotton subsidies are also a main issue in World Trade Organisation (WTO) negotiations. The US has the largest subsidies for cotton-producing farms but these subsidies are not directly related to actual production of cotton, thus giving rise to disputes on how to interpret the WTO rules. US cotton subsidies have been equivalent to about two-thirds of the market value of production during the period 2000-2005. On average, this is equivalent to 120,000 dollars per US cotton farmer (The World Bank, 2008, p. 99). Recent WTO negotiations have placed hard pressure on the USA to cut cotton subsidies and have been partly successful (Global Policy Forum, 2008).

The EU is also subsidising individual cotton farmers, mainly in Greece and Spain. However, European cotton production has a much lower total export value than US production. According to FAO (2004, p. 1), the cotton produced in the EU could instead have been imported at one-third of the cost.

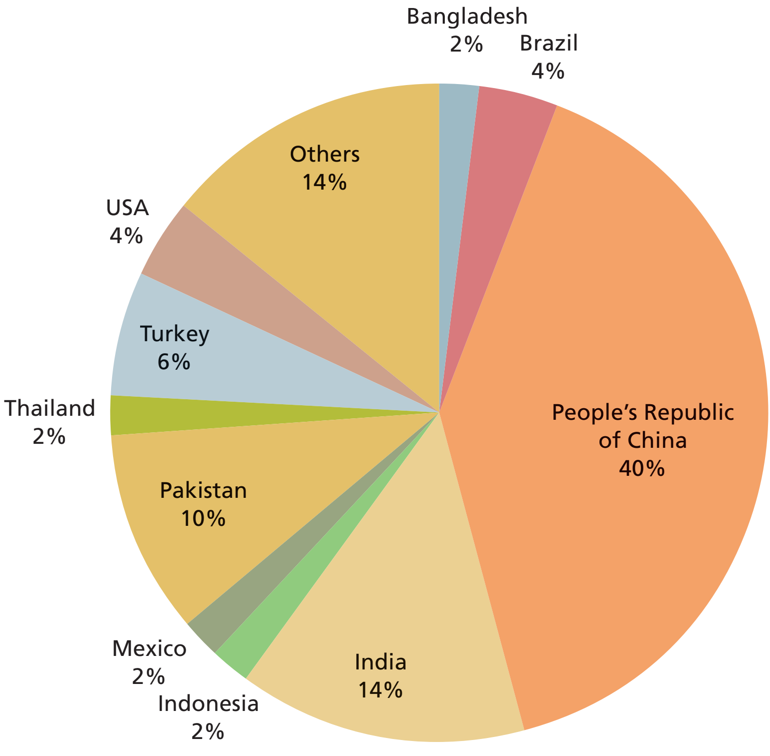
Cotton subsidies have a very large impact on the world market price of cotton products, according to a recent report produced by Oxfam America, which states that “With a complete removal of US cotton subsidies, the world price of cotton would increase by 6-14%, prices that West African farmers would receive for their cotton would increase by 5 -12%. At household level, this



World’s largest cotton producers 2006/07
Source: USDA, 2007.

increase would result in additional income that could cover all health care costs of four to ten individuals for an entire year, or schooling costs for one to ten children, or a one year supply of food for one or two children." (Alston et al., 2007).

Brazil has notified the World Trade Organization and the US Government that it will move forward on its requests for authorised retaliation. Brazil's requests, first submitted in 2005, claimed the authority to retaliate for about $3 billion of "prohibited" subsidies. However, the National Cotton Council of America claims that the US cotton programme is not causing any economic damage to international trade in cotton (NCCA, 2008).



World's largest cotton consumers/importers 2006/07

Source: USDA, 2007.

4. Understanding the general conditions for cotton production

The cotton plant is annual, i.e. it must be sown each year. It needs a growing season of 150 to 180 days (FAO-AGLW, 2008). Cotton cultivation practices differ widely between growing areas due to variations in temperature and water availability in particular, but also due to labour costs, the political and legal framework and traditions. In the US, where cotton production is highly mechanised, the average yield of cotton was almost 1 400 kg per ha in 1993 (Ellebaek Laursen & Bagh, 1997). In India, the average cotton yield during 2006-2007 was only 540 kg per ha (Cotton Corporation of India, 2008).

The following very brief description of cotton cultivation is based on Ngugi et al. (1978), Lee (1984), Ellebaek Laursen & Bagh (1997) and Kooistra et al. (2006). Further information on cotton production and trade can also be obtained from Classic Encyclopedia, 2008.

The key on-farm elements for successful cotton growing, apart from the genetic properties of the seed, are temperature, sunlight, water, cotton cultivar/genetic breeding, soil type, soil management, level of technology, sowing, fertilisation, weeding, control of insects, fungi and other pest infestations, crop rotation, and harvesting.

Developmental stages and planting time of the cotton plant

Stage of development (length in days)					
Establishment	Crop development	Flowering/ budformation	Maturing/ ripening	Planting time	Crop region
30	50	60	55	Mar-Maj	Egypt, Pakistan, California, USA
45	90	45	45	Mar	Californian desert, USA
30	50	60	55	Sept	Yemen
30	50	55	45	Apr	Texas, USA

(Data from fao-agwl, 2008).

Temperature

Germination is most favourable at temperatures of +18-20°C. The early vegetative growth of cotton needs temperatures higher than +20°C, optimally +30°C. Night temperatures during bud formation and flowering should not fall below +12-27°C. Finally, during the maturing of the boll, the temperature should be close to or above +30°C.

Sunlight

Cotton is a short-day plant but there are varieties of cotton that are day-neutral. During flowering the plant cannot have too many rain days since this can impair flowering. Too much rain at later stages can also have negative effects, such as higher incidence of fungal and insect infestations.

Water

Cotton is the most water-demanding of all agricultural crops; about 8 000 l water is needed to produce 1 kg of the consumed product. –This means, in order to produce a cotton shirt weighing about 250 g, about 2000 l water is needed (Hoeckstra & Chapagain, 2007). Depending on climate and length of the total growing period, it needs 500-1 300 mm of water (5 000-13 000 m^3 water per ha). This water has to be well distributed throughout the growing season to give a good crop. Most of the water, ~50% of the total demand, is required during flowering (a period of 60-70 days; see TABLE 1). Not many places in climatic areas where cotton successfully meets its other requirements have such rainfall patterns and thus most cotton is grown under irrigation. Irrigated cotton yields on average 850 kg cotton per ha, compared with an average of 390 kg per ha of the rain-fed crop (Kooistra et al., 2006).

However, the demand for water in cotton production differs widely. Irrigation is much dependent upon good practices to be efficient. In many parts of the world where cotton is a major crop, knowledge of good irrigation practices is either low or is deliberately ignored. Irrigation schemes, when carried out efficiently, use about 7-8 000 litres per kg cotton. However, more than three times this amount (approximately 29 000 litres per kg cotton) is used when irrigation practices are ill-planned, or badly maintained and operated. When the discharging river carries less water, the relative concentrations of pollutants such as pesticides, fertilisers etc. are higher in the remaining water.

Cotton production uses 7% of all irrigation water in the world.

Prevention of salinization is difficult under large-scale irrigation schemes. In climates such as those where cotton is grown, i.e. in hot and sometimes arid areas, salts accumulate close to or on the surface. When water is transpired through the plant or evaporates from the soil surface, salt is left in the plant or on the soil surface. The more salt that accumulates, the more irrigation water is needed for leaching it out. The salt/fresh water balance is then disturbed and the extra water extraction sometimes results in a falling groundwater level.

Plants have a limit on the salt concentration they can tolerate. Fortunately, cotton is fairly tolerant to soil salinity. The yield decrease of cotton at increasing salt concentrations, measured as electrical conductivity (ECe) values, is: 0% at ECe 7.7 mmhos/cm; 10% at 9.6, 25% at 13, 50% at 17 and 100 % at ECe 27 mmhos/cm (FAO-AGLW, 2008; 1,0 mmhos/cm= 640 mg/l). Large-scale irrigation schemes can also lead to significant downstream effects, such as water shortages for humans and ecosystems. Large-scale irrigation requires detailed water management and water storage, in addition to withdrawal of water from rivers. Channelling of river water can result in the creation of swampy areas, with little water downstream in the rivers. This is particularly the case in a situation such as that along large parts of the Amu Darya River in Turkmenistan and Karakalpakstan, where the irrigation canals are installed in sand without any lining. The water infiltrates into the ground, elevating the groundwater level and decreasing the quantity of water that actually reaches the cotton plants.

The elevated water level in the soil results in pores becoming water filled, so the cotton plants no longer receive the oxygen they need. This phenomenon, which can also be caused by over-watering, is called water-logging.

Falling groundwater tables and water-logging can both be caused by poor irrigation management. Concerning the irrigation practices, lack of independent expertise is one reason for this mismanagement. Another reason is that before 1991, improving the efficiency of older irrigation systems or even completing newly planned system were lower-paid jobs than planning new schemes. (Libert, 1995). Today reasons of ill-managed irrigation schemes are more often that money is not re-invested in maintenance or modernisation due to short term economic interest, and that the cotton production sector has very low wages and status. For this reason it does not attract the young and well educated people.

Cotton types

The cotton plant *Gossypium* (family *Malvaceae*) includes some 40 species. White, brown and green fibres can be found in nature. Growing coloured cotton can sometime enhance the environmental aspects of cotton production, since those varieties are less prone to pest and disease attacks. However, the fibre quality is usually not as good as that of the white varieties (Dickerson et al., 1999). Genetic engineering is widely used to produce cotton with resistance to herbicides or lower susceptibility to pest and insect attacks, especially in highly mechanised cotton growing areas such as the USA, South Africa and Australia. The aims of modern plant breeding are usually to increase yield capacity and reduce the quantity of pesticides and herbicides used. Genetically modified (GM) varieties of cotton have been developed. For instance some GM cotton types contain a gene from soil bacteria (*Bacillus thuringiensis*) which enables them to produce a toxin that kills certain types of pests. This can reduce pest attacks on the cotton crop and also reduce the costs of spraying cotton fields with chemicals. Other GM cotton varieties are more resistant to certain herbicides, allowing selective herbicides to be used in weed control. The use of chemicals in cotton production has now decreased, but many people are very critical of the use of GM seed, since it is very expensive and there are suspected ecological risks associated with its use.

Genetically modified cotton varieties are now available all over the world and not only in the USA, where they were first tested. There have been enormous increases in yields with these varieties. It is estimated that 26% of world cotton growing area was sown to GM or biotech cotton varieties in 2005/06, which would account for about 35% of total world production (Sadler, 2006).

It is possible that the use of GM seed could cause ecological imbalances due to cross-pollination with other crops in agriculture. It is argued by e.g. Greenpeace that in the long run, the use of GM crops will build up pesticide resistance in certain insects, for instance the cotton bollworm (Planet Ark, 2002). GRAIN, the international NGO, argues that GM varieties of cotton only protect the crop against one pest but point out that cotton is attacked by no less than 165 pests. This raises the chances of a resurgence of secondary pests and farmers ending up spraying crops with the same quantity of pesticides as in the past (if not more) (GRAIN, 2007). Furthermore, GM crops threaten biodiversity since they can involve the spread of genetic information between species. This may result in weeds becoming resistant to herbicides.

The major firms developing GM cotton species, such as Monsanto, Bayer and Syngenta, claim that the use of these GM species reduces the amount of chemical spraying needed, thus improving the health of farm workers and lowering the amount of chemical pollution to air and water.

Within the EU, it is prohibited to plant GM cotton and the practice is constantly under debate.

Soils

Cotton can be grown on many different soil types. Important factors are that the soil is deep, has a good structure and is well-drained.

Soil management

In East Africa, the creation of ridges in which the seeds are sown is very common. These ridges are sometimes interlinked to retain water (e.g. in a square-type pattern).

Sowing

The normal seed rate is 11-22 17 kg per ha. Under less mechanised conditions, 5 seeds are usually planted together and the plants are thinned to two plants per spot after 3-4 weeks. Row x plant spacing normally varies between 50-100 x 30-50 cm.

Fertilisation

Like all other agricultural plants, cotton needs nitrogen, phosphorus, potassium and micronutrients. Fertiliser is usually applied before sowing or before flowering, and two-thirds of the nutrients are taken up during the first 60 days of the growing period (Peel, 1998, cit. Kooistra et al., 2006). In India and Pakistan, around 55 kg of nitrogenous fertiliser are applied per acre, while in the Ferghana Valley, situated in Uzbekistan/Kyrgyzstan/Tajikistan, at least twice this amount is used. Figures from UNDP, 1995 show that Central Asian cotton fields receive about 424 kilograms of compound fertiliser per hectare, more than five times the normal dose for the former Soviet republics! However, FAO figures (FAO, 2003, TABLE 11, p. 22) show an average use of about 210 kg N per ha in Uzbekistan in 2000, also a very high figure. Poor irrigation practices increase the demand for fertilisers, since excessive irrigation to remove salt also leaches out plant nutrients and since water-logging decreases the plant's ability to take up nutrients and renders it more susceptible to pests, insects and diseases.

The practice of flooding the fields with water can also physically wash the applied fertilizer away from the fields.

A wide range of fertilisation rates have been used under more industrialised conditions – from 250 kg N and 53 kg P per hectare and year in Spain to 40 kg N and 0 P in Argentina (Ellebaek Laursen & Bagh, 1997. FAO (2000, p. 11) recommends to use chemical fertilizers (in Egypt and similar climatic conditions, and in addition to organic manure) at a rate of 145 to 180 kg/ha N, 35 to 70 kg/ha P2O5 (approx. 25-50 kg P) and where needed 55 to 60 kg/ha K2O (approx. 46-50 kg K).

Weed control

Cotton is very susceptible to weed competition, especially during the early stages of crop growth, when the growth rate is rather slow. Several different herbicides for eradicating the main weeds are used in conventional cotton farming.

Insects, fungi and other infestations

The cotton crop is prone to a wide variety of fungal and insect infestations. If irrigation starts too early and with too high amounts of water, it becomes much easier for the fungi and insects to invade the crop. Conventional cotton production thus needs to make use of many different insecticides, applied repeatedly during the season.

Harvest

When the fruits, or bolls, are mature, they burst to reveal soft white fibres attached to seeds. These hair-like fibres consist to 90% of cellulose. The bolls also contain shorter fibres known as linters, which are used industrially for making water-soluble polymers and paper.

Before harvest, chemical defoliants are often used to facilitate mechanised picking. This practice is particularly prevalent in the US and other highly industrialised countries.

In non-mechanised farming, large numbers of workers are required for the laborious task of hand-picking, which to be effective must be carried out on several occasions during the harvesting period (Zeander, 2002). Hand-picking is common in low income countries such as India and Uzbekistan.

After picking, the cotton seeds and the fibres must be separated. This is done entirely by machines in highly industrialised countries, while in low income countries it is done by hand. After this first process, the raw cotton product can be sold in bales.

Crop rotation/one or two crops per year

Cotton is usually grown in rotation with other crops in order to improve the fertility of the soil, maintain soil structure and reduce soil erosion and pathogenic fungi and nematodes. A practical reason for crop rotation is that it also spreads the workload more evenly during the season. However, it is also practised to allow two crops to be grown per year even though this has several drawbacks, especially the need for more chemicals because of the higher pressure from soil-borne pathogens.

5. Environmental and ecological consequences of cotton production

Freshwater systems are considerably affected by cotton production in terms of both quantity and quality. As cotton fields are usually irrigated, water availability in downstream areas can be severely decreased, which is the major cause of the rapidly depletion of the Aral Sea. Long-term irrigation also results in increasing salinization of irrigated areas, in turn adversely affecting the health of ecosystems and human beings.

The use of crop protection chemicals for cotton production causes pollution of surface waters, the groundwater and the soil system. This is particularly the case when the irrigation water largely consists of return waters (drain outflow from irrigated areas, industrial wastewater and municipal sewage waters), as is the case in downstream areas of the Aral Sea river basins.

Biological diversity, both terrestrial and aquatic, is severely affected by a reduction in accessible water for anything but cotton growth and by freshwater contamination by fertilisers and pesticides. A concrete example having impact on the diet of people in the area is that the fish biodiversity in the Big Aral has been reduced from 40 to 5 species by the end of the 1990s (Aladin et al., 1999) and mammal and bird species by 50% (Glazovsky 1995). By 2005 all fish species had disappeared from Large Aral (Micklin, personal communication). The creation of large salty areas is the first stage in the creation of salt deserts. The climate also changes and those areas only can support limited vegetation. Partly, due to the decreasing water body, in the Aral Sea area summers become dryer and winters become longer and colder. This in turn means that the growing season becomes shorter and that yields of all crops, not only cotton, eventually decrease (UNEP/GRID Arendal, 2007).

Saline soil particles are more easily detached from the soil mass because their physical properties are altered, and these soil particles can be carried away by the wind, resulting in dust storms being created when the soil is bare. The high content of salty particles, sometimes contaminated by chemicals, can also cause an increase in airborne diseases for people living in the area.

The processing of cotton after harvest requires inputs of chemicals, labour and energy. Processing includes ginning, colouring, weaving, sowing, packing, transporting, marketing, storing, selling at retailers, and possibly also (if the end-user is conscious about the environment) reuse and re-processing of the fibres to a new garment. During these processes, chemical use in conventional cotton processing is about 0.6-1 kg per kg cotton, the lower figure being used in Sweden by industries subject to legal restrictions on chemical use (Tecoindustrierna, 1996). However, a more important factor than the amount of chemicals used is their degree of toxicity for ecosystems and man. The textile industries tend to establish their most dangerous processes in countries with lax environmental restrictions.

School Children harvesting cotton in Uzbekistan

Fetching the daily water allowance of 40 litres to the family

6. Social consequences of cotton production

There are both positive and negative effects of cotton production. World-wide, cotton production provides an important income for approximately 350 million people on at least 100 million farms. Figures from 2005 estimate that cotton is grown in 85 countries, of which 80 have been identified as developing countries (28 being among the least developed countries (LDCs) according to the UN definition; WWF, 2005).

However, cotton is also a demanding crop, and yield can vary greatly from year to year depending on rainfall and irrigation facilities. Yield is also dependent on insect attacks, pests and other failures that can reduce yield considerably.

Potential negative consequences of cotton production in low income areas include:

- Poverty and pollution-related consequences: low nutritional status and lower general health status of humans and animals, especially of women and children
- High labour demand and lack of freedom in times of high demand for labour (e.g. harvest)
- Use of child labour
- Increased risk of cancer and other diseases related to working in cotton fields
- Increased salinity of drinking water in down-stream areas (since cotton is a salt-tolerant crop, producers often allow salinity to increase in water drained from the fields)
- Decreasing fish population where high salinity and/or pollution with fertilisers or pesticides have created waters where fish cannot survive – leading to a decrease in jobs in the fishery sector and less fish in people's diets

The relationship between serious health problems, child mortality and other social consequences on the one hand and the Aral Sea catastrophe on the other is thoroughly described and discussed in Lindahl Kiessling (1999). Other aspects on the social conditions in Central Asia are described in a book entitled "Prospects for democracy in Central Asia" by Professor Birgit Schlyter, published 2008.

7. Approaches for sustainable cotton production

Organic or ecological cotton production claims to use methods and inputs that have a lower impact on the environment than conventional production. Organic production systems are obliged to use environmentally friendly fertilisers such as animal manure, to maintain soil fertility and to avoid using any toxic and persistent pesticides, resulting in biologically sound agriculture. Organic cotton must be certified by independent and trustworthy certification organisations that can verify that producers are complying with the rules of organic production. In 2002, less than 1% of all cotton produced in the world was organic cotton (Zeander, 2002, p. 17). The proportion has grown in recent years but it is still not much higher than 1%.

A problem when introducing organic cotton production is that in order to meet the certification requirements, a transition period of at least 5 years must elapse without the farmer using any chemicals or pesticides on his crop. During this 5-year period, the farmer suffers from low yields, yet cannot benefit from the higher price for organic produce because his land has not yet received organic certification.

Another problem is that organic cotton gives lower yields, especially initially, but needs as much water as conventional cotton. When organic cotton farming is introduced, a yield reduction of about 25-50% can be expected (Kooistra et al., 2006). A 6-year study in the San Joaquin Valley in California showed that organic cotton production costs 50% more than conventional cotton production (Swezey, 2002).

Eventually, when the farmer has obtained certification, he can get a higher price for his organic cotton. Demand for organic cotton is increasing but it is difficult for producers in low income countries to adopt organic production since it requires sophisticated knowledge of biological fertilisation and pest control methods. Furthermore, organic farmers only receive a small proportion of the value added in organically produced cotton. Typically, a farmer may be able to sell his organic cotton at a 100-150% price premium, but the final textile is generally sold at a 600 to 800% premium (Sadler, 2006).

Organic farmers must use crop rotation as one important means to solve insect, pest, weeds and fertiliser problems. At least two years of other crops are needed between cotton crops on a specific area. This means that irrigation installations must either be flexible or used for all the crops.

Other important crop management methods used by organic farmers are:

- Careful choice of cotton varieties
- Special tillage practices
- Practices to retain adequate organic matter in the soil
- Alternative crop protection methods
- Stopping irrigation earlier in the season
- Careful nitrogen management, for instance using strip cropping in combination with lupines
- Shredding crop residues after harvest
- Ploughing under of cotton residues to 6 inches (15 cm)
- Weeding and defoliation using flaming technology.

In order to substantially increase the amount of organic cotton produced, larger land areas need to be used for cotton production (meaning that other crops will have to be decreased), The need for crop rotation in organic farming and the lower yield are serious draw-backs, and are often used to justify conventional cotton production. Genetically modified cotton varieties are said to be one solution – such varieties would need less pesticides and insecticides, and are perhaps also more effective water users.

There is an urgent need for improved certification of cotton – not only in terms of an "organic" or "ecological" label, but also including regulations on labour conditions, energy consumption, irrigation management, etc. so consumers are able to make informed choices when buying clothes. Organic cotton is either grown in rain-fed areas (resulting in very low yields per ha), or uses irrigation, which usually places a strain on limited resources in the arid or semi-arid areas where cotton can best be grown. Water use has its particular problems and demands high energy inputs, as described earlier in this report, and the combination of organic cotton production and irrigation could well be considered an unsustainable practice when considering climate change. Another complication is that organic production normally needs more mechanical weeding and thus more soil tillage, which in turn uses more diesel-fuel for the tractors and increases the risks of soil compaction.

8. Alternatives to cotton production

An alternative to growing more conventional or organic cotton is to recycle existing clothing. This could be done much more efficiently than is the case today. More effective industrial methods are currently being developed.

Another alternative is to use more synthetic fibres, although these will probably become more costly as energy prices rise.

The last and most obvious alternative is for consumers everywhere to limit their demand for fibres for textiles.

9. The Aral Sea example: Why cotton is a traditional crop in the Aral Sea Area

The area close to the Aral Sea has been irrigated for horticultural and agricultural purposes since 3 000 BC (Aladin, 2001; Falkenmark, 2003). This was one of the most prosperous areas around the Silk Road, which linked Europe with Far East since several thousand years BC. The great rivers in the area provided a steady and continuous supply of water, which led people to regard the area as an oasis, a paradise-like place with plenty of food. Here agriculture, fishing, hunting, and markets flourished. In the more untouched areas there was a rich biodiversity of plants and animals (Glanz, 1999).

The countries in the Aral Sea Watershed are Uzbekistan, Tajikistan, Kyrgyzstan, Turkmenistan, parts of Kazakhstan, Afghanistan and, to a smaller extent, Iran. The first four of those countries formed part of the Soviet Union from the beginning of the 1920s until the 1990s, while Kazakhstan was a member from 1936. Before this, all except Kazakhstan belonged to Czarist Russia since the mid-1800. Cotton, together with other crops, has been grown in parts of the area and irrigated by the rivers and the lakes since around 400 AD.

Renewable water resources of the Aral Sea basin

	Area			Renewable Surface Water Resources					
Country or Zone				Amu Darya basin		Syr Darya basin		Aral Sea basin	
	km²	% of basin area	% of country area	km³ per year	% of basin	km³ per year	% of basin	km³ per year	% of basin
South-Kazakhstan	540 000	28	20	-	0.0	4.50	12.1	4.50	3.9
Turkmenistan	466 600	24	96	0.98	1.2	-	0.0	0.98	0.8
Uzbekistan	447 400	23	100	4.70	6.0	4.84	13.0	9.54	8.3
North-Afghanistan	234 800	12	36	6.18	7.9	-	0.0	6.18	5.3
Tajikistan	141 670	7	99	62.90	80.2	0.40	1.1	63.30	54.8
Kyrgyz Republic	117 500	6	59	1.93	2.5	27.25	73.4	29.18	25.2
Total	1 947 970	100		76.69	97.7	36.99	99.6	113.68	98.3
Basin *				78.46	100.0	37.14	100.0	115.60	100.0

* Time series and methods used for water resources computation for the basin as a whole and for each country may vary, which explains the difference between the total of countries and the value for the whole basin.

Lenin declared that the Soviet Union would become a self-sufficient cotton producer, while Stalin and his ministers in the 1930s were very keen to engineer a planned economy which would be able to provide the Soviet Union and its allies with all kinds of strategic products. Cotton was identified as being one such strategic commodity. The rivers discharging into the Aral Sea Area were seen as a resource to irrigate Soviet cotton production, since the climate and soils of this area were suitable and water could be diverted to large irrigation schemes. However, there was not enough labour for building all the irrigation installations, nor for producing this labour-intensive crop. This difficulty was solved by large-scale relocation of people from other parts of the country.

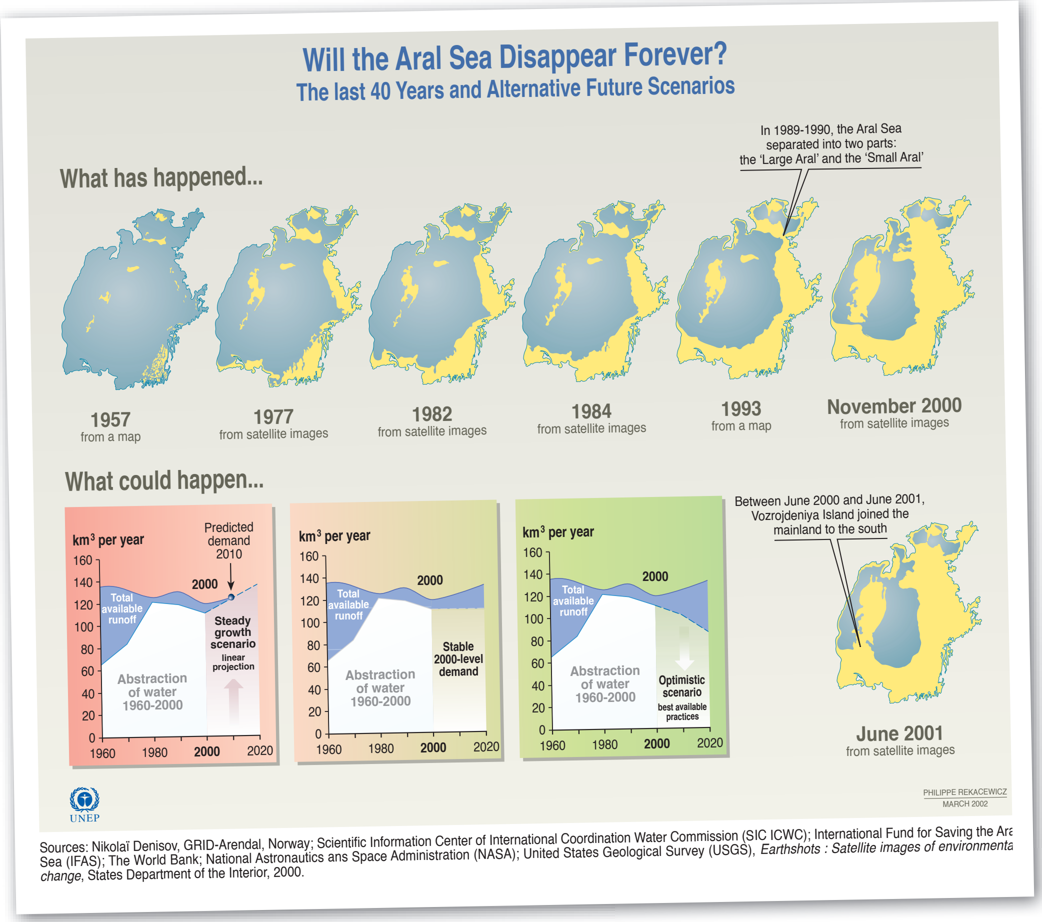
The major project of increasing cotton production volumes began to yield results in the 1950s. When Nikita Chrustjev, Soviet president from 1953, included rice production in the country's ambitions to be self-sufficient, irrigation schemes in areas such as the Aral Sea became even more important and also larger in scale (Kooistra et al., 2006). Important state and collective farms paid low, subsidised prices for energy, fertilisers and machinery. More importantly for the area,

The Aral Sea Basin. Source: Rolle et. al (2006).
http://www.ilec.or.jp/eg/lbmi/pdf/01_Aral_Sea_27February2006.pdf

very large state investments were made in irrigation (large dams, pump stations, ditches, etc.). Between 1971 and 1985, 28% of total investment in agriculture in the Soviet Union was in irrigation and drainage (Libert, 1995). According to official statistics, 24% of the irrigation water evaporated or was lost to infiltration in water reservoirs or irrigation canals (Goskomstat, 1991, cit. Libert, 1995). In reality, in some places up to 70% of the water was lost before reaching the crop (Minashina, 1988, cit. Libert, 1995). And this trend has continued in the post-Soviet period. An important task for irrigation management is to increase the efficiency of irrigation and one of the most important measures is to decrease evaporation. Modern irrigation minimize the use of flooding as irrigation method, since this method both increases evaporation, decreases efficiency of fertilisers (also animal manure fertilisers used in organic farming) and increases contamination of down-stream waters.

Fertilisers and pesticides were applied in high quantities but did not increase yields a great deal, probably due to ineffective irrigation and poor agricultural practices. The negative effects of intensified production first became apparent in the 1960s but the environmental catastrophe in the Aral Sea Area became evident to a wider public in the 1970s, when satellite images revealed the extent of the problem. The Aral Sea itself had decreased substantially in size by then. Additionally, vast areas of the soil in the area was increasingly salinized, to some extent due to the use of unlined irrigation channels such as the Karakum canal, the construction of which was began in in 1954 and able to divert half the water from the Amu Darya River into the desert areas of Turkmenistan.
The enormous investments in irrigation and other technologies have cemented a pattern of land use in the area which continues today, almost 20 years after the break-up of the Soviet Union. The five states in the Aral Sea basin, Uzbekistan, Tajikistan, Kazakhstan, Kyrgyzstan and Turkmenistan, became independent in 1991. Of these countries, Uzbekistan and Turkmenistan still have cotton as one of their main agricultural products, although the acreage has decreased. Cotton is also quite important in Tajikistan and to a lesser extent important in Kazakhstan.

In 1991, approximately 40% of everything produced in Uzbekistan originated from the agricultural sector. Cotton production made up 41% of the value of these agricultural products, cereals 32%, fruit 11%, vegetables 4% and other crops 12%. Since the climate in the five countries close to the Aral Sea is arid, almost all crops need irrigation and thus the 55 million people (1995) living in these countries are dependent on functioning irrigated agriculture. In 2002, agriculture produced 33% of the Gross National Product (GDP) of Uzbekistan and over 50% of the labour in the country was employed in the agricultural sector (Martius et al., 2005).



The shrinking of the Aral Sea. 2008.
Source: United Nations Envrionmental Programme UNEP.

Competing interests between the Central Asian countries for water resources

Since the break-up of the Soviet Union, the competing interests in and demands upon the Amu Darya and Syr Darya water resources by the newly-independent republics have intensified. Even though the republics decided in 1990 to keep to their quotas from the Soviet era for the time being, they also affirmed their rights to control land, water and other natural resources within their territories, not only for cotton production but also for energy purposes. Management systems were also completely changed. For instance, Kyrgyzstan, the most upstream country of the Syr Darya River, is now heavily dependent on Russia and neighbouring countries for its *energy supply* and demands the possibility to explore the *hydropower* potential within its borders. Uzbekistan, lying downstream of Kyrgyzstan and then of Tajikistan, has access to cheaper energy production with its own fossil fuel but depends on Kyrgyzstan to release water at the right time for the country to be able to use it for *irrigation of its cotton fields*. Kazakhstan, the most downstream country, now receives a reduced quantity of water of lower quality, but has claims on the upper riparian states to increase quantity and improve quality mainly for irrigation of its cotton fields.

Where the Amu Darya is concerned, Tajikistan, the most upstream country, has not yet fully explored its hydropower potential, nor has Afghanistan, which is an upstream riparian of the river water resources. Turkmenistan and Uzbekistan are making competing claims to the downstream water, the most downstream lying within Karakalpakstan in Uzbekistan, to feed their increasing population – and to maintain cotton production (Björklund, 2005). Although there are legal agreements in place to share water between the countries, these agreements are not fully kept. For example, in mid- 2008 Kyrgyzstan refused the downstream countries their agreed share as there was too little water to satisfy its own demands. This winter was exceptionally cold and the need for Kyrgyzstan to use its only important source of energy, thus, important, resulting in even more strained relations to the downstream countries.

Aral Sea 2003 09 04. Source: Nasa Earth Observatory 2009.
http://visibleearth.nasa.gov/view_detail.php?id=5731(retrieved 2009-08-26)

10. The current situation and the future of the Aral Sea Area

Using Uzbekistan as an example, since the population of that country, in particularly its downstream, autonomic part Karakalpakstan, seems to have suffered most from the environmental catastrophe, we can conclude that the cotton acreage of this country has decreased from approximately 2 million ha in the 1980s to 1.4 million ha in 2000 (Ellebaek Laursen & Bagh, 1997). Today substantial privatization has taken place.

The recent environmental changes in the area, combined with the overuse of irrigation water, thus decreasing surface water-body, have led to a climate which is more extreme than it used to be, with temperatures in the summer up to +40°C and temperatures in the winter as low as -20°C. The average temperature has increased by 1°C over the last 35 years, and during this same time span the size of the glaciers upstream (from which the major rivers are fed with the majority of their water) has been reduced by 22% (Dukhovny and Sokolov, 2003).

The powers that be in Uzbekistan, e.g. government ministers and local leaders, are not interested in privatisation since many of the rules and regulations used during the Soviet times still are in place (for instance, the local market price of cotton is decided by the state). Corruption throughout the system is also a great obstacle to progress (Thurman, 2001).

As noted above, irrigation in arid climates can cause salinization of the soils and can also give rise to shortage of drinking water. According to several sources, more than 40% of the agricultural land in Uzbekistan is salinized and the salt content has risen from 14 grams per litre to more than 100 (Micklin & Aladin, 2008).

According to Micklin & Aladin (2008), in 2007 the Aral Sea was only one-tenth of its original volume and biodiversity in the area was severely reduced, with 85% of the wetland area having been lost and large numbers of birds and other animals having disappeared. According to the same source, both humans and animals have severe health problems associated with cotton production practices in the area. It is not only the cotton production areas that are affected, since windstorms can carry salt, dust and contaminants as far as 500 km.

Aral Sea 2009 08 16. Source: Nasa Eart Observatory 2009.
http://earthobservatory.nasa.gov/IOTD/view.php?id=39944 (retrieved 2009-08-26)

One specific example of the misuse of pesticides is the use of DDT and its chemical relatives. DDT was banned in the West in the 1970s due to its detrimental environmental effects, but it was still in use in the Aral Sea Area several decades later (Jensen et al., 1997). Today, however, these practices are not recommended.

The high salt contents in water resulting in severe fish death have resulted in the loss of about 60 000 jobs in fishing and related activities in the Aral Sea Area (Micklin & Aladin, 2008).

The rapid depletion of the Aral Sea has also already affected the climate around the sea. The winters have become harsher, the humidity lower and the summers hotter as there is less water to mitigate temperature extremes. Ongoing global climate change is also resulting in melting glaciers and as the main source of the Amu Darya River is glaciers in the Tajikistan Mountains, this will result in severe changes in water access for cotton irrigation in the downstream countries.

However, there are some small signs of improvement. While the southern parts of the Aral Sea are still declining in size and salinity is increasing, the northern Small Aral, fed by the Syr Darya River, is recovering. One important reason is that a dam has been built to stop water from flowing to the southern parts of the Aral Sea. Fish have now returned to the Small Aral and salinity has dropped steadily, to about 10 g per litre in 2008 (Micklin & Aladin, 2008).

11. How to achieve sustainable cotton production in the Aral Sea Area and other cotton growing districts

Cotton has a life cycle which is long and complex, demanding knowledge of very many issues and subjects. Apart from the common problems faced by cotton production, many of which are mentioned in this report, adaptation to climate change must now be added to the list of essential measures that must be taken in order to have sustainable cotton production in the future. According to the World Bank and the International Bank for Reconstruction and Development (2008; TABLE 7.3 on p. 209, CITING IPCC, 2007), geographical areas that are already under heat stress (such as areas where cotton is best grown) are more likely to suffer from yield decreases due to higher summer temperatures, increased insect outbreaks, increased water-logging, and increased freshwater salinity.

Better knowledge, management and ethics are needed in each of the steps between production and use of the different cotton products, for example:

- Improved soil management practices and energy use
- Improved water management practices (technologies/legal frameworks/ international conventions and regulations) both in rain-fed and irrigated fields
- Improved post-harvest issues: chemicals, energy and water use in industrial processing, etc.
- Improved conventional cotton production through Better Management Practices (BMP)
- Improved conventional cotton production through Integrated Weed and Pesticide Management (IPM)
- Improvements in labour conditions for cotton workers: working hours, seasonality and demand for labour, use of children as workers, etc.

- Improvements in the health of cotton field workers and humans and animals in the vicinity by preveting air and water pollution induced by elevated salinity levels and residues of fertilisers and crop protection chemicals
- Better understanding of technology levels, credit, etc. for different types of producers, e.g. huge industrial farms on the one hand and small farming enterprises on the other
- Increased research into the effects of GM cotton on long-term ecosystem health in the vicinity
- Increased research on how organic production methods can be made more effective, so as to increase yields of organic cotton to sustainable levels in both rain-fed and irrigated fields
- Increased labelling of cotton fibres and cotton products.
- Introduction of more a detailed and strict industry code of conduct for primary producers, the processing industry, textile industry and retailers, e.g. by giving more substance to "Corporate Social Responsibility"
- Improving the role of retailers as the main link in the long chain between primary producer and end-user (mainly in the US but also for EU cotton growers)
- Fairer (on the global scale) government subsidisation of cotton
- Fairer (on the global scale) trade regulations in WTO negotiations
- Increased discussion and reflections to increase consumer knowledge on the impact of cotton production methods on man and nature (consumer responsibilities, etc)
- Increased efficiency and quality of cotton fabric recycling.
- Increased international cooperation
- Increased political awareness and actions

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Appendix 1

Some national and international organisations and academic institutions working with cotton

ACIAR / The Australian Centre for International Agricultural Research
www.aciar.gov.au/node/8549

FAO / Food and Agricultural Organization
www.fao.org/

HRW / Human Rights Watch Europe/Central Asia //hrw.org/doc/?t=europe

IMF / International Monetary Fund
www.imf.org/

NCA / National Cotton Council of America:
www.cotton.org

ODI / Overseas Development Institute
www.odi.uk

UNECE United Nations Economic Commission for Europe
www.unece.org/

UNEP United Nations Environmental Programme /grid Arendal. enrin.grida.no/aral/aralsea/english/general/history.htm

UNESCO / United Nations Education, Scientific and Cultural Organisation www.unesco.org/

WTO / World Trade Organization
www.wto.org/

The Cotton Corporation of India
www.cotcorp.gov.in/technology.asp

USDA / Foreign Agricultural Service
www.fas.usda.gov/

The World Bank
www.worldbank.org/

Appendix 2

Links to different organizations on cotton issues

AgBio Forum
http://www.agbioforum.org/welcome.htm

ATTRA (Appropriate Technology Transfer to Rural Areas): www.attra.ncat.org/

Cotton and Grain Irrigation: http://www.cottonandgrains.irrigationfutures.org.au/

The Fairtrade Foundation: www.fairtrade.org.uk/

Global Policy Forum: www.globalpolicy.org/

GRAIN: www.grain.org/front/

National Cotton Council of America: http://www.cotton.org/index.cfm

Oxfam: www.oxfam.org/en/

PAN Germany/Directory for organic cotton: www.organiccottondirectory.net/

PAN International (Pesticide Action Network): www.pan-international.org/

Svenska Aralsjösällskapet (The Swedish Aral Sea Society): www.aralsjon.nu

Svenska Naturskyddsföreningen: www.naturskyddsforeningen.se

Swedenorganics: www.swedenorganics.com/

WWF World Wildlife Fund (in Sweden): www.wwf.se/vrt-arbete/stvattenvtmarker/problem/1128210-bomull-1a-sida

SVENSKA ARALSJÖSÄLLSKAPET

Swedish Aral Sea Society

HALMSTAD TRYCKERI

Global environmental issues are a matter of justice and crucial to our future

This is confirmed, not least, by the report on the huge problems associated with the Aral Sea. Countries with good economies, such as Sweden must take responsibility and work on environmental issues, both large and small. And we have made progress so far. Today, Sweden is one of the few countries where the Gross National Product is increasing while emissions of greenhouse gases are decreasing. At Halmstad Tryckeri we have been working for many years towards becoming one of Sweden's most environmentally adapted printworks. We started to use the more environmentally friendly printing method of waterless offset at the beginning of the 1990s. We were one of the first printworks in Sweden to be certified in accordance with the ISO14001 environmental management system back in 1999. Since the summer of 2008 we have been able to brand our printed materials with the FSC symbol, and from October 2009 we will be offsetting our carbon dioxide emissions by buying carbon offsets to make us climate neutral. Visit us on www.miljövänligaretryck.se

Lalle Nilsson
MD Halmstad Tryckeri AB