Biotechnology, the Environment and Sustainable Development: Case Study of Genetically Modified Soybeans in Argentina

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PREFACE

The following work was prepared by Grant Binder in mid 2001 for CEDHA's Sustainable Trade Program on a fellowship sponsored by NY York University School of Law. The paper is intended to frame future studies on the sustainability of genetically modified soybean production in Argentina, particularly on the social and environmental impacts of genetically modified soybean. CEDHA's Sustainable Trade Program, along with several other institutions worldwide are beginning to look at Sustainability Assessments as a useful tool to measure the impacts of certain types of productive activities, not only on the natural resources of a given region or area, but also on the human impacts of the activity.

I. INTRODUCTION

"Every technological advance brings potential benefits and risks, some of which are not easy to predict. The benefits of technologies can be far greater than what their creators foresaw. At the same time, the hidden costs of technologies can be devastating." - 2001 United Nations Human Development Report.

The introduction of genetic engineering technologies into agriculture has unleashed a great debate with regards to their potential consequences upon the environment, health, and the sustainable development of nations. Genetic modification ("GM") technologies introduced over the last thirty years have allowed for the development of plants that are resistant to various herbicides and insecticides, have the potential to increase yield, and have altered the characteristics of some plants to, *inter alia*, increase nutritive value, prolong shelf life, and increase resistance to abiotic stresses, such as salinity and drought. The potential benefits from these technological advances in the agricultural sector include enhanced yields, decreased dependence on chemicals, greater flexibility in crop management, and the possibility of more nutritious food for consumers. Proponents stress

the advances that genetically modified plants ("GMOs") could bring towards improving stewardship of the environment and our finite natural resources, especially in an increasingly populous planet with pressing issues of malnutrition and hunger. Proponents of these technologies often deride environmental advocates as "Luddites" or look for other motives, such as trade protectionism, for their anti-GMO stance.

Many groups around the world have expressed serious concern about the potential effects of GM technologies and feel that important concerns and risks with regards to human health and ecological stability are being overlooked in the rapid introduction and commercialization of GM technologies into many environments. Further, they feel that the benefits of GM technologies are being overstated and fail to see the promised results in practice. Critics see the end result of GMOs as contributing to a further disharmony between agriculture and the environment.

The overwhelming majority, over 95%, of transgenic crops are planted in three countries: the United States, Argentina, and Canada. Almost three quarters of these crops were modified only against herbicides. This paper will examine the effects of transgenic crops on the environment - an issue that both opponents and proponents claim provides support for their beliefs about the technology. This study will be further limited by examining only one country, Argentina, and by focusing on one crop in particular - transgenic soy.

Argentina is one of the few developing countries that has developed a national biotechnology industry. While most of the research, development and production of genetically modified organisms has taken place in the United States and Western Europe, Argentina has taken advantage of a well-developed educational and agricultural infrastructure to develop a thriving industry in genetically modified plants: primarily soy, corn, and cotton. As an early adopter of the technology, Argentina finds itself in an increasingly precarious position due to its dependence on biotech exports to bring in income for its troubled economy. The specter of bans and moratoriums on their exports to traditional trading partners in Europe have caused many to question the wisdom of adopting policies that rely so heavily on controversial biotechnological products. Furthermore, questions have been raised about the ability of agricultural biotechnology to contribute to the sustainable development of Argentina.

This paper will provide primarily a legal perspective on the regulation of transgenic soy and examine how the regulatory regime, both national and international, adequately or inadequately takes into consideration the environmental risks that have been identified. After providing an overview of the sector and its development in Section II, Section III will look at the debate over the environmental impacts from the widespread commercialization of transgenic soy. Section IV will focus on the regulatory regime in Argentina and provide a brief discussion of the relevant international regulations in order to provide background for the discussion on international trade and its linkages to the environment that follows in Section V. Finally, Section VI will attempt to begin to analyze the impact of the soy industry through the paradigm of sustainable development and will argue that a sustainability assessment should be undertaken to more intensely analyze the situation.

II. OVERVIEW OF SECTOR

A. **Soybean RR**[1]

The development of soy tolerant to the herbicide glyphosate - commonly sold by Monsanto under the trade name Roundup - began in the early 1980s in the United States. After years of greenhouse and field tests, the Food and Drug Administration (FDA) and the United States Department of Agriculture (USDA) in 1994. The Environmental Protection Agency (EPA) granted approval in 1995 and the new glyphosate tolerant soybeans were made available to U.S. farmers for planting the following year.[2] The seeds were sold and marketed by Monsanto, the giant U.S. biotechnology corporation, who also sold the complementary herbicide, Roundup. A complete package, seed and herbicide, was therefore sold by Monsanto.

The herbicide glyphosate is a broad range herbicide that is used to control weeds by inhibiting the enzyme 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS), which catalyzes the synthesis of amino acids essential for the survival of plants and bacteria.[3] Several bacterial species exhibit tolerance to glyphosate, one of which, the soil bacterium *Agrobacterium* sp. strain CP4 was isolated and introduced into the genome of the soybean cultivar using a genetic engineering technique called the particle acceleration method. After incubation and selection, successfully transformed soybeans were selected that maintain the same agronomic traits (height, sturdiness, time for maturity) as their unaltered parents.

B. **Argentina and Transgenic Soy**

Argentina is blessed with some of the richest and most fertile soil in the world. The Pampas region in particular, an area that covers over 9,000,000 hectares, is considered one of the bread baskets of the world. Agriculture has always been one of the primary economic activities of the country, but both the scale and form of agricultural activities have changed dramatically over the last thirty years. Traditionally, the dominant system of production was based on a rotating system of cattle pasture and grain production with many of the complementary industrial activities also taking place within the country. Beginning in the early 1970s, the system evolved dramatically into one more focused on the export of basic commodities. Within this context of agro-industrial change, the production of soy as a cash crop started to become much more important with 37,700 hectares planted with soy during the 1970-71 season.[4] The production of soy increased exponentially in the following several decades and in 1996-7 over 6,000,000 hectares were planted with soy.[5]

The vast majority of soy production in Argentina takes place in the Pampas region, a vast region in the heart of the country that has similar agro-ecological characteristics to the “grain belt” of the United States. This similarity in agro-ecology, combined with the agro-industrial changes over the last twenty years, facilitated the rapid adoption of transgenic soy, which has been primarily developed, through massive research and investigation, for the grain belt region of the U.S.

Argentina was one of the early adopters of transgenic seeds and has now established itself as one of the worldwide leaders in the production of genetically modified

grains. While six different GMOs have been approved for production in Argentina,[6] of primary importance is the soybean genetically engineered for tolerance to glyphosate. The soybean Roundup Ready (soybean RR) has rapidly been accepted by farmers and now covers 90% of all soy that is planted - 8,550 hectares in total. The area sown with soybean RR has almost doubled in only the last two years - in 1998/1999 only 4,800 hectares were planted with soybean RR. In comparison, the United States, the largest producer worldwide, has only 56% of its cultivated land sown with soy is planted with soybean RR.[7]

Soybean RR was commercialized in Argentina by Nidera, another large biotechnology company which now controls almost 70% of the market in Argentina[8]. One of the largest proponents of this massive diffusion of transgenic soybeans has been the *Associacón de Semilleros Argentinos* (ASA), an organization of producers closely associated with the biotechnology industry, who encouraged its use to improve production and compete in the export market.

Although many consider the biotech revolution in Argentina to be a great success story, critics within the country have begun to question whether Argentina's dependence on biotech crops comes with a heavy price. Greenpeace, an international non-governmental organization, has attacked both the industry and the government as part of its "True Foods" campaign. In addition, local NGOs, most prominently, the *Grupo de Reflexión Rural*, has begun to question whether the risks associated with GMOs have been adequately addressed.

C. Soy Industry's Importance to the Economy

The agricultural sector is of particular importance to Argentina's economy and soybean production is one of the primary sources of foreign exchange for the country. Over 80% of the soy produced in the country is destined for exportation and of total exports, soy accounts for 13%. That number rises to 27% when the export scope is limited to Europe.[9] These exports to the European Union are possibly in danger given the overwhelming concern among consumers in the EU and the real and potential trade barriers that have been erected to limit the importation of genetically modified soy. The following diagram illustrates the different products of the soy industry and their respective destinations.

Argentine Exports of Soy to the World and to the European Union - 1995/1997[10]

Description	World (a) US$ (Thous.)	%	European Union (b) US$ (Thous.)	%	EU Proportion (b/a)
Soy industry (total)	3,067,053	100	1,180,795	100	38.5
Cakes, solid residue	1,681,963	55	856,977	73	51

Oil	962,230	31	1,909	.16	.2
Beans	422,828	14	321,900	27	76
Flour	31	0	9	0	28

D. Biotech Industry

The biotechnology industry has promoted the introduction of genetic engineering techniques into agriculture as providing the next Green Revolution for developing countries as well as developed. Their aggressive marketing campaigns attempt to alleviate concerns by placing the latest technological advances along a broader continuum of technological change and advancement that has occurred in agriculture over the last several hundred years, i.e. genetic engineering is not substantially different or more dangerous than the hybrid crossing that has occurred for well over the last century. To further this goal, one of their marketing techniques has been to attempt to change the nomenclature surrounding the industry by calling their products "living modified organisms - LMOs" and by renaming the industry the "life sciences industry". While it is true that the term "biotechnology" encompasses traditional animal breeding and plant hybrid techniques, many argue that the novel techniques of modern biotechnology, including, but not limited to, the introduction of genes from one species into another, represents a departure from the breeding techniques of the past.

In addition, the biotech industry invokes the Malthusian specter of imminent worldwide hunger unless their new technologies are embraced, brushing aside the arguments of many economists that view the problem of food shortage as not simply one of greater production but rather of more equitable distribution and increasing income.[11] These concerns are also included in a seminal report produced by a blue-ribbon panel of seven different national academies of science. "Income generation, particularly in low-income areas, together with the more effective distribution of food stocks, as equally, if not more, important. GM technologies are relevant to both these elements of food security."[12] This is especially interesting given that Monsanto cites the same paper, which includes a qualified approval for GM technology, on its web site.[13] However, looking beyond the often deceptive and overly enthusiastic statements of the biotech industry, there are undoubtedly some potential benefits from the adoption of agricultural biotechnology.

E. Benefits Derived from Agricultural Biotechnology

The primary benefits generally associated with transgenic seeds include the following: improved yield, reduction of costs due to fewer inputs used (primarily fewer agrochemicals), innovations and improvements in nutritional value (in theory, although none of the seeds currently planted in Argentina substantially alter the nutritional content of the seeds), and more ecologically sustainable agricultural practices (due largely to an increase in no-till farming and reduction in quantity and kind of agrochemicals).

a. YIELD

Monsanto states that the yields of the primary crops in Argentina have increased their yield by more than 50% over the last 20 years due to genetic

improvements.[14] However, it fails to distinguish how much of this increase was due to traditional hybrid technologies and how much was a result of recent genetic innovations. As stated earlier, Monsanto attempts to not distinguish between the traditional breeding techniques and genetic engineering technology. The promise of higher yields from transgenic crops has not largely materialized as of this point. While it is important to note that biotechnology is at an early stage of its development, it is equally important to begin to remove some of the hubris that has become associated with it. With regards to soybean RR, it is important to note that it has been genetically modified to be resistant to a certain chemical pesticide, not necessarily to increase the inherent yield potential of the crop. This is in contrast to transgenic crops such as Bt corn and cotton which have been specifically engineered to increase crop yields.

A study of the yields for the past ten years in Argentina have remained largely steady and do not show a dramatic increase in production. In 1998 and 1999, when the vast majority of soybeans planted were of the transgenic variety, the average yield was 2.3 tons per hectare. This exhibits only a slight increase over the average yield, 2.25 tons per hectare, in 1990-1991 (prior to the introduction of soybean RR).[15] In fact, a number of studies in the United States have been produced recently that have failed to find a significant increase in yield with the soybean RR and in fact have found slight decreases, 5 to 10%, in the yield.[16] Globally, it has been estimated that increased production might be increased by an estimated 2 percent or less, an amount that is unlikely to sufficiently protect natural habitats.

b. Reduction in Cost of Inputs

The primary reason that farmers have been adopting the use of soybean RR are because of the reduced costs of production and ease of crop management. After the introduction of the first transgenic seeds, Monsanto reduced the price of its herbicide Roundup thereby making it much more cost-effective for farmers to use the combination of soy RR and Roundup. In Argentina it is estimated that producers save almost 20 - 30 % over conventional varieties due primarily to the savings in agrochemicals; the cost of transgenic seeds are similar to the conventional varieties.[17]

The ease of crop management is attributable to the use of only one chemical rather than a mixture of different varieties depending on climatic and pest factors. Roundup is applied twice during the season. The control of weeds in the Pampas region was a problem prior to the introduction of the Roundup Ready system and most producers in Argentina are pleased with the effectiveness and efficiency of the Roundup Ready system. Indeed in a survey of farmers in the Córdoba region, 70% said the primary reason for using the soy was to save time.[18] The savings in time have been so great in some cases that farmers have been able to take second jobs in order to increase their income.

Furthermore, the costs in Argentina are less due to the lack of technology licensing fees that producers in the United States and Canada have to pay. This has been a source of contention between farmers in the United States and Argentina: U.S. farmers maintain that farmers in Argentina are able to flood the market with a cheaper product.[19] Farmers in Argentina respond by pointing out the subsidies that U.S. farmers receive as more than balancing any benefit that they receive from the lack of technology fees.

c. **Improved Nutrition**

The soybean RR is commonly called a first generation GM crop, which means that it has the same nutritional value and composition as traditional varieties. It is the second generation crops, such as the highly touted 'golden rice' which incorporates vitamin A, that provides much of the hope of biotech enthusiasts for revolutionizing global agriculture and helping developing countries. These second generation crops have inspired a heated debate between some activists who see the efforts of the industry to develop applications such as 'golden rice' as little more than a public relations ploy to make genetic engineering more acceptable to consumers and politically palatable to global leaders and those supporters who view it as an integral part of improving nutrition in the developing world. Activists often point out the absurdity of a $100 million research project, largely supported by the Rockefeller Foundation and the EC Biotech Program, to cure vitamin A deficiency when there are ample alternative, cheaper sources of vitamin A such as green vegetables and unpolished rice.[20] Industry leaders respond my pointing out the high initial start up costs of any endeavor and point out the great benefits that can be gained in developing countries. Leaders in developing countries are split in views with some, such as the Nigerian president, endorsing the implementation of biotech in Africa, while politicians from Ethiopia and other countries criticize the latest "quick-fix" from the North.

As Argentina does not produce any second-generation GMOs, this paper will not focus on this particular debate other than to emphasize the controversial nature of second-generation applications and the contentious debate over the wisdom of using scarce development funds on expensive technological innovations.

F. Risks Associated with Agricultural Biotechnology

The main risks associated with biotechnology are commonly divided into three categories: (1) risks to the environment; (2) risks to the economy, and (3) risks to health. The first category will be covered under the following section and the second will be covered under the sections on trade and sustainable development. Health risks are a very important concern to consumers and many advocacy groups and will be treated under the trade section as potential barriers to trade.

III. ENVIRONMENTAL RISKS

The growth of the environmental movement in the latter part of the 20th century was one of the most important developments of the last fifty years. Concern for the environment and reducing the impact of man on the natural resources now infuses policies in a wide variety of sectors: economic, security, health and others. The impact of agriculture on the environment is particularly great given the vast amount of land that is used for agricultural purposes. Reducing the need to expand agriculture into new areas, particularly ecologically sensitive ones, encouraging the use of ecologically-sensitive production techniques, and preserving biological diversity are several of the main intersections between agricultural and environmental policy. In Argentina the primary environmental problems related to agriculture are the increase in soil erosion and the expansion of cultivated land, which has reduced the level of biodiversity. Both of these problems are directly related to the increase in intensive agriculture over the course of the last twenty years.

The following will therefore attempt to detail both the utility of transgenic soy in reducing these environmental problems as well as other positive environmental externalities related to its usage and then look to identify pertinent risk factors. It is important to keep in mind that the complex interactions between agriculture and the environment often require a large time frame in order to fully understand the both the benefits and the risks of any new agricultural innovation. In Argentina the time frame for the study of transgenic soy is limited to approximately five years. However, hopefully, it is possible to begin to outline some of the contours of what will surely be a complex and important debate over the upcoming years.

A. Environmental Benefits

The potential environmental benefits from the production of transgenic soy include the following: the use of fewer, less toxic, or less persistent pesticides; a reduction in the need to convert additional land to agricultural purposes due to the increased yields; a decrease in the use of water; and a reduction in soil tillage.

1. **Reduction in use of pesticides**

One of the side effects of the first Green Revolution was its reliance on large amounts of chemical fertilizers and herbicides to improve production. Increased chemical use has had lasting effects on the water supplies in many countries and has led to an increase in health problems. The second Green Revolution promises to reverse some of the problems associated with intensive agriculture by reducing the use of agrochemicals in production. However, as with the improved yields, some of the conventional wisdom that transgenic crops use less herbicides is coming into question through a detailed analysis of soy production over the last several years. Indeed, it is becoming apparent that planting transgenic soy might actually increase the use of herbicides.

While it is true that less applications of Roundup is required than other herbicides, more active ingredients are applied of Roundup in each of their applications. Most herbicides require an average of less than .1 lbs. of active ingredients per acre; Roundup is usually applied at about .75 lbs. per acre. In 1998, the use of herbicides for soy RR was 30% or more greater than the average of conventional varieties in six different states in the U.S.[21] The use of chemicals is therefore often less frequent, but often more intense and, in the aggregate, uses more environmentally harmful active ingredients. The reduction in costs for the farmer can be largely seen as a result of an aggressive pricing policy by Monsanto to encourage the adoption of their system, rather than a greatly reduced use of chemicals. The use of glyphosate will only become greater as weeds develop a greater tolerance, a risk factor which is detailed later in more detail. The increase in the volume of glysophate used is truly startling as it has risen from less than 20 million liters in 1996/97 - when soy RR was introduced - to almost 60 million liters in 1999/2000; estimates from the current year -2000/2001 - reach close to 100 million liters.[22]

2. **Toxicity**

Glyphosate is less toxic and has fewer negative impacts on the soil and water then the herbicides that it replaces. The substitution therefore of glysophate for more toxic herbicides, such as imazethapyr, pendimethalin, and trifluralin, is undoubtedly a positive as

research indicates that glyphosate is 3 to 16 times less toxic than herbicides it commonly replaces and is 1.6 to 1.9 times less likely to persist in the environment.[23] Research from the U.S. indicates that 13.4 million pounds of glysophate have been substituted for 9.9 million pounds of other synthetic herbicides. While glyphosate is indeed considered to be a low risk herbicide, it is often mixed with other chemicals which are toxic. Several of the most common formulations used in Argentina are considered toxic to the development of fish as well as other aquatic organisms.[24]

3. **Reduced Soil Tillage and Water Use**

Zero or reduced till farming is a conservation practice that has been used in a variety of agricultural settings as a method to reduce soil erosion caused through pre and post-harvest cultivation. Such cultivation has traditionally been used to prepare the soil for planting, as well as a means of reducing weeds. Non-transgenic soy can also be planted through no-till methods, but the costs of controlling weeds is significantly higher.

One rather unexpected positive environmental externality related to no-till farming is the retention of a greater amount of greenhouse gases. This has reduced the amount of carbon released into the atmosphere. As the total area under direct planting in Argentina increased from 300,000 hectares in 1990//91 to over 5.5 million hectares, some experts estimate that over 100 million metric tons of carbon have been conserved.[25]

B. **Environmental Risk factors**

Ecologists are widely concerned about the negative impacts of transgenic crops on eco-systems. The release of exotic, non-GM, plants into foreign ecosystems has wrecked havoc in a wide variety of locations over the years. Concerns are amplified with GM crops because they are not only different from native plants and animal species, they are also new and novel. These are brand new organisms that have not been released into any ecosystem.

1. Weediness

There is a concern that GM plants will begin to grow and multiply on their own like weeds and overtake native plants in the area. This concern is mitigated with soybeans (*glycine max*) as the cultivated soybean is not regarded as a weed and the glysophate tolerance is not likely to confer any additional weedy characteristics. Soybeans are selected for a lack of dormancy and it is thus extremely unlikely for a soy plant to overwinter. Essentially, the soybean has been selected for domestication for so many years that it is extraordinarily unlikely that it could survive on its own.

2. **Outcrossing**

Outcrossing, or the crossing of GM soybeans with native plants, is an issue for countries that have wild annual species of the same subgenus, *glycine*. As soy is not native to Argentina, no wild species are found and it would be impossible for outcrossing to occur. This is not the case for sunflowers in Argentina and thus far commercialization of GM sunflowers has not occurred for precisely these concerns. With respect to soy, the wild species are found in China, Japan, and Korea.

Concern for outcrossing in general should not, however, be quickly dismissed, particularly considering the great biological diversity that exists in Argentina and in other countries in the region. The Americas region is the center of genetic diversity for a large number of plant species and the introduction of GM plants could further reduce genetic diversity. This concern is particularly relevant to Mexico with regards to corn as it is the center of origin for that crop. [26]

3. **Non-Target Effects**

There exists strong concerns among many ecologists that crop biotechnology might impact non-target organisms such as animals, plants, and microorganisms which are not pests. These concerns were given some support by research that monarch butterfly larvae that fed on milkweed leaves dusted with Bt corn pollen had a significantly higher mortality rate. However, this research has been widely criticized in most scientific circles. The concern of non-target effects is primarily a concern for insect-resistant plants and not herbicide-resistant ones. Glyphosate tolerant soybeans are judged to have no detrimental effects on non-target organisms. Field observations have revealed no negative effects on non-target organisms including insects, birds, or other species that frequent soybean fields.[27] However, glysophate as a broad-range herbicide also kills many organisms that are beneficial such as spiders and other insects.

4. **Weed Resistance**

In the past, it has been well documented that the repeated and massive use of only one herbicide leads to the gradual development of resistance among weeds. Herbicide resistant weeds are a genuine concern for many who worry about the truly massive amounts of glyphosate that are currently being used on fields. Glyphosate is generally considered to be an herbicide with a low risk for the development of weed resistance and has been widely used for over 20 years. However, resistant weed populations have been reported in Malaysia and Australia and recent studies of the Pampas region has identified a variety of weeds (*Parietaria debilis, Petunia axilaris, Verbena litoralis, Verbena bonariensis, Hybanthus parviflorus, Iresine diffus, Commelina erecta, Ipomoea sp)* that are suspected of developing a resistance to the recommended dosis of glysophate.[28] These recent studies are supported by the practice of farmers in the fields who have been increasing their application of glyphosate over past years.

IV. NATIONAL REGULATION

As the prior section illustrated, the past several years have begun to detail certain environmental risks factors caused by the introduction of transgenic soy into the agricultural system - primarily the development of weed resistance and the ever-increasing use of glyphosate. The objective of the present section is to analyze the regulatory system in Argentina for dealing with risks associated with GMOs in order to see how the country is managing these risks.

In general, the national regulatory system is Argentina for dealing with genetically modified products is considered to be quite advanced and sophisticated. In the 2001 UN Human Development Report, Argentina's regulatory system, along with that of Egypt, was specifically cited as providing a good example of how a developing nation has developed

regulations for safely introducing GMOS.[29] The national guidelines for Argentina were developed in the early part of the 1990s and were formulated by examining regulations from other countries, primarily the U.S., Canada, and the E.U., and then adapting them to national agricultural conditions.[30]

A. INSTITUTIONAL STRUCTURE AND METHODOLOGY

Regulation is overseen by a special interdisciplinary regulatory commission, *Comisión Nacional Asesora de Biotechnologia Agropecuaria* ("CONABIA")[31], which was created in 1991 in order to provide advice and technical support to the Secretary of Agriculture[32]. The composition of the commission includes representatives from both the private and the public sector. CONABIA focuses on all aspects of the regulatory process, from food safety to environmental assessments. The regulatory system is a "science-based" risk approach, which implies that crops are to be approved for commercialization as long as there is no scientific proof of harm. Such a system is more similar to that of the U.S. than the more "precautionary" approach used by the European Union. Under the EU regulatory system, a transgenic crop is not approved for market until there is firm evidence that it does not cause harm. The EU's more stringent approach obviously greatly reduces the number of plants that are allowed to be commercialized. While the Argentine approach does allow for more crops to pass through the initial stages of regulation, the introduction of market factors, and in particular the ability of a product to be commercialized in the E.U., has substantially limited the number of GM products that have been commercialized.

The development of an interdisciplinary commission is more similar to that of European regulations and differs greatly from the system employed by the United States and is generally considered to be a more effective regulatory approach. The U.S. system, which splits authority between the USDA, the FDA, and the EPA has been criticized for leaving substantial gaps in the regulatory coverage.

The approval system for all GMOs in Argentina is a six-step process:[33]

1. Permission to realize tests in greenhouses.
2. Authorization for field tests - under strict biosecurity requirements
3. Permission for release into the environment - which includes more facilities during the experimental stage.
4. Analysis of the evaluations of environmental impact, human and animal health - with participation of *SENASA (Servicio Nacional de Sanidad y Calidad Agroalimentaria).*
5. Evaluation with regard to the possibility of commercialization, in order to avoid negative impacts on exports - this study is undertaken by the *Dirección Nacional de Mercados Agropecuarios*
6. Permission for commercialization.

Soy RR was the first product approved for commercialization on March 25, 1996.[34]

B. PROBLEMS ASSOCIATED WITH REGULATORY REGIME IN ARGENTINA

1. Funding

One of the primary problems of the regulatory process is the funding of it. Tests are realized not by CONABIA or INTA but rather by the agrochemical companies themselves with government scientists and consultants serving as witnesses. One of the principle challenges for developing nations is not the development of appropriate regulations, but rather the funding needed to research the new challenges presented by biotechnology.[35] INTA's budget has been severely slashed in recent years and there are few resources available to independently finance studies of the effects, particularly long-term, of biotech crops on the environment. The approval process is paid for and carried out by the very biotech companies that want to commercialize the GMOs. INTA provides only supervision for the laboratory tests and the field trials. This problem is not limited to Argentina however, field trials in the U.S. are largely carried out under similar conditions, although universities and research institutes in the U.S. have done some independent research.

2. Control, Compliance, Long-term testing, Bio-vigilance

Currently there is no national system of monitoring and control of transgenic crops, however, the President of INTA, Guillermo Moore de la Serna, foresees the day when Argentina could see itself obliged to implement regional programs of biovigilance.[36] The costs of establishing and maintaining such a system could be prohibitive and are unlikely to be undertaken unless more problems develop with transgenic crops.

Vigilance is currently largely undertaken by the farmers themselves as they are in the best position to ascertain if a particular variety of transgenic soy is underperforming or performing in a way that could damage neighboring crops or the environment. Furthermore, any landowner whose fields are damaged by neighboring GMO crops could be expected to report any such damage to the local authorities.

3. Commercial viability

Step number five of the regulatory process addresses the issue of export viability of the proposed GMO in question. This step essentially limits the crops to those particular varieties that have already been accepted by the European Union. It is for this reason that a much smaller number of GMOs have been approved in Argentina as opposed to the United States. This policy might be changing a bit under the current administration in Argentina.

The past government has maintained that it will not approve any product that it cannot commercialize and had self-imposed a moratorium for three years until more information could be obtained about the risks of GMOs.[37] However, in May of 2001, glyphosate-resistant cotton was approved for commercialization. The release of cotton RR was hailed as a breakthrough for the biotech industry in Argentina and seems to have ended an internal conflict within the government of President De la Rua as to the role of GMOs within the development policy of the nation.[38]

V. TRADE AND ENVIRONMENT

International trade in transgenic soy is one of the most important exports of Argentina and the continued, open access to export markets is essential if cultivation of

transgenic soy, as opposed to conventional soy, is to continue in the country. The relationship between trade in transgenic soy and the environment is difficult to ascertain due to the uncertainty surrounding the environmental risk factors associated with its cultivation. If these risks prove to be relatively minor and controllable, then it is plausible that increased trade could indeed positively contribute to environmental sustainablity. Chudnovsky describes the introduction of transgenic soy to be a "win-win" outcome in terms of protecting the environment and increasing profits for farmers.[39] He sees a "virtuous cycle" developing in the 1990s with the increase of agricultural exports also bringing positive environmental externalities through the introduction of improved technology, in particular, the incorporation of transgenic soy. His analysis of environmental risks factors does however, fail to take into account some of the more recent risks and potential risks that were detailed earlier. If Chudnovsky's argument is accepted, then greater benefit to the environment can be achieved through greater trade and a continued expansion of the area devoted to transgenic soy.

However, the export of transgenic soy could be in jeopardy due to the rising consumer concerns in many parts of the world. Particularly in Europe, but also in the Australia and Japan, consumers are demanding that, at a minimum, products produced with GMOs be identified as such on the package. Some consumer groups have even called for the outright banning of GMOs in the food supply. The issue therefore is how will these labels and standards fit within the international trading regime and in particular within the WTO framework as well as the guidelines established by the new Biosafety Protocol. Stringent labelling requirements or standards against the use of GMOs could substantially alter the exports produced by Argentina and would have a corresponding effect on the production of GMOs within the country and would affect the environment by forcing a shift back to the use of conventional crops. Whether this shift would be a positive or negative for environmental sustainability depends largely on whether the argument for a "virtuous cycle" is accepted. At this stage of development, the positive benefits (decreased use of agro-chemicals, decreased soil erosion) do seem to outweigh the current harms (potential increase in weed resistance). The issue is, of course, whether the *potential*harms will shift the balance in the opposite direction.

VII. SUSTAINABLE DEVELOPMENT

A primary criticism of much of the research on negative environmental effects of transgenic crops has been the narrow scope employed by scientists. In order to truly determine whether the environment is improving or deteriorating a more holistic approach is necessary. The concept of sustainable development provides a theoretical model for looking at the environmental effects of transgenic crops, while also taking into account the socio-economic changes that have been caused through the introduction of transgenic soy.

While the definition remains a bit hazy, "sustainable development" was initially defined by the World Commission on Environment and Development, commonly referred to as the Brundtland Commission, as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." This definition was later explicitly endorsed by major international agreements such as the Marrakesh Agreement Establishing the World Trade Organization[40] and the Rio '92

Agreement. However, this principle is generally a bit vague and is usually only stated in the preface to agreements as a goal for all signatory nations to strive for. The implementation of the principle has proven to be difficult in practice and different nations have developed a wide variety of different policies and regulations in order to achieve the goal. Argentina, as well as most other countries, has accepted the principle of sustainable development as a guideline for policy development and it is therefore fruitful to examine whether the policies and regulations adopted with regards to transgenic soy truly contribute to the sustainable development of the country.

Concern for the environment in Argentina must be tempered by the economic reality that continued or increased economic growth in the agricultural sector is an imperative for the nation. The agricultural sector still comprises one of the most important sectors of the economy and its continued health, growth and stability is imperative for the country to break loose from the economic depression of the last several years. However, concern for growth cannot be allowed to overshadow equitable considerations; the biotech industry should encourage the equitable distribution of wealth if it is to serve as one of the cornerstones of the sustainable development of the country. It is this concern for equity, as well as long-terms environmental risk factors and the possibility of disruption of trade, that must be investigated in greater detail in order to ascertain whether transgenic soy can truly contribute to sustainable development.

A sustainability assessment would need to look at the more general factors listed above, but would also need to look at specific factors, including but not limited to: the growing dependence of farmers on biotech companies, the acceleration of agro-industrial complex and the subsequent increased in the scale of farms, the uniformity of crops, and the potential disruption of ecological balance. Specific studies should be undertaken to look more closely at the cost/benefit advantages to individual farmers, an in-depth study of glysophate usage, and the potential effects on biodiversity. Such an assessment would make an invaluable contribution to determine whether, in the context of a developing nation, biotechnology can assist in sustainable development as its advocates so often proclaim.

VIII. CONCLUSION

Developing firms conclusions about the merits or dangers of genetically modified crops is extraordinarily difficult and the rhetoric on both sides of the debate has often obscured the issues as much as it has clarified them. In the case of Argentina, it seems apparent the debate has shifted beyond *whether* to accept GM technologies to *how* to best control their use in order to contribute to the sustainable development of the nation. Indeed, in the case of certain crops, such as corn, the process of cross-pollination would make it difficult to ever make the entire country GMO-free again. Reduction is possible; elimination is probably not. Nature has evolved in many ways more quickly than the debate and it is important to recognize this and shift to a more nuanced discussion of how the nation can effectively use and properly control this new technology.

The current legal regulatory system is adequate for the current stage of development and the important economic stage - that all approved crops are able to be exported to the European Union - has largely insulated the country from the problem of trade bans and

moratoriums. However, the possible restrictions to trade are likely to increase and it is important that Argentina prepares itself for this eventuality. Furthermore, it is important that more emphasis is placed on compliance in order to avoid potential environmental disasters in the future.

In addition, it is imperative that greater crop diversity, including the planting of non-GMO plants, is encouraged. Not only would this help to reduced the potential for environmental problems, but also it could provide an important new avenue for economic gain. A more mixed system of crops would also help lessen the country's current precarious dependence on two or three varieties of GMO seeds

Finally, it is important that more research be done to assess the sustainability of the current system. The promised of GM technologies is indeed great and Argentina presents an ideal laboratory to begin to examine some of the long-term effects not only to the environment, but also to the agriculture industry and rural communities. The hidden costs of technology are often not discovered until much later in its development and it is imperative that any potential risks be identified before Argentina and other countries begin to adopt the latest offerings of the biotech industry.

FUTURE DIRECTIONS FOR GMO SOYBEAN SUSTAINABILITY STUDY

Further study is needed in some very key areas surrounding GMO soybean production. Some questions we might focus on in subsequent research:

1. Examine more specifically the impacts of GM soybean on human health. Relationship between the growth in chemicals used in the production of GM soy and the related health swings of workers or residents living near soy fields.
2. The Evidence seems to show that yields do NOT increase with GM soy, so is the savings on time of production, balanced by the marginal gains less the costs? What are the related risks and impacts of opting for GM soy?
3. Pesticides in GM soy production are used more intensely than in organic soy. Can we look more closely at the environmentally harmful active ingredients in these pesticides, define and trace influences on human and/or environmental/biological health?
4. Can we identify argentine consumption patterns of these ingredients, examining import volume swings with the rise in GM soy production. What are these risks?
5. Further to 3 and 4, if we can identify what the potential environmental and health risks are for these pesticides, and given the volume changes in consumption, can we draw conclusions for the sustainability of the Argentine market as far as GM soy in concerned?
6. We may decide to do a special in-depth section or study on glyphosate, one of the main herbicides used in GM soy. What available health studies exist on glyphosate? What are its principle environmental impacts? And How do these affect the sustainability of Argentine agricultural production?
7. We might also look at surfacactantes or coayudantes with some of the same questions as in (6).

8. What about the biodiversity impacts of soy for insects? Spiders for example. What negative environmental externalities (affecting the biological chain) might occur if we eradicate certain insects with GM soy?

APPENDIX I: REGULATORY SYSTEM IN ARGENTINA

1. Decreto N. 6.704/66 defensa de la salud de las producciones agricolas y modificaciones.
2. La Ley N. 20.247/73 sobre semillas y creaciones fitogenéticas Decreto Reg. 2183/91 y Resolución SAGyPN 656/92 (Resolución modificada por Resolución SAGyPN N 837/93 y Resolución SAGpyA N 289/97
3. La Ley N 13.636/49 sobre productos veterinarios supervisión de su creación y comercialización - Resolución SAGyPN 226/97

B. Ley N. 6.938/81, Política Nacional del Medio Ambiente

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[1] "Soybean RR" is the specific term generally used to identify soy genetically modified for resistance against glyphosate or Roundup. It is therefore a variety of transgenic soy - the more general term for soy that has been genetically modified in some fashion. The two terms will be used somewhat interchangeably throughout the paper as Soy RR is the only type of transgenic soy currently produced in Argentina.

[2] Janet Carpenter, *Case Studies in Benefits and Risks of Agricultural Biotechnology: Roundup Ready Soybeans and Bt Field Corn*, National Center for Food and Agricultural Policy (2001).

[3] Id., 11.

[4] Walter A. Pengue, *Expansion de la soja en Argentina. Globalización, Desarrollo Agropecuario e Ingeniería Genética: Un modelo para armar*. GRAIN, 3 (2001) at http://www.biodiversidadla.org/documentos/documentos167.htm.

[5] Id.

[6] Carlos Galperín, Leonardo Fernández & Ivana Doporto, *Los productos transgénicos, el comercio agricola y el impacto sobre el agro argentino*, in COMERCIO Y MEDIO AMBIENTE EN EL SECTOR AGROALIMENTARIO ARGENTINO (Universidad de Belgrano, 2000).

[7] Sean Murphy, *Biotechnology and International Law*, Harvard International Law Journal, 55 (Winter 2001).

[8] http://www.nidera.com.ar

[9] Carlos Galperín, Silvia Fernández & Ivana Doporto, *Los requisitos de acceso de carácter ambiental: Un problema futuro para las exportaciones argentinas?* in COMERCIO Y MEDIO AMBIENTE EN EL SECTOR AGROALIMENTARIO ARGENTINO (Universidad de Belgrano, 2000), 10.

[10] Id.

[11] Amartya Sen, Development as Freedom, "Population, Food and Freedom" (Ch. 8) for a clear exposition of the position. Mr. Sen concludes by saying "there is little reason for any great pessimism that food output will soon start falling behind population growth. In fact, a tendency to concentrate on food production only, neglecting food *entitlement*, can be deeply counterproductive." p. 209.

[12] *Transgenic Plants and World Agriculture*, National Academy of Sciences (2001),.3-4.

[13] Http://www.monsanto.com.ar/biotechnologia

[14] Id.

[15] Pengue

[16] Charles Benbrook, *Tiempos problemáticas en medio del éxito comercial de la soja Roundup Ready*, Northwest Science and Environmental Policy Center (2001). "There is clear and voluminous evidence that the soy RR produces 5 to 10% less per acre than other varieties cultivated under similar conditions."

[17] Pabla Ortega, *La Segunda revolución verde*

[18] Adolfo Boy, *Soja y trigo transgenicos*, Grupo de Reflexion Rural (2000).

[19] Mike Holmberg, *Cheaper Roundup Ready seed gives Argentina an advantage,* Contemporary Review (2000).

[20] Dr. Mae Wan Ho, *Golden Rice: An exercise in how not to do science,* Third World Network (2000), http://www.twnside.org.sg.

[21] Benbrook, p.2 analyzing information provided by the USDA. One important caveat, however, it is important to note the crudeness of these statistics as a number of other factors such as pest infestation levels, crop rotations, soil and climate factors could also affect the use of pesticides in any given year or period of years.

[22] Pengue, 8,9.

[23] Daniel Ervin, *Transgenic Crops: An Environmental Assessment*, Henry A. Wallace Center for Agricultural & Environmental Policy at Winrock International (2000), 17.

[24] Pengue, 11.

[25] Daniel Chudnovsky, Sebastián Rubin, Eugenio Cap & Eduardo Trigo, *Mejoras Ambientales sin Politicas Específicas : Las exportaciones manufactureras y agrícolas en los anos 1990,* Centro de Investigaciones para la Transformación (1999), 8.

[26] See Alejandro Nadal, *Genetic Variability and Trade Liberalisation: The case of corn in NAFTA.*(on file with author).

[27] Carpenter., 15.

[28] Pengue, 11.

[29] 2001 UN Human Development Report, 75.

[30] Id., 76.

[31] www.sagyp.mecon.ar

[32] *Secretario de Agricultura, Ganaderia, Pesca y Alimentación*

[33] Galperin, 45.

[34] Resolution SAPyA N. 167, www.sagpya.mecon.gov.ar

[35] 2001 UNHDR

[36] Guillermo Moore de la Serna, *Bioseguridad Alimentaria*, Archivos del Presente, no. 19, March 2000, Buenos Aires, 6.

[37] Angel Palermo, "El Gobierno dice que será estricto" La Nacion, May 12, 2001, sec. 5, p.7.

[38] Id., 5.

[39] Chudnovsky, 3.

[40] From the preamble: "The Parties to this Agreement, Recognizing that their relations in the fields of trade and economic endeavours should be conducted with a view to raising the standards of living, ensuring full employment and a large and steadily growing volume of real income and effective demand, and expanding production of and trade in goods and services, while allowing for the optimal use of the world's resources in accordance with the objectives of sustainable development, seeking to protect and preserve the environment and enhance the means for doing so in a manner consistent with their respective needs and concerns at different levels of eco