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Genetically Modified Crop and Farm Livelihoods: Comparing India, China and Brazil

Abstract

Globally controversial, genetically modified (GM) crops has been adopted widely by framers in developing countries. According to its proponentsGM crops has led to increased productivity and farmers profits, GM crops will usher in a second Green revolution The critics of biotechnology continue to doubt its usefulness, particularly for small farmers in developing countries and its significant environmental risks. This paper argues that both proponents and opponents discuss benefits and risks of GM cotton in a narrow technological framework. What are the impacts of new technology when it is introduced in three different socio-political country or regional contexts, such as widely different state regimes and policies, land size distribution and ownership patterns, societal factors, and distribution and access to ecological resources? This paper compares the introduction of GM crops in India, China, and Brazil, the leading adopters of GM crops, which are vastly different in social and political factors to understand the effects of technology on farm livelihoods.

In the case of India, GM cotton was introduced in 9 cotton growing states, namely Maharashtra, Karnataka, Gujarat, Punjab, Madhya Pradesh and Andhra Pradesh. The initial cotton seeds were developed largely through foreign private sector collaborations. Initially produced and marketed illegly, the cotton producers face significant new problems with poor regulation of quality, prices, and extension and preexisting ones of

water scarcity, crop failures, and pesticide pollution, and market integration. This led to the technology being a risky proposition for small and medium farmers. In the Chinese case, GM cotton, was largely developed by the state and bred into local varieties. Later varieties have been developed through Monsanto collaboration. Smallholder farmers appeared to gain benefits from GM cotton in the regions of Xianjing, Yangtze River Valley and Yellow River valley despite issues of farm sustainability such as water scarcity, etc. In Brazil, the soya farmers from RioGrande Sul region, have for several years smuggled GM soya from the neighboring country of Argentina[1]. With a minimal role played by the state due to the adoption of neoliberal reforms in 1980s, GM soyabean was legally adopted in Brazil, mainly by large and commercial farmers. These have been marketed by foreign transnationals in soya bean dominated regions of Legal Amazon and Cerrado. A strong role has been played by the judiciary and the agency of the farmers themselves, in ensuring gains from seeds to farmers vis a vis foreign multinationals.

Keywords: GM cotton, GM cotton, GM soya, India, China, Brazil

Introduction

Globally controversial, genetically modified (GM) crops have been adopted by farmers in India, China and many developing and developed countries. International agencies claim that the adoption of GM crops or the Gene Revolution will redefine the success of the Green Revolution and will create gains for areas surpassed by the first Green Revolution. For instance, Fukuda Parr of United Nations Development Program (UNDP) writes that "the high-yielding selective breeding technology of 'the Green Revolution' of the 1960s and 1970s is now being overtaken by 'the Gene Revolution' — the development and spread of GM crops across the world" (Fukuda Parr 2006). Gordon Conway, Ford Foundation writes in his book the *Doubly Green Revolution,*

[1] http://www.guardian.co.uk/science/2003/sep/26/gm.food

> The technologies of the Green Revolution were developed on experiment stations that were favored with fertile soils, well-controlled water resources and other factors suitable for natural production. There was little perception of the complexity and diversity of farmer's physical environment, let alone the diversity of farmer's physical environments let alone the diversity of the social and physical environment. The new Green Revolution must not only benefit the poor directly but must be replicable in highly diverse conditions and be environmentally sustainable. In effect, we require a Doubly Green Revolution, a revolution that is more productive than the first Green Revolution, and even more green and we must try to repeat the successes of the Green Revolution. (Conway 1997,22)

Through GM crops, "productivity gains could have the same poverty reducing impact as those of the Green revolution" (Pinstrup-Anderson and Cohen: 2000).

The importance of GM crops is stressed by country governments as well. For instance, Technology is the main mover towards crop productivity where natural resources are fixed. At least one third of the future growth agriculture should come through new technologies. Significant breakthroughs are required to improve production technologies in predominantly rainfed areas.[2]." (Planning Commission:XII Five Year Plan. According to Huang Dafang, former director of the Biotechnology Research Institute of the Chinese Academy of Agricultural Sciences (CAAS), confronted with land degradation, chronic water shortages, and a growing population that already numbers 1.3 billion, China is looking to a transgenic green revolution to secure its food supply, and win the race against the west to identify and patent genes of high value. Once intellectual property rights are in place, says Huang, transgenic technology could transform Chinese farming "from high-input and extensive cultivation to high-tech and intensive cultivation[3]. Premier Wen Jiabao declared in the annual gathering of the Chinese Academy of Sciences (CAS) and the Chinese Academy of Engineering that to solve the food problem,

[2] http://planningcommission.gov.in/plans/planrel/12appdrft/appraoch_12plan.pdf
[3] http://www.brown.edu/ce/adult/arise/resources/docs/China%20-%20GM%20foods.PDF

we have to rely on big science and technology measures, rely on biotechnology, rely on GM."

The proponents also claim that superior technology of GM crops has led to increased productivity, increase in acreage under GM crops and farmers profits. According to International Service for Acquisition of Agribiotech applications, 170.3 million hectares of land is under GM crops in 2012 worldwide, and this area is expanding at an annual growth rate of 6%. There was an unprecedented 100 fold increase in 2012 area under GM crops globally, which makes biotech crops the fastest adopted crop technology in current times. Of the 28 countries which planted biotech crops in 2012, 20 were developing and 8 were industrial countries. The five leading developing countries are China and India in Asia, Brazil and Argentina in Latin America, and South Africa on the continent of Africa, after USA[4].

It is claimed that fact that farmers have adopted the technology with enthusiasm, often through stealth, showcasing its success and popularity. For instance, in the case of India, even before its official release in 2002, illegal seeds were found growing in the central western state of Gujarat 1998, possibly stolen through a gene from Monsanto (Herring: Various). The unauthorized seeds have then spread to other states as well.

The critics of GM crops continue to doubt its usefulness, particularly for small farmers in developing countries, suggesting that they pose significant environmental risks.[5] GM crops have drawn, and continue to draw, criticism at both global and local levels, particularly because of the risk they pose to biodiversity on forests and farms, to farmers' rights and to human health. Sanvido, Romies and Bigler (2007) suggest that because GM crops are manufactured through genetic manipulation, a risk is present that genes in GM crops could unintentionally flow from transgenic gene species to wild species, which could lead to the extinction of the sexually compatible wild species. The use of GM crops could also lead to contamination of the non-GM crops, and that would lead to problems for those farming organic crops, for their organic certification could be revoked (Thies and Devare 2007). They suggest thatgene products persist in the

[4] http://www.isaaa.org/resources/publications/briefs/44/executivesummary/default.asp
[5] http://onlinelibrary.wiley.com/doi/10.1046/j.1365-313X.2002.01401.x/full

environment itself with deleterious effects because GM technologies have been proved to harm unintended and beneficiary organisms. Other deleterious effects have been noted too. GM crops are also hypothesized to make crops weedier, and create resistance in the pests that they are intended to target. GM crops could also have other negative effects on the larger environment.

Anti-GM activists also claim that the GM crops that require the presence of a harmonized set of intellectual property rights (IPRs) are incompatible with farmers' rights: "IPRs are an important part of agri-business controlled agriculture in which farmers no longer grow native seeds but grow seeds supplied by the transnational corporation industry. IPRs become a monopoly that wipes out farmer's rights to save and exchange the seeds" (Shiva: 2005).M crops allow seed monopolies to gather profits even though it is the farmers whose practice has preserved plant and seed biodiversity for centuries. The gathering of profits by seed monopolies is facilitated by international trade and finance institutions such as the World Trade Organization (WTO). "The state is under siege," writes Vandana Shiva (2005). "New IPRs are being introduced in the area of plant genetic resources under the pressure of the U.S. government in the Trade Related Intellectual Property Rights (TRIPs) regime, under the WTO."

This paper argues that both proponents and opponents discuss benefits and risks of GM cotton in a narrow technological framework. They do not give credence to the settings where GM crops are being introduced in. What are the impacts of new technology when it is introduced in two different socio-political country or regional contexts, such as widely different state regimes and policies, land size distribution and ownership patterns, societal factors, ecology? Since it is difficult to include the vast gamut of above-mentioned factors, this paper will largely concentrate on the political and social factors, leaving the rest for a longer paper.

Literature from science and technology studies, urban planning and development studies highlights the importance of the above-mentioned social and political factors in understanding effects of techno-centric solutions on farm livelihoods in different settings.

This book compares the adoption of GM cotton in India and China which are vastly different countries to understand the effects of technology on farm livelihoods.

This research is significant because many parts of the world are suffering from food crisis. On the other hand farmers are suffering from pest problems and committing suicides. GM crops are heralded the next panacea that will solve all problems.

GM crops in India: State, Judiciary, and Non State Actors

Produced by the transnational agro-corporation, Monsanto, Bt cotton has been adopted widely in India's cotton belt. Even before their official release, "illegal" or unofficial GM seeds were found growing in the state of Gujarat in 1998. Monsanto's Bt varieties that were officially approved in 2002 have made a dramatic acreage gain since then in the cotton regions of India (ISAAA, 2006). According to GM crop proponents, the popularity of GM crops necessitates their introduction on a wider basis. Bt cotton, and GM crops, will increase agricultural productivity and usher in a "second Green Revolution" (Sibal, 2008; Singh, 2005; Rai, 2006; Patil, 2008). Technology is a crucial component for revitalizing the agricultural sector in the current government policy (Planning Commission, 2006). "Technology fatigue is the major cause underlying the deceleration of the performance of the agricultural sector. Since the green revolution in the sixties there has been no major technological innovation which could give fresh impetus to agricultural productivity. The absence of productive technology which also reduces risks is particularly serious for rainfed, dry land situations. In the longer run, growth in agricultural productivity can be sustained only through continuous technological progress." (Approach Paper to the 11th Five Year Plan, Planning Commission: 2006b). Calling for the need for a second green revolution, the Five Year Plan paper notes: "The supply side of increasing agricultural growth is really formidable. This is especially so because no dramatic technological breakthrough comparable to the green revolution is presently in sight. We are also not exploiting the potential of existing technology."

The Indian state which has already been a premier state in the adoption of the green revolution technologies already boasted of a strong conventional plant breeding establishment. Global trends in biotechnology had since then been closely watched by the

Indian state. In the sixth five year plan (1980-85) the Indian state declared that genetics would be a new priority area and set up a National Technology Board in 1982 (Rajan: 1996). In 1986, to build indigenous capacities for biotechnology development in line with international trends, the Indian government established the Department of Biotechnology in 1986.[6]

Despite the Indian state's positive stance towards biotechnology development and the establishment of Department of Biotechnology, there was no national level policy per se as on biotechnology and its relation to the problems of the agrarian sector.

In 1993, Monsanto, an agro-transnational that had been operating in India as a pesticide company since 1950s, approached the Indian government to sell transgenic technology, an offer that was turned down by the Planning Commission[7] owing to the high costs of the transgenic genes (Bhatia: 2001). The advent of liberal policies towards foreign firms and investments, post-1985 and gaining momentum after 1991, facilitated Monsanto forming a collaboration with the Indian seed company Mahyco, a big seed company established in India since 1964. Already the 1988 National Seeds Act encouraged the entry of foreign-owned and large Indian firms in the seed sector and easing regulations on technology transfer (Pray and Ramaswami: 2003).

Meanwhile, in 1993 itself the opposition to transgenic seeds started coalescing and occupying various protest forums. The environmental movement most prominently led by Vandana Shiva, provided prolific coverage against GM crops through internet websites, newsletters and campaign websites.[8] Opposition constituted by a section of farmers movements, primarily the Karnataka Rajya Ryotha Sangha (KRRS), occupied other forums for protest such as burning of field trial plots of Bt cotton in 1998 in Karnataka, destroying the seed company Cargill's office in Bangalore in 1993, uprooting trial fields and staging demonstrations against GM crops and multinationals (Herring: 2005). Citizen's juries and workshops that discussed principles of locally led rural

[6] Govind Rajan (1996) provides a North-south angle to the development of the biotechnology industry. He notes that aware of the developments in the North, the Indian state became concerned that the lack of access to this technology would further widen the development gap between the North and South. In the negotiations for the Convention for Biological Diversity, the Indian state argued for technological transfer and location of gene banks in India.

[7] Interview, Bhagirath Chaudhury, ISAAA, Delhi, July, 2006

[8] For instance, see: http://www.navdanya.org/, or http://www.gmwatch.org/archive2.asp?arcid=4245 or http://www.genecampaign.org/News/news-gmcrops.html

development, initiated by groups such as Deccan Development Society, were also held in Andhra Pradesh and Karnataka (Scoones: 2006). Small groups practicing organic and sustainable agriculture formed other forms of protest against GM crops.[9]

On the other hand, the pro-biotech alliance, which included a segment of the farmers movement, the seed industry, multinational seed companies, bio-pharma entrepreneurs, the central Indian state and federal states[10] led a strong campaign, holding workshops, initiating policy dialogues and large conferences where policy makers are invited (see chapter 2 for some of these statements).

GM seeds were promoted, embedded in the liberal discourse of "making Indian agriculture competitive in the global market," "India should shed its conservative stance on GM crops" and "Bt cotton is providing the right policy signals for global venture capitalists to invest in India (Cited in Scoones: 2006).

The Indian seed industry formed a number of associations with alliances developing within the seed industry and with seed MNCs such as the All India Crop Biotech Association which contains members who were previously with the government.[11]

Using strategies such as public interest litigations and petitioning the Genetically Engineering Approval Committee (GEAC)[12] the environmental movement made important interventions in the creation of the hithertho non-existent biotechnology policy and the formulation of bio-safety policy.[13] After substantial hue and cry was raised by organizations such as Gene Campaign (see Sahai: 2004) a Task Force for evaluating agricultural biotechnology was formulated in 2003[14] and a biotechnology policy in 2004.

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[9] These groups include Deccan Development Society located in Andhra Pradesh: http://www.ddsindia.com/www/default.asp

[10] The success of the information technology sector formed the basis of the political discourse of states in promoting biotechnology. For instance, the Chief Minister of Karnataka in his budget speech for the year 2000-2001 noted, "While Karnataka is the acknowledged leader in IT, I would like the State to lead the next revolution in Biotechnology." See: B for Bangalore and Biotech. In HinduBusinessLine (2001). http://www.hinduonnet.com/businessline/2001/05/07/stories/100767g1.htm

[11] For instance, RK Sinha who is the head of the All India Biotech Association was previously with the Ministry of Environment and Forests.

[12] GEAC is a central level body constituted under the Ministry of Environment and Forest that approves GM trials

[13] For instance, see: India needs a biosafety policy: http://www.hinduonnet.com/fline/fl2110/stories/20040521001708200.htm. Biotech Policy: Secretive and Hasty. http://www.indiatogether.org/2006/apr/agr-btpolicy.htm#continue,

[14] Interview, Bhagirath Chaudhari, Interview, ISAAA, Delhi, April, 2006

Overall, the movement has been successful in creating only a discursive space(Scoones:2006) providing an "enhanced sense of democracy in policymaking"[15] and delaying the regulatory process (Scoones: 2006).

Scholars such as Herring (2006) attribute the failure of these movements to the non-representativeness of the movements of the farmers and their class position. "Farmers are driven by necessity, unlike the activists for whom controversy is the mode of production." However, the power of the seed industry that has been increasing due to the government support to the industry since the 1980s is the real reason why GM crops have been introduced in India in 2002.

Cotton in India is grown in 9 states, most prominently, Gujarat, Andhra Pradesh and Maharashtra. Bt cotton has had varied success in these three states. Documenting the events in these three states can give a representative picture of adoption of Bt cotton in India.

The case of Gujarat has been much cited in literature, in terms of the agency of farmers in using unauthorized seeds vis a vis a victimized portrait of the farmers under corporate control (Shiva). Reports suggest that Bt gene had been inserted in a hybrid cotton that has been grown for several years using public germplasm and a gene stolen from Monsanto by a local firm called Navbharat. While the central state ordered the state of Gujarat to destroy the seeds, the state government and farmers refused to follow suit, leading to the formal introduction of Bt cotton created by Mahco-Monsanto combine in 2002.[16]

Literature also suggests that Gujarat farmers are more privileged than their counterparts, in steadily increasingly the productivity of cotton and capturing the profits. Roy (2007) notes that farmers have been able to take advantage of the technology despite the fact that it is unauthorized because of trust bonds developed between farmers over years.

[15] Comment, Shiv Vishwanathan, Social Scientist, CSDS, Delhi, July, 2006. This stands in stark contrast to the policy making during the green revolution period when the policies were more closed door but were created prior to the introduction of the new seeds.
[16] http://www.ids.ac.uk/files/Wp197.pdf

Gujarat is also unique in terms of the role of cooperatives, which have allowed farmers unlike in other states, to be independent in purchase of inputs like fertilizers from the government. Cooperatives have given them better bargaining power to negotiate for better prices with textile mills. Cooperatives and trust bonds amongst farmers also allow farmers to eliminate the need for extension information from government or private seed agents.

Cotton in Gujarat is grown under irrigated conditions unlike the state of Maharashtra and Andhra Pradesh. These are some of the factors that have played a role in increased productivity of cotton in the case of Gujarat.

The state of Gujarat after experimenting with largescale use of Bt cotton, is set to produce and distribute genetically modified seeds across India at competitive rates in comparison to private players.[17] The Gujarat government wants the price of Bt cotton seed to be regulated and put under its control despite opposition to it from the country's top seed producing companies.[18]

In the case of Maharashtra, the adoption of Bt cotton was at first largely unauthorized, through seeds being supplied from Gujarat via small private sector seed agencies. With the approval of the Mahyco- Monsanto produced MECH cotton in 2002, the sale of GM cotton in Maharashtra also became authorized. However, at the same time, an epidemic of farm suicides was noted in Maharashtra, that led to a number of court cases, including studies by Tata Institute of Social Sciences, Indira Gandhi Institute of Development Research, Planning Commission and multiple newspapers and newschannels in 2005-2006. Reasons cited were indebtedness to local moneylenders, the removal of the State run Cotton Monopoly Procurement Scheme, and the higher cost of cultivation vis a vis Minimum Support Prices. Other reasons included, the absence of irrigation systems in drought-prone areas (especially in Maharashtra), combined with specialization in high-

[17] See more at: http://www.indianexpress.com/news/in-a-first-state-govt-set-to-sell-bt-cotton-seeds/1075170/#sthash.FnVUTiug.dpuf
[18] http://articles.timesofindia.indiatimes.com/2012-03-08/ahmedabad/31135446_1_bt-cotton-seed-seed-companies-national-seed-association

cost crops, low market and support prices, and the absence or failure of the credit system specially after the economic reforms of 1992. It is also possible that under the conditions in which it was introduced, that Bt cotton might have played a role in the overall indebtedness of certain farmers in some of the suicide-prone areas of these two states, particularly in its initial years[19]. The farm suicides led to the provision of a number of relief packages on part of the central and state government to Maharashtra and other states.

Analyzing the farm suicides, analysis of social movement literature suggests the rise of a alliance of new social movements that have brought the material reality of farm crisis into national and international limelight. The state of Maharashtra had witnessed the rise of the Shetakari Sangathana, a nation wide farmers movement. The current farm movement is a fragment of the Sangathana, which has allowed the percolation of relief packages for the suicidal farmers, working in close alliance with the environmental movement, with the help of media.

Andhra Pradesh, is also another state where their have been multiple farm suicides. The state of Andhra Pradesh has been unique in the activist role played by the judiciary in regulating Bt cotton prices, a problem nationwide. The seed prices that Monsanto-Mahyco had put forth were too high because of the technology fee and the monopoly that Monsanto had over the Indian GM seed market. However, the state of Andhra Pradesh filed a case in the Supreme court regarding the high prices, which led to a reduction of seed prices by half which was applied nation-wide. Later, the government of Andhra Pradesh also entered into agreements with seed firms and farmers, which bypasses the certification of cottonseeds for quality and yield. Under the agreement, if farmers suffer any losses, farmers can approach a tripartite body comprising government officials, and representatives of the seed company and farmers, for compensation.

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19 http://sap.einaudi.cornell.edu/sites/sap.einaudi.cornell.edu/files/Suicides%20Bt%20cotton%20JDS%20great.pdf

Conflicting studies exist regarding the benefits of Bt cotton. For instance, in the case of Maharashtra, a study conducted in 2006 found that yield advantages differed for the same hybrid by region and within regions, by hybrid. Another study in 2004 and 2005, confirmed the spatial and temporal variation in partial productivity of Bt cotton. In some areas, they found that farmers did not benefit at all. A third study in Andhra Pradesh found that Bt cotton was found inferior to non-Bt cotton in terms of yields, pesticide use was negligible for both types of cotton, non-Bt farmers had higher profits and lower costs of cultivation, and suspected Bt cotton of a root rot that affected their soils for subsequent crops. Concerns exist that highlight the importance of host germplasm for Bt effectiveness. It was suggested that host germplasm was not broadly adapted to Indian growing conditions given the high degree of heterogeneity among farmers in terms of agroecological, social, and economic conditions and the better adaptation of local non-Bt hybrids compared to Bt hybrids (germplasm effect) influenced farm level benefits. Studies also report that black market sales of unapproved cultivars and sales of F2 seed at lower prices explain some crop losses[20].

GM cotton in China: the Role of the State

China grows 25% of the global cotton constituting 45% of world trade in cotton. Cotton industry has played a pivotal role in China in developing its rural and industrial economies and driving textile trade,[21] with 300 million people dependent on cotton[22].

The Chinese state made a major investment in biotechnology research starting mid 1980s making it one of the biggest biotech research programs in the world. Insect pests, mainly bollworm are a major threat to cotton production in China. Cotton producers have to struggle against many pests and resort to spraying pesticides. Despite an increasing use of pesticides, cotton productivity on Chinese farms was declining.[23] Concerned about the

[20] http://www.agbioforum.org/v9n3/v9n3a06-zambrano.htm

[21] http://www.bettercotton.org/files/Regions/China/BCI_Solidaridad_Scoping_Study_China_final.pdf
[22] http://www.unep.ch/etu/publications/Synth_China.PDF
[23] http://www.currentscience.ac.in/Downloads/article_id_086_06_0778_0782_0.pdf

pest problems, in early 1990s, scientists in the Cotton Research Institute started working on their own varieties, releasing their varieties in the late 1990s.

With funding primarily from government research sources, a group of public research institutes led by the Chinese Academy of Agricultural Sciences (CAAS) developed Bt cotton varieties using a modified Bt fusion gene (*Cry1ab* and *Cry 1Ac*). The gene was transformed into major Chinese cotton varieties using China's own methods (pollen-tube pathways). Researchers tested the varieties for their impact on the environment and then released them for commercial use in 1997.

Meanwhile, Monsanto, in collaboration with developed Bt cotton varieties in USA which were approved for commercial use in 1996. They began to collaborate with the Chinese National Cotton Research Institute of CAAS in the mid-1990s. As Bt cotton spread in Chinese provinces, government research institutes at the province and prefecture levels also produced new Bt varieties breeding CAAS varieties into their own local varieties and back-crossing the Monsanto varieties. Interviews with officials from local seed companies in July 2001 confirmed that such practices were widespread in almost every province in North China.Approved by the Chinese Biosafety Committee, conflicting reports exist whether their varieties worked well in China or not.

At present, CAAS has permission from the Biosafety Committee to sell 22 Bt cotton varieties in all provinces of China. The Biosafety Committee has approved the sale of five Monsanto Bt varieties in four provinces. Many other varieties from national institutes (such as the Cotton Research Institute, Anyang) and from provincial institutes are being grown, but some of these local varieties do not go through the official approval procedure set by the Chinese Biosafety Committee.[24]

The main difference from other countries is the major role of the public sector in providing GM technology in not only developing but also selling seeds. Political support from these scientists to allow commercialization of GM technology is one of the reasons that China approved the commercialization of GM crops earlier than most other

[24] http://onlinelibrary.wiley.com/doi/10.1046/j.1365-313X.2002.01401.x/full

developing countries (Paarlberg, 2001). The fact that Bt cotton was developed by government researchers at about the same time that international companies were introducing it into China clearly made it more palatable to the government, and ensured a strong lobby in favour of the technology. In addition, the competition between local government firms and foreign firms in providing Bt cotton varieties is one of the critical reason why the price of Chinese GM cotton seed is lower than other countries. That the Bt gene was bred into local varieties also led to a reduced price.

Between 1995 and 1999 the biotech funded more than doubled, with plans to increase by 400% in the near future. While more foreign sector firms will be entering China after accession from WTO[25] China is accelerating its investments in agricultural biotechnology research focussing on commodities that have been ignored in western laboratories.
While the spread of Bt cotton has relied on the varieties introduced by the public research system and seeds sold (at least initially) by the state-run seed network, the adoption of Bt varieties has been the result of decisions by millions of small-scale farmers. Like Indian, Pakistani, or Indonesian cotton growers, producers in China are primarily smallholders. On average, China's cotton farmers have even smaller farms than those in other countries. Cotton in China is grown in three main regions: Yangtze (Jiangsu, Anhui, Heibei, Hunan, Jianxi, Sichuan, Zhezang), Yellow River (Hebei, Shandong, Henan, Shangtzi, Shangtzi province), with the largest volume of cotton supplied by Xinjiang at 42%. In terms of water availability, there are relatively rich water resources in Yellow River and Yangtze river basin but insufficient cotton resources in the inland cotton area in Northwest specially the Xinjiang region. The Xinjiang region however, has large agricultural plots but low income due to high dependence on cotton. In contrast, both Yangtze and Yellow River while have scattered land holdings are close to the centers of textile industry.[26] The Yangtze river region has a growing season of 180 days and thus it has to adopt early maturing varieties. The American upland species especially the big bolls types has been found particularly suitable for this region.[27] Xinanjing mainly grows upland quality of long fibre length and high quality. The dryness conditions in the Yellow River have kept

[25] http://www.ers.usda.gov/media/303360/aib775m_1_.pdf
[26] http://www.bettercotton.org/files/Regions/China/BCI_Solidaridad_Scoping_Study_China_final.pdf
[27] http://s3.amazonaws.com/zanran_storage/www.ers.usda.gov/ContentPages/4093190.pdf

the pest problems to the minimum. Droughts, floods and unsustainable use of water are also issues of concern while continuous cotton cultivation for more than 10 yeasr in the same plot in China is reducing soil quality. Cotton production in the recent years has shifted towards the Xinagzi province which has favorable production conditions[28] and the production is mechanized[29]. Despite the fact that Chinese cotton production has displayed an upward trend, China will face issues of sustaining its cotton production in the future. There is little scope of increasing area under cotton, even if cotton production shifts to the northwest, one of the major strategies adopted in the introduction of more water tolerant varieties have to be introduced. A second strategy is the use of transgenic technologies, which will be used for a longer period of time[30].

Bt cotton was first introduced first in Hebei and Shandong provinces (Yellow River, North China), reviving production in the region although this was limited by water resources. Cotton production was at its highest level in 1991 when the region produced more than 3 million tons. Production in the Yellow River region then plunged to 1.4 million tons 2 years later, in 1993. This was largely due to a severe bollworm infestation, as well as increased labour costs in the region and changes in relative crop returns (Hsu and Gale, 2001). When Bt cotton started to spread extensively in the region in 1999, the cotton area increased. In Hebei and Shandong provinces the cotton area grew from 729 700 ha in 1998 to 876 100 ha in 2000 (NSBC, 2001). Farmers were responding to the pest-resistant characteristics of Bt cotton which allowed them to grow cotton successfully despite the bollworms, reduced their production costs and saved labour.

At the same time, cotton production in the Yangtze region (south China) has remained steady, while cotton production has risen gradually in the north-west. The north-west cotton region is basically irrigated desert. As a result there are fewer pest problems, higher yields, and higher fibre quality than in other regions of the country. The major problem is being so far away from cotton markets, which are primarily in the Yangtze

[28] http://ageconsearch.umn.edu/bitstream/55338/2/WP%20157.pdf
[29] http://ageconsearch.umn.edu/bitstream/55338/2/WP%20157.pdf
[30] http://ageconsearch.umn.edu/bitstream/55338/2/WP%20157.pdf

region and to a lesser extent in the Yellow River region. To offset the costs of transportation and encourage more production in this region, the Chinese government provides subsidies for important inputs such as irrigation, mechanized tillage, planting and harvesting[31].

In case of technology adoption, 100% adoption has taken place in case of two heiban counties and 74% in Sahndong province[32]

Controversy exists whether Bt cotton has benefited farmers or not, as secondary pests seemed to emerge in areas, after use of Bt cotton. Concerns also exist whether there exists sustained productivity of Bt cotton. Yet other reports affirm the success of Bt cotton in the Yellow River region of China where resistance to insecticides had evolved and farmers applied 10 to 12 treatments, as compared to 2 to 4 in most countries. However, contrary evidence exists in the Yangtze river valley (Jiangsu) and other provinces, where pest pressures are lower and the germplasm is not as well adapted to local conditions. There are a number of institutional factors, such as 1) the decentralization of breeding efforts in China, leading to the "enviable wealth of cotton varieties," 2) the low seed costs for both the newly released cotton hybrids and varieties, 3) the competitive nature of the seed market, and 4) despite the elimination of support prices and subsidies, an effective price premium due to import controls in the domestic cotton industry which are leading to the success of Bt cotton.

China's rural economy is evolving quickly and it may be that the environment has changed so much in the past several years that the benefits and costs of Bt cotton to farmers in China have also changed. Although the commercialization of cotton markets began in the late 1990s, most cotton was still purchased by the state Cotton & Jute Corporation in 1999 at a price fixed by the government. Since 2000, the government has allowed the price of cotton to fluctuate with market conditions. Cotton mills are now allowed to buy cotton directly from growers. On the input side, the New Seed Law passed in 2000 gave legitimacy to private seed companies and allowed them to operate in

[31] http://onlinelibrary.wiley.com/doi/10.1046/j.1365-313X.2002.01401.x/full
[32] http://down.aefweb.net/WorkingPapers/w509.pdf

many provinces. These changes led to sharp changes in the price of cotton; increased Bt cotton seed availability; and changes in the pricing strategy of Bt cotton seed.

GM crops in Brazil: Foreign Multinationals, Judiciary and Farmers

Transgenic technology in Brazil has been used in the case of soyabean, maize and cotton. Soyabean is grown in the Amazon and Cerrado regions of Brazil, which have high availability of water and produce a high quantity of soya, making soyabean the number two export in Brazils agricultural exports and 18% of the global economy[33]. About 85% of Brazil's massive soyabean crop output is produced from genetically engineered seeds. Brazil exports about $24.1 billion worth of soyabeans annually, more than a quarter of its total agri-exports[34]. The U.S. share of world soybean exports fell to 43 percent last year from 60 percent in 1997 as competition increased from Argentina and Brazil, according to the U.S. International Trade Commission.[35] China is one of the biggest buyers of soyabean[36].

In terms of biotech research, while Brazil has a well established biotech program, the agricultural state agency EMBRAPA is only able to spend 1-2 million in biotech research vis a vis foreign companies which spends 1-2 million on biotech research. EMBRAPA has struggled with finances since economic reforms,

The first GM soy seeds however, were neither supplied by the government or the foreign companies in Brazil. In fact, soya farmers from RioGrande Sul region, have for several years since 1998[37] have smuggled GM soya from the neighbouring country of Argentina[38]

[33] http://www.brightergreen.org/files/brazil_bg_pp_2011.pdf
[34] See more at: http://www.qwmagazine.com/2012/06/15/brazilian-farmers-win-2-billion-judgment-against-monsanto-2/#sthash.Wn055cMd.dpuf
[35] http://www.bloomberg.com/apps/news?pid=newsarchive&sid=al4QLtjW1ci4
[36] See more at: http://www.qwmagazine.com/2012/06/15/brazilian-farmers-win-2-billion-judgment-against-monsanto-2/#sthash.Wn055cMd.dpuf
[37] http://www.qwmagazine.com/2012/06/15/brazilian-farmers-win-2-billion-judgment-against-monsanto-2/
[38] http://www.guardian.co.uk/science/2003/sep/26/gm.food

Introduction of transgenic crops to Brazil proceeded in what David Hathaway (2002) called 'a vacuum in the exercise of authority'. The state was divided over the decision to introduce GM crops. The political struggle for legitimacy to rule on transgenics engaged different levels of the court system, divisions within the federal government and disputes between the states and Brasılia.[39] Brazil's Biosafety Law was passed by the National Congress in 1994. It granted authority over both pharmaceutical and agricultural GMOs to a National Technical Biosafety Commission (CTNBio). Transgenics are also regulated by the Industrial Property Code of 1996, which explicitly responded to new requirements of WTO's Trade-Related Aspects of Intellectual Property Rights (TRIPS), granting legal protection to inventions related to pharmaceuticals, food processes, and biotechnology. CNTBio approved commercial release of three varieties of Monsanto's Round-Up Ready (RR) soybeans in September 1998.

GM crops were declared legal despite several years of protests by environmental groups such as Greenpeace. The government took this decision partly because it realized that it is going to be difficult to convince the farmers who had been suggling GM seeds from Brazil.[40]

In protest, both Greenpeace and Commission from the Institute for Consumer Defense (IDEC) filed legal appeals; in l999. Commercial cultivation of Rundup ready soybeans was legally banned, on grounds that they had not been adequately tested for human health and environmental impacts. The authority of CNTBio was challenged by a law suit in 2000, seeking an injunction against decisions on transgenic-crop releases before the government formulated rules for assessing bio-safety. A third decision, issued in 2002 in response to a suit brought by the federal Public Ministry, suspended all further field tests of 'biopesticide' transgenics until Brazil's pesticide legislation is enforced. These decisions combined to produce a 'judicial moratorium' on the commercial release of transgenic crops in Brazil.

As the government banned the use of GM cotton, protests also ensued on part of the farmers against foreign MNCs. Brazilian soya producers had reportedly paid one billion Brazilian reals (US 530 billion) for the use of Roundup Ready.[41] Five million Brazilian farmers have taken on US based biotech company Monsanto through a lawsuit

[39] http://government.arts.cornell.edu/assets/faculty/docs/herring/JDS_HerringStealthSeeds.pdf
[40] http://www.guardian.co.uk/science/2003/sep/26/gm.food
[41] http://www.viacampesina.org/downloads/pdf/en/Monsanto-Publication-EN-Final-Version.pdf

demanding return of about 6.2 billion euros taken as royalties from them. The farmers are claiming that the powerful company has unfairly extracted these royalties from poor farmers because they were using seeds produced from crops grown from Monsanto's genetically engineered seeds[42].

On the other hand, U.S. farmers are urging the Bush administration to take action against Brazil, saying that growers there are pirating Monsanto Co.'s gene-altered soybeans. The U.S. farmers told the US office of Trade that Brazilians are defying their government's ban on growing genetically modified organisms by planting biotechnology seeds without paying royalties to Monsanto and then marketing the crops as ``GMO free."

Monsanto previously obtained patent protection in Brazil for its first-generation Roundup Ready soybean products. It sought to correct the term of its patent rights in Brazil to conform to a 2014 patent term granted in the United States.

However, the court in the southern Brazilian state of Rio Grande do Sul, ruled in favor of the farmers and ordered Monsanto to return royalties paid since 2004 or a minimum of $2 billion. The ruling said that the business practices of seed multinational Monsanto violate the rules of the Brazilian Cultivars Act. Monsanto has appealed against the order[43]. In 2011, Monsanto had also made a parallel legal bid to the Brazilian Supreme Court of Justice. The company argued that the syndicates had no legal status to bring their case, and also that any final ruling should be limited to Rio Grande do Sul, fearing that its losses would be even greater if it applied to the whole country. The Brazilian Supreme Court ruled against Monsanto, deciding unanimously that the ruling by the Justice Tribune of Rio Grande do Sul, once it is made, should apply nationwide[44].

Further, the Brazilian government is of the opinion that it will let those crops be sold rather than pay the cost of compensating farmers for destroying the plants. Brazil relies heavily on export revenue to pay its $300 billion debt[45]. The ban has since been lifted and

[42] http://www.qwmagazine.com/2012/06/15/brazilian-farmers-win-2-billion-judgment-against-monsanto-2/
[43] - See more at: http://www.qwmagazine.com/2012/06/15/brazilian-farmers-win-2-billion-judgment-against-monsanto-2/#sthash.Wn055cMd.dpuf
[44] http://www.nature.com/news/monsanto-may-lose-gm-soya-royalties-throughout-brazil-1.10837
[45] http://www.grain.org/article/entries/1990-monsanto-s-seed-wars-several-updates

now 85 percent of the country's soybean crop (25 million hectares or 62 million acres) is genetically modified.

Fears still exist in EMBRAPA that Monsanto might withdraw its support, as part of the funds for EMBRAPA come from Monsanto.

Thus, farmers in general have benefited by the activist role played by judiciary and the agency of the farmers themselves.

Conclusion

GM crops have been introduced under different political and economic circumstances in all the three countries, with varied roles played by non-state actors and farmers themselves.

Table 1 summarises the major points of the social and political aspects of GM development in the three countries.

Countries/Factors	Technology	Social Class	Political (State and Non state actors)	Impacts
India	Hybrid Bt cotton	Medium Class Inequality	State: Weak Role Private Sector: Strong Role Judiciary: Strong Role NGOs and CBOs: Strong Role Social Movements: Strong Role	Uncertain Benefits. Might Improve over time
China	Bt cotton is Non hybrid cotton transfused with Bt gene	Low Level of Inequality	State: Strong Role Private Sector: Weak Role Judiciary: No role Social Movements and NGOs: No role	Positive Benefits

Brazil	GM soya is a transgenic soybean that has been immunized to the Roundup herbicide.		State: Weak Role Private Sector: Strong Role Judiciary: Strong Role Social Movements and NGOs: Strong role	Unequal Benefits if any

As evidenced in Table 1, in the case of India, with the advent of 1991 economic reforms, an uneasy partnerships exist between the state and public sector, and judicial intervention define the context of adoption of new seeds by small holder cotton farmers in India. Farmers benefits where strong farmers cooperatives or social capital exists, as in the case of Gujarat. Benefits are also captured when there is intervention of judiciary as in the case of Andhra Pradesh, while benefits are snatched when a strong social movement emerged in Maharashtra. Evidence, however is mixed whether GM crops have played a positive role in ameliorating the condition of areas suffering from farm crisis, partly because of socio-political factors but also ecological ones, given the diverse agrarian conditions. In the case of China, a strong role is played by the state in developing and diffusing Bt cotton amongst small holder farmers in cotton growing regions, which has allowed the price of cotton to be low, thus promising greater gains for the farmers in comparison with other countries. Ecologically, China might not present a very strong condition as it experiences groundwater depleition and water scarcity. In Brazil, farmers who had already been smuggling seeds from neighboring Argentina, played a major role in influencing the state in elimiating royalties charged by Monsanto. Yet since the role played by the Brazilian state was weak as compared to China,the judiciary has played an active role in preventing Monsanto in collecting royalties from the farmers. Ecologically, expansion of GM soya can lead to further deforestation of the Amazon.

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