EXECUTIVE BRIEF

Environmental Benefits of Biotechnology in Brazil

"The YieldGard corn case"

Agriculture is the oldest and most important economic activity in the planet, occupying, at present, approximately 40% of the global area (COAG, 2007), generating 1.3 billion jobs and annually producing circa US$ 1.3 trillion in raw materials and merchandise (EL FEKY, 2000).

According to the United Nations Population Fund – UNFPA, the increase in population, and, consequently, in consumption, are aggravating the stress on the environment worldwide, increasing global heating, deforestation, and water shortage, and decreasing areas of harvestable land.

Even in face of intransigent disputes, the harvest of genetically modified crops has expanded throughout the world, and has become the fastest adopted technology in the history of agriculture, being singled out as vital to breakthrough the barrier of productivity (MANN, 1999) and as providing a solution for the restrictions imposed by biotic and abiotic stress, particularly in areas in which low productivity, malnutrition and hunger are constant threats (HERRERA-ESTRELLA, 2000).

The responsible management of biotechnology has enabled the first twelve years of GM crops to be conducted without any of the terrifying results predicted by the technology's opponents. In 2007, 114.3 million hectares of GM crops were planted by 12 million farmers in 23 countries, in comparison to the 102 million hectares planted by 10.3 million farmers in 22 countries in 2006.

According to Peter Raven, it is evident that global climate changes require fast adaptations to be made in crops for food production, which can only be sustained by using the most efficient tools available, including those that allow for greater water conservation. However, these changes will not be achieved if the paradigm of the negative effects caused by GM crops is not overcome. A great contradiction lies in the fact genetically engineered medications are approved in industrialized countries because they need them, while the production of food by a similar method is not approved for undernourished Africans.

In this sense, the most promising option in terms of technology to increase the supply of food, animal feed, and fibers, is to combine the advantages of the old and new, integrating the best of conventional technology (adapted germplasm) with biotechnological applications (new traits) (JAMES,2006).

In 2007, Brazil continued ranking third in areas planted with GM crops, planting in 15 million hectares, despite the fact that estimates show that the country has reached its greatest absolute growth this year, with a variation of 3.5 million hectares with GM plantations, followed by the Unites States, with 3.1 million hectares, and India, with 2.4 million hectares (JAMES, 2007).

Approximately millions of producers are already employing GM varieties in their plantations worldwide (JAMES, 2007). Thus, the implementation of genetically modified crops may be considered one of the pillars of the global strategy for the fight against poverty and hunger, which needs to include a sufficient distribution of improved foods (JAMES, 2006).

GM corn is the third GM agricultural trait to receive approval for planting in Brazil, following soybean and cotton.

The approval of insect-resistant corn in Brazil in February of 2008, will bring about benefits such as a decrease in water and soil contamination; a drop in the emission of greenhouse gases; and the guarantee of better health and life standards for producers (VILLALOBOS, 2007).

The overall purpose of this study is to analyze the environmental impacts generated by the adoption of insect-resistant corn in Brazil by reviewing the scientific literature on the environmental impacts resulting from growing it in Brazil and, as a world reference, to establish and explain the social-environmental benefits achieved and observed by the producer as a result of adopting the genetically modified corn technology.

Secondly, through this study it was also possible to analyze the user's expectation (rural producer) related to the social-environmental aspects inherent to the YieldGard technology.

METHODOLOGY

The methodology used in this study included conducting local interviews with rural producers chosen from maize producing regions. The states sampled for the 1st corn crop (summer corn crop) were Paraná, Rio Grande do Sul, Minas Gerais, Goiás, Santa Catarina, São Paulo, and Mato Grosso, which account for 90% of the total harvested with corn in 2006/07. On the other hand, for the 2nd corn crop (winter corn crop), the states sampled were Paraná, Mato Grosso, Mato Grosso do Sul, Goiás, São Paulo, and Minas Gerais.

In view of the corn planted areas in the 2007/08 crop year (10,162 thousand hectares), the interviews with producers were planned based on a ratio of one interview for every 55.8 thousand hectares of planted area, amounting to a total of 182 interviews (statistically rounding off numbers, being 92 interviews for 1st corn crop and 90 interviews for 2nd corn crop).

Even before these aspects, the results obtained in this study showed that the rural producer expects that the adoption of YieldGard corn in Brazil will result in social-environmental benefits.

Phase I

In this phase I, technical visits were made to regions that are reference in the production of corn in Brazil. In this visits, interviews were made with agricultural consulting companies responsible for the technical accompaniment of properties in the region.

As a reference, to summer corn crop area, Paraná and Goiás model producers were interviewed, as technical assistance companies, aiming to determine what is the potential outcoming from YieldGard corn adoption in Brazil of producers known as first class, referring to manager and agronomical practices. The model producers of winter corn crop were interviewed in Mato Grosso and Mato Grosso do Sul states, as technical assistance companies from those regions.

With the information obtained on field interviews was possible to estimate:

- The reduced use of water;
- The reduced use of fossil fuel;
- The reduced emission of carbon dioxide.

Still in the first stage study, by means of the agronomic model of handling and production, it was possible to estimate the use of active ingredient (a.i.) and assess the toxicological profile of the main agrochemicals used in the corn crop, having the conventional and transgenic (YieldGard) crops as reference. To do so, the methodology was based on the survey of the following production item for both production systems:

- Number of agrochemical sprays;
- Survey on the average consumption of fuel;
- Survey on the average consumption of water used in the preparation and application of the agrochemical solution;
- Survey on the typical package of inputs used

For these variables, the units used were: hectare (10,000 m^2) for area, kilogram (Kg) for mass, and liters or m^3 for volume.

Phase II

The phase II was essentially aimed at assessing the socio-environmental benefits observed by a wider sampling of 1st and 2nd corn crops producers and thereby, identifying their perception of general socio-environmental themes, and themes that are specific to the YieldGard technology.

In the first part of the questionnaire, with general themes, was intended to obtain the opinion of rural producers regarding themes like genetics and biology of the YieldGard corn, the influence of transgenics in the physical environment (soil, air, and water) and in biodiversity, aspects of food safety, health, and safety of rural workers, quality of life, and agricultural production.

The second part of the questionnaire was intended to identify the level of attractiveness and environmental risk experienced by the rural producer through the adoption of the YieldGard corn. With the purpose of providing information to assist the studies on the environmental impact of the YieldGard corn in Brazil, adaptations of the SWOT analysis methodology and the Porter strategic positioning analysis were developed. Both methodologies were used to elaborate prospective scenarios, defining environmental indicators and evaluating strong points, weak points, opportunities, and threats that influence the environment.

In this study, the strong points and opportunities were referred to as environmental attractiveness, while the weak points and threats were referred to as environmental risk, so as to demonstrate the advantages and disadvantages of the adoption of genetically modified products.

Therefore, relevance (weight) and efficacy (response) values were assigned to each indicator in a relative way (considering the importance of each indicator compared with all others), in order to obtain indexes for the intended evaluations. These indexes result from the multiplication of the values assigned to the relevance (between 0 and 100%) by the efficacy values (between 0: poor response, and 10: superior response) of each impact. Below is the mathematic reasoning used to define the analysis of attractiveness and environmental risk.

$$At = \sum_{1}^{n!}(N \times W) \qquad\qquad Ri = \sum_{1}^{n!}(N \times W)$$

Where:

At : socio-environmental attractiveness

Ri : socio-environmental risk

n! : total number of interviews made with producers

N : Grade assigned to each variable defined to attractiveness and socio-environmental risk, as the relevance indicator

W : weight assigned to each variable

Provided that, N for the attractiveness (minimum: 0 and maximum: 10) and N for the risk (minimum: 10 and maximum: 0), reminding that at least one variable must be graded 10.

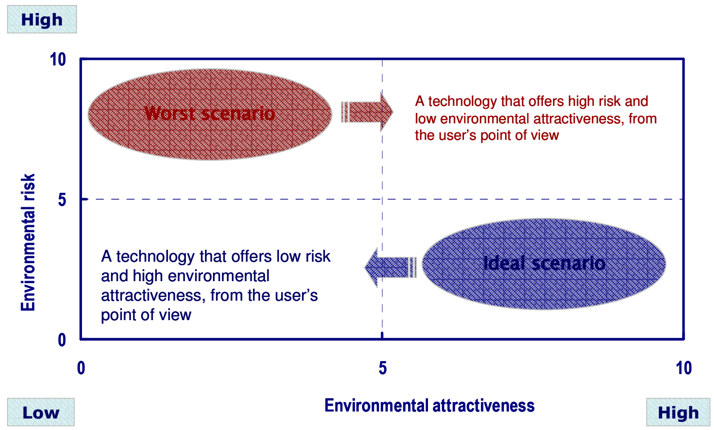
Provided that, W is the weight assigned to each variable, ranging from 0.0 to 1.0, with total equal 1.0.

The sum of the indexes related to the environmental attractiveness and environmental risk, when compared, shows if the advantages overcome the disadvantages, in order to assess the validity of a continuation in the adoption of the technology, considering the impacts involved (PESSÔA; CARVALHO; PEREIRA JR., 2005).

The values considered for weights (W) were based in the fundaments of the technology developed, from evaluations of the transgenic agriculture and conventional agriculture available in the scientific literature. Differently, the values for the relevance indicator (N) were obtained from field researches in the states selected in the study.

By means of the analysis of matrixes elaborated for the YieldGard corn, it was possible to build the matrix that demonstrate what the ideal scenario would be to continue the adoption of transgenics, and the worst scenario, which would result in the discontinuation of the adhesion to the technology.

Figure 1. Projection of the ideal scenario and worst scenario to evaluate the continuation of the adoption of transgenics



Source: Céleres Ambiental

PHASE I RESULTS

Water is an indispensable natural resource, since it is a vital input for production and a strategic resource for economic growth. Water is also crucial for maintaining the biological, geological, and chemical cycles that hold together the balance of ecosystems, being thus considered essential for agricultural production.

Hydric resources are most commonly and frequently used in connection to the agricultural sector (irrigation), industry, and urban supply. As economic activities become more diversified, the need for water increases and levels of sustainability need to be achieved to counterbalance the pressures of the consumer society, and industrial and agricultural production.

Biotechnology is a strategic tool in environmental conservation as it allows for the rationalization of the employment of natural resources. The adoption of biotechnology, in the case of YieldGard corn, decreases the number of insecticide sprayings, which results in many environmental gains, such as a substantial decrease in the volume of water used in the mixture sprayed on the fields, a decrease in volume of diesel oil used as fuel in the sprayers, and, consequently, a drop in greenhouse gas emissions released into the atmosphere.

Analyzing the corn crop in Brazil and using the states of Goiás e Paraná as references (for the summer crop) and Mato Grosso and Mato Grosso do Sul (for the winter crop), considering an average consumption of 120 liters of water used to prepare the mixture sprayed per hectare, an annual savings of 360 liters of water per hectare is expected, assuming an average decrease of 3 applications of insecticides on YieldGard corn fields, considering a self-propelled sprayer with a 2,000-liter tank capacity.

Environmental problems are caused by an intensified use of natural resources, particularly of fossil fuels (Kaya & Yokobori, 1997), nonetheless, in many urban centers around the world, the emissions from vehicles are increasingly contributing towards the deterioration of air quality and environmental damages (Kojima & Lovei, 2000).

One of the social-environmental benefits from the adoption of Biotechnology is the saving in fossil fuels, in this case, diesel oil.

Still assessing the states considered as reference for the 1st corn crop, Goiás and Paraná, and for the 2nd corn crop, Mato Grosso and Mato Grosso do Sul, we can expect a savings in the consumption of diesel oil of three liters per hectare annually considering a self-propelled sprayer, with an average yield of 12 liters of diesel per hour.

Taking into account a drop in the insecticide sprayings on YieldGard corn fields, and, consequently, savings in the consumption of diesel oil, it is possible to quantify the emission of Greenhouse Gases – GEE in Portuguese, which decreased as a result of the drop in use of the fossil fuel. This assessment was based on the IPCC (Intergovernmental Panel on Climate Change) methodology, which analyzes the emissions of greenhouse gases from moving sources, considering the quantity of burnt fuel, carbon content, and the corresponding CO_2 emissions.

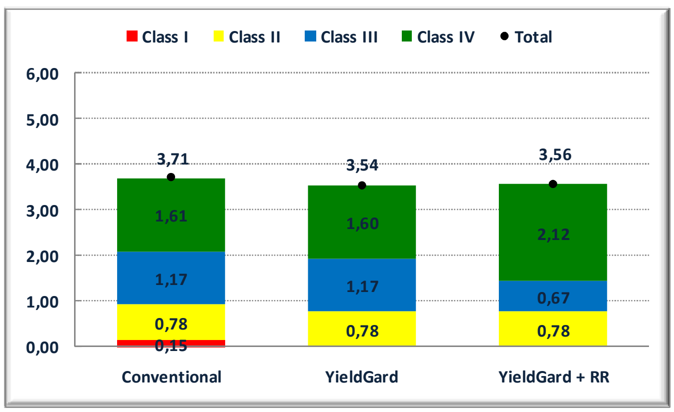
The projected savings of 3 insecticide sprayings on YieldGard corn fields implies a CO_2 annual decrease of 0.0077 tons per hectare, released into the atmosphere, i.e., minus 7.7 kilos of CO_2 projected for the crops that adopt this technology, using the same sprayer described above.

One of the major problems faced by the farmers in Brazil is the incidence of pests in the corn crop. Based on information gathered in the field interviews with farmers and the technical staff of consultants in charge of monitoring some properties, it was possible to identify the package of products used in the summer and winter corn crops in Brazil. This information served as tools used to analyze the technological package for the YieldGard and YieldGard+RR treatments. The Brazilian states considered for the analysis of the 1st corn crop technological package were Goiás and Paraná, and for the 2nd corn crop, the states of Mato Grosso and Mato Grosso do Sul.

The YieldGard technology ensures a drop in insecticide applications on the corn fields, which translates into a large environmental benefit of smaller quantities of active ingredients contaminating the soil and springs and, thus allowing for a more protected environment.

Based on the management observed in the conventional corn fields for the summer crop, and in view of the figures expected around the technological package with the adoption of the YieldGard technology, the total quantity of active ingredient per hectare (a.i./hectare) would drop by 4.6% through the adoption of YieldGard corn, and 4% through the adoption of YieldGard+RR.

Figure 1. Profile of the use of active ingredients employed in corn in the state of Goiás, per kg of a.i./ha



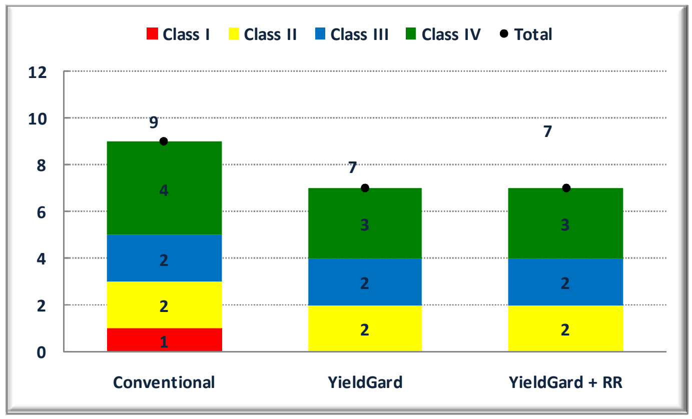
Source: Céleres Ambiental based on technical field visits.

It is worth stressing that what is most significant in terms of environmental impact is the reduction in the active ingredients from toxicological classifications that are more aggressive to the environment and human health. In view of the foregoing, and analyzing it, we notice that both the YieldGard, as well as the YiledGard+RR treats allow for the exclusion of toxicological class I products, deemed to be the most aggressive to the environment.

Besides directly reducing the usage of the active ingredient per hectare, the adoption of the new traits would have a direct impact in reducing the number of agrochemicals employed in the management of the corn fields, with implications on logistics, as a smaller volume of transported inputs would be needed; on the environment due to the smaller volume of discarded packages; on management as the need for storage would decrease; on security as it would diminish the risk of agrochemicals being stolen in farms, and, above all, by greatly facilitating the production process management.

According to the corn management observed in the state of Goiás, we can conclude there has been a 22.2% drop in the number of products employed in the fields that adopted the YieldGard or YieldGard+RR traits, showing that these traits will bring about huge social, environmental, and economic benefits for the corn crop in Brazil. This occurs because, according to estimates, there has been a gradual decrease in the number of products employed with the adoption of YieldGard and YieldGard+RR, enabling a reduction of up to 2 products through the adoption of such technologies.

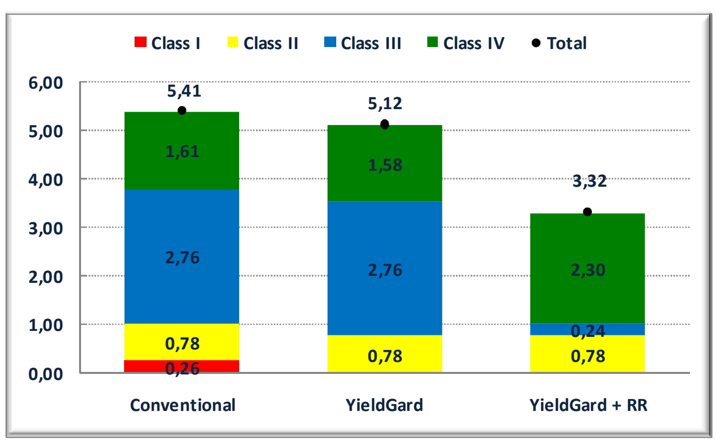
Figure 2. Number of products used in the corn crop in the state of Goiás, and estimate of number of products after YieldGard and YieldGard+RR have been adopted



Source: Céleres Ambiental based on technical field visits.

In the state of Paraná, also for the 1st corn crop, it was observed that more products were being used in the fields in comparison to the state of Goiás. However, the adoption of YieldGard corn would allow for a decrease by 5.4% in the total of active ingredients in relation to conventional corn. When comparing conventional corn to the YieldGard+RR trait, the total reduction of active ingredients would amount to 38.6%, further reinforcing the already proven environmental benefits from the traits that are being commercialized. It is further possible to conclude that, besides the total drop in the quantity of active ingredients once biotechnology is adopted, another benefit must be taken into account, the elimination of toxicological class I products, deemed to be the most aggressive to the environment and human health.

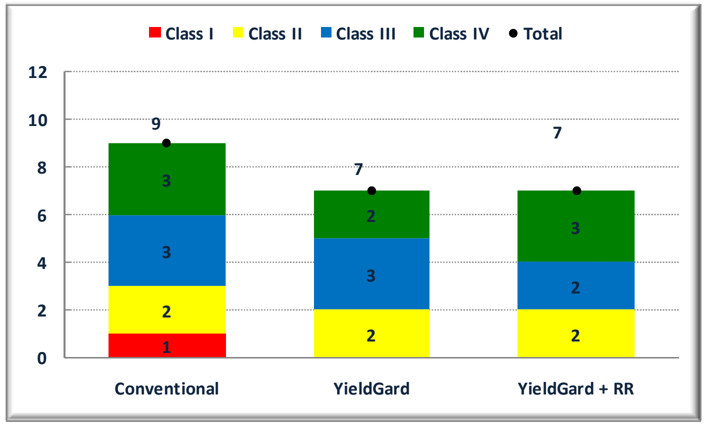
Figure 3. Profile of the use of active ingredients employed in corn in Paraná, per kg of i.a./ha



Source: Céleres Ambiental based on technical field visits.

It can be declared that the elimination of toxicological class I products in the case of adopting YieldGard corn and the possible approval for the commercialization of YieldGard+RR corn, which implies in a smaller use of active ingredients in the fields per hectare, the use of less aggressive products and, consequently, a smaller environmental impact.

Figure 4. Number of products used in the corn crop in Paraná, and approximate number of products after adoption of YieldGard and YieldGard+RR

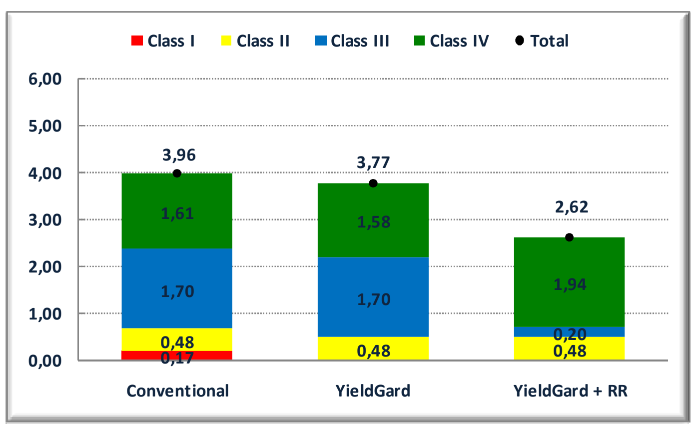


Source: Céleres Ambiental based on technical field visits.

Thus, the same technological package analysis projected for the 1st corn crop was applied to the 2nd corn crop in the chosen states, as a reference being Mato Grosso and Mato Grosso do Sul.

In the case of the management observed in areas cultivated with corn in Mato Grosso, the YieldGard technology reduces by 4.8% the total volume of active ingredients used, per hectare, in the corn crop however, the adoption of new traits can lead to a drop in up to 33.8 % in the volume of a.i. per hectare in the case of the projection for YieldGard+RR. Another relevant data is that the YieldGard and YieldGard+RR technologies allow for the elimination of toxicological class I, which is very aggressive to the environment and human health.

Figure 5. Profile of the use of active ingredients employed in corn in Mato Grosso

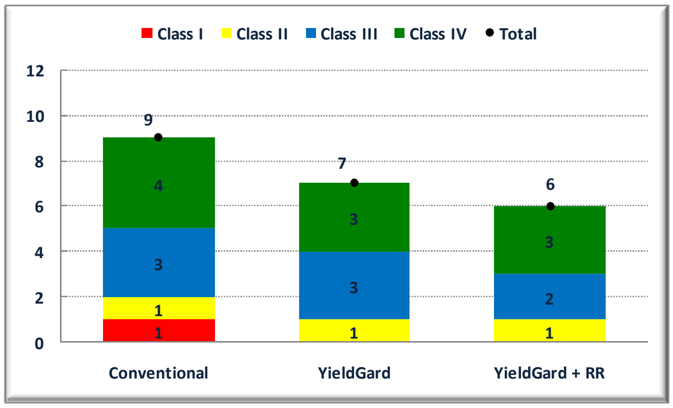


Source: Céleres Ambiental based on technical field visits.

As in the example of the setting projected for the 1st corn crop we also expect a decrease in the number of agrochemicals used for the 2nd corn crop after the new traits have been put in place. The positive impacts are seen in the decrease in volume of transported products, benefiting logistics; in a smaller volume of discarded packages, avoiding negative impacts on the environment; in a reduced need for storage due to a reduction in the volume of products; in the reduced risk of agrochemicals being stolen in farms, providing for greater security in the farming zones; in the improved production process management; and, furthermore, in the benefit of the rural worker's health.

According to the 2nd corn crop management observed in Mato Grosso, we noticed a reduction in the number of products for the YieldGard corn crop in comparison to conventional one. Out of the 9 products used in the conventional crop, the YieldGard technology enables a savings of 2 products. However, after the approval of the new YieldGard+RR trait, the number of products needed in the crops would be of only 6, which reinforces the need for approval of the other new traits so that Brazil may achieve the positive results already confirmed in countries in which these new traits have already been approved.

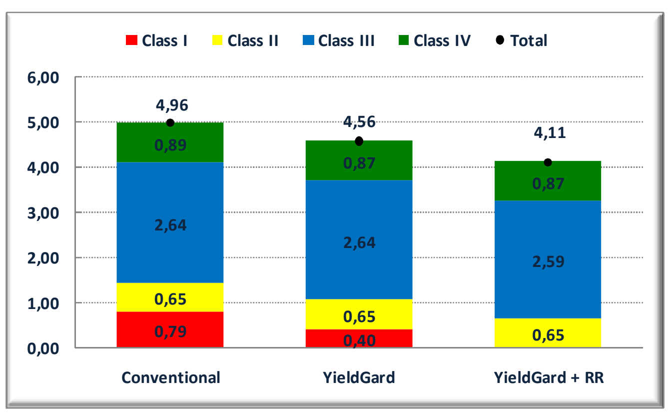
Figure 6. Number of products employed in the corn crop in Mato Grosso, and approximate number of products after YieldGard and YieldGard+RR have been adopted



Source: Céleres Ambiental based on technical field visits.

In the state of Mato Grosso do Sul, according to the data from field surveys and interviews conducted with the consulting companies in order to identify the corn technological package, the YieldGard corn technology favored a drop of 8.06% in the total active ingredients in the corn crop in comparison to the conventional corn crop. The forecast for the YieldGard+RR trait is of a drop of 17.13% in the total active ingredients in comparison to the conventional corn crop. It is worth highlighting that this trait would enable the exclusion of the toxicological class I products, which are the most aggressive to the environment and human health.

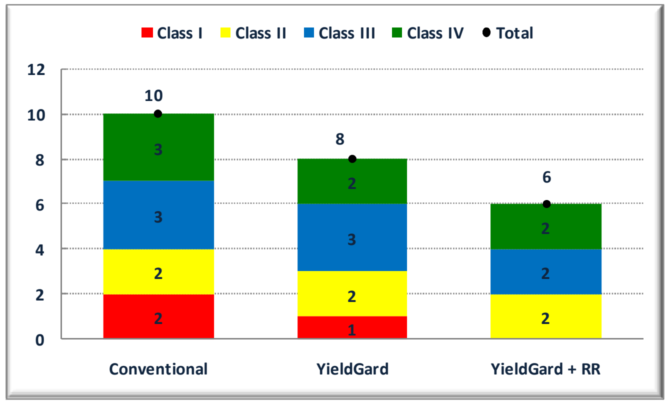
Figure 7. Profile of the use of active ingredients employed in corn in Mato Grosso do Sul



Source: Céleres Ambiental based on technical field visits.

The field research results in the state of Mato Grosso do Sul indicated the approximate number of products employed in the conventional corn crop and the number of products for the YieldGard and YieldGard+RR traits. It can be observed that the YieldGard technology will enable a savings of 2 products in the technological package in comparison to the conventional corn crop and the YieldGard+RR trait, and, it will save the application of 4 products in comparison to conventional corn. Again, it is important to emphasize that the social-environmental benefits grow with the new traits, which shows the need for their approval.

Figure 8. Number of products employed in the corn crop in Mato Grosso do Sul, and estimate of products after the YieldGard and YieldGard+RR traits are put in place



Source: Céleres Ambiental based on technical field visits.

PHASE II RESULTS

By means of environmental questionnaires, conducted during the field visits, it was possible to gather relevant social-environmental information related to corn growing in Brazil. The questions asked included both the quantitative and qualitative aspects related to the possible social-environmental benefits from adopting YieldGard corn, with a view at gathering relevant information on this subject with rural producers.

The farmers were questioned about the environmental and social benefits expected as a result of adopting YieldGard corn. The questions addressed their expectations regarding water, soil, wildlife, and air quality improvement.

1st Corn Crop – Summer

In the case of water, most rural producers expect there will be some difference in the quality of the water in their farms. It was observed that their expectation is that this difference would be a large difference in terms of quality, and for most of the interviewed, it would add a significant advantage to their business.

Regarding the increase of wildlife locally and surrounding the farm, a great part of the farmers interviewed expect some difference in wildlife, and the vast majority expects the number of animals to be quite different, that is, to increase with time. According to the questionnaires filled out during the field interviews, nearly 83% of the producers see this difference in wildlife as a major advantage for their business.

The farmers also expect an improvement in soil quality with the adoption of the YieldGard technology. The trait enables a smaller number of entrances of machines into the ground, with a drop in insecticide sprayings. It was observed that most of the interviewed agreed that the improvement in soil is a major advantage for their business.

The improvement in the quality of the air is one of the most difficult benefits to measure according to the farmers. However, it can be concluded that the YieldGard technology enables a smaller traffic of machines in the fields, and, therefore, it ensures more savings in fossil fuels, generating, in turn, a drop in greenhouse gas emissions released into the atmosphere, contributing to the quality of the air. In view of the foregoing, it is observed that most of the interviewed expect some improvement in the air quality in their farms, which, according to them, is a benefit that translates into a large advantage for the activities they perform.

2nd Corn Crop – Winter

For the 2nd corn crop, the questions asked revolved around the same expectations in terms of water, soil, wildlife, and air quality improvement.

Regarding water quality, most of the interviewed expect there will be some improvement. And according to the vast majority, this is a major advantage for their business.

Regarding the increase of wildlife locally and surrounding the farm after the adoption of YieldGard corn, a vast majority of the interviewed expects the technology to facilitate an increase in the number of animals since it will allow for a drop in volume of insecticides used in the fields. Furthermore, according to the reports of the interviewed, this environmental benefit is a major advantage for their business.

In terms of their expectation regarding soil quality improvement, most of the interviewed expect some difference, which for owners or farm administrators is a major advantage for their business. This improvement in soil quality is directly related to decreased erosion and compacted soils resulting from decreased traffic of heavy machinery in the fields once the YieldGard trait is adopted.

Based on the literature reviewed and field visits at the summer and 2nd corn crop farms, the indicators considered as being the most significant and their respective weights regarding YieldGard corn in Brazil are shown in the attractiveness and environmental risk matrices below.

Figure 1. Environmental attractiveness matrix for YieldGard corn in Brazil

	SCORE CRITERIA*		Weight
	MÍN	MÁX	(0% a 100%)
Increase protection against pests and diseases	0	10	40,5%
Reduction in agrochemicals use	0	10	27,0%
Biotech events released through more strict procedures for biosafety	0	10	16,2%
Better quality and sustentability of production	0	10	8,1%
Better optimization of production factors	0	10	5,4%
Greater safety conditions for workers	0	10	2,7%
Weighted Environmental Attractiveness			100,0%

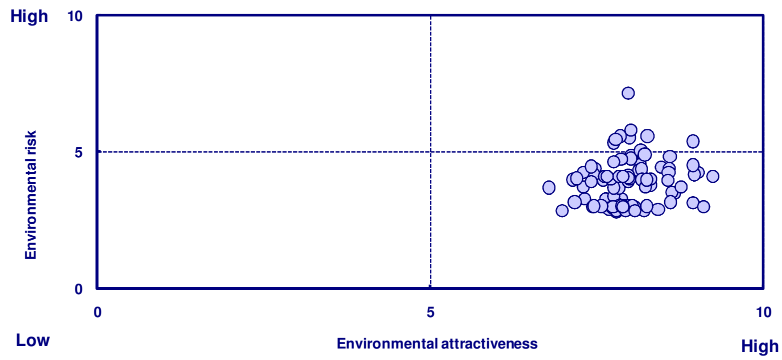
Figure 2. Environmental risk matrix for YieldGard corn in Brazil

	SCORE CRITERIA*		Weight
	MIN	MAX	(0% to 100%)
Contamination of conventional crops by gene flow	10	0	25.0%
Dependence of farmers to acquire the technology	10	0	17.0%
Development of resistance by target plagues	10	0	15.0%
Lack of knowledge by farmers on biosafety procedures	10	0	13.0%
Reduced biodiversity	10	0	12.0%
Appearance of undesirable new species and substances	10	0	10.0%
Uncertainties about the spot of insertion and expression of the genes inserted	10	0	8.0%
Weighted Environmental Risk			100.0%

The analysis of the field data and of the answers given in the interviews did not only show, but above all, reinforced the expectations around the benefits from the YieldGard trait. Thus, the simple interpretation of the results obtained from the attractiveness and environmental risk matrices, in which the sum of the relationship between the attractiveness weight and relevance overrides the sum of the variables resulting from environmental risks, shows favorable results towards the adoption of YieldGard corn in Brazil, although there are differences in opinions amongst the 1st corn crop and 2nd corn crop growers.

The expected distribution of the results from the environmental attractiveness analysis based on each of the field questionnaires for the summer and 2nd corn crops, shows that the YieldGard technology offers a low environmental risk and high environmental attractiveness.

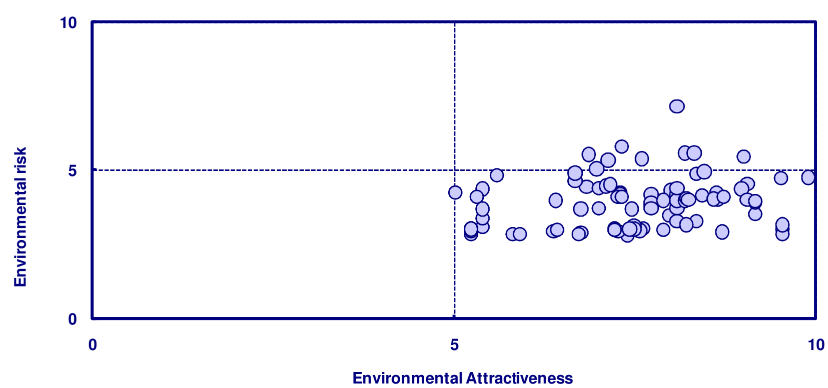
Figure 3. Attractiveness/ risk environmental matrix of the YieldGard 1st corn crop in Brazil



Source: Céleres Ambiental based on field survey

Similarly, the following figure shows the distribution of the outcome of analysis of expected environmental attraction based in each of the field questionnaires to 2nd corn crop, showing that in this case, YieldGard technology offer low risk and high environmental attractiveness environment as well.

Figure 4. Attractiveness/risk environmental matrix of the YieldGard 2nd corn crop in Brazil



Source: Céleres Ambiental based on field survey

It is worth stressing that judging from the data and information obtained with the farmers in the field survey, there are differences between the results from the attractiveness/ risk environmental matrix for the summer and for winter corn crops, and this is basically due to the fact that the 2nd corn crop growers already have some kind of comparative parameter from the insect-resistant traits, for being eminently concentrated in the midwest, particularly in Mato Grosso and Goiás, since in these states the production of Bollgard cotton has been already in existence for at least two farm years.

In view of the foregoing, we observed high expectations from the farmers regarding the social-environmental benefits from adopting the YieldGard trait.

EXAMINING THE SOCIAL-ENVIRONMENTAL BENEFITS FROM ADOPTING YIELDGARD CORN IN BRAZIL

Minimizing the use of natural resources implies in reducing the negative impacts on the environment, favoring the preservation of ecosystems. Biotechnology is an important tool within this context, as it enables rationing the use of natural resources such as water and the fossil fuel. In this context it is evident the need to estimate and quantify the social and environmental benefits that can be obtained by Brazilian corn producers, for the simple adoption of YieldGard trait.

Taking as reference the data obtained from the benchmark for the states of Paraná, Goiás, Mato Grosso and Mato Grosso do Sul, optimizing the use of water for the preparation of spray volume was estimated in 360 liters per hectare per year with YieldGard trait. Based on this analysis and extrapolating the data to the national scenario, considering the projection of planting 1.44 million hectares with YieldGard corn crop year in 2008/09 (CELERES, 2008), and reduction of 3 applications of insecticides, we can infer a reduction in the use of water of approximately 519 million liters this season only.

We conclude that depending on the effectiveness of YieldGard trait in controlling target pests and operational efficiency of equipment, the effective reduction in the use of water for the preparation of the solution may range from 144.1 million to 1.4 billion liters a year.

Figure 1. Reduction in water volume for preparing the mixture sprayed on the YieldGard corn fields in Brazil. 2008/09 crop year

Solution applied (l/ha)	Number of applications reduced with YieldGard maize					
	1	2	3	4	5	6
	Volume of water saved (million l/year)					
100	144,1	288,3	432,4	576,6	720,7	864,9
110	158,6	317,1	475,7	634,3	792,8	951,4
120	173,0	346,0	518,9	691,9	864,9	1.037,9
130	187,4	374,8	562,2	749,6	937,0	1.124,4
140	201,8	403,6	605,4	807,2	1.009,0	1.210,9
150	216,2	432,4	648,7	864,9	1.081,1	1.297,3
160	230,6	461,3	691,9	922,6	1.153,2	1.383,8

1/ Considering a self-propelled sprayer with a load capacity of 2,000 liters.
2/ Considering a self-propelled sprayer with an average consumption of 12 l of diesel/hr.
Source: Céleres Ambiental based on field survey

Along the same line of reasoning, based on data gathered and summarized in the above mentioned states, and also taking into account the same planting projection of 1.44 million hectares (summer + winter) for YieldGard corn in the 2008/09 crop year (CÉLERES, 2008), it is possible to predict an annual savings for Brazil from 1.7 to 6.5 million liters of diesel oil, depending on the YieldGard corn trait efficiency. In the base scenario at stake, with a savings of 3 insecticide sprayings, we estimate a drop in diesel oil usage of 4.3 million liters already for the 2008/09 crop year, which planting procedures have already begun.

Figure 2. Diesel oil volume reduction in the YieldGard corn fields in Brazil. 2008/09 crop year

Yield (ha/h)	Number of applications reduced with YieldGard maize					
	1	2	3	4	5	6
	Volume of diesel saved (thousand l/ano)					
10	1,73	3,46	5,19	6,92	8,65	10,38
11	1,57	3,15	4,72	6,29	7,86	9,44
12	1,44	2,88	4,32	5,77	7,21	8,65
13	1,33	2,66	3,99	5,32	6,65	7,98
14	1,24	2,47	3,71	4,94	6,18	7,41
15	1,15	2,31	3,46	4,61	5,77	6,92
16	1,08	2,16	3,24	4,32	5,41	6,49

Source: Céleres Ambiental, 2007

In admitting the potential drop in the greenhouse gas emission as a result of adopting YieldGard corn in Brazil, we can conclude that, even assuming a conservative estimate, in respect to the drop in the number of sprayings, the figures arrived at are meaningful.

The total carbon gas that is kept from being released into the atmosphere per hectare per year seems small. However, analyzing the YieldGard corn planted area of 1.44 million hectares for the 2008/09 crop year, we expect a drop of 11.2 thousand tons of CO_2 that will no longer be released into the atmosphere.

Figure 3. Drop in GEE emission in tCO_2 resulting from a decrease in diesel use in YieldGard corn in Brazil. 2007/08 crop year

Yield (ha/h)	Number of applications reduced with YieldGard maize					
	1	2	3	4	5	6
	Reduced emissions in tCO2 (tCO2/year)					
10	4,46	8,92	13,38	17,85	22,31	26,77
11	4,06	8,11	12,17	16,22	20,28	24,34
12	3,72	7,44	11,15	14,87	18,59	22,31
13	3,43	6,86	10,30	13,73	17,16	20,59
14	3,19	6,37	9,56	12,75	15,93	19,12
15	2,97	5,95	8,92	11,90	14,87	17,85
16	2,79	5,58	8,37	11,15	13,94	16,73

Source: Céleres Ambiental, 2007

Assuming the current pattern of economic growing, the maize produced in Brazil gets relevant importance in international market, taking the country as an important global supplier of this cereal.

Thus, it is projected for the next ten years that the production of corn will go from current 56.9 million tonnes to 94.5 million tonnes in 2017/18, only as a means of keeping relations of the cereal supply and demand in balance. To cope with the pressure of corn consumption, which grows both in traditional practices as for ethanol production in some countries, the productive sector of corn in Brazil need a smaller effort, measured in terms of planted area, if adopt the biotechnology as springboard for the average productivity of Brazil.

From the growth trend in corn productivity in Brazil observed in the last ten crops, to achieve the necessary production for 2017/18 will require the planting of 19.7 million hectares, between 1st and 2nd corn crops, while that, with the adoption of YieldGard corn, considering the assumptions for productivity gains of transgenic hybrids planned for the local reality, the planted area needed will be lower, or 16.4 million hectares.

Unlike the case of cotton, which has similarities given the characteristic of the biotech event which promotes gains in productivity, the total size of corn planting makes the impact of non adopting biotechnology much greater.

On average of the period considered, the additional area necessary to offset the loss of marginal productivity to the non adoption of YieldGard corn is 2.5 million hectares per year, although at the beginning of the projection, the increase is only 700 thousand hectares but the projection can reach an increase of 3.3 million hectares.

In projections of the environmental benefits of this study, for the period 2008/09 to 2017/18, were the premises of the area and the adoption of 1st and 2nd corn crops shown in following Figure.

Figure 4. Principles of adoption of area considered in the calculation

	Acreage (million ha)			1st Harvest YieldGard		2nd Harvest YieldGard	
	Total	1st Harvest	2nd Harvest	Potential	Adoption	Potential	Adoption
06/07	13.7	9.3	4.4	4.1	0.0	2.9	0.0
07/08	14.4	9.6	4.8	4.4	0.0	3.2	0.0
08/09	13.6	9.2	4.3	4.3	0.6	3.0	0.8
09/10	14.7	10.0	4.7	4.8	2.7	3.3	0.9
10/11	14.9	10.1	4.8	4.9	3.8	3.4	1.5
11/12	15.2	10.2	5.0	5.0	4.9	3.6	2.2
12/13	15.1	10.1	5.1	5.2	5.2	3.8	2.5
13/14	15.1	9.9	5.2	5.7	5.5	3.9	2.9
14/15	15.2	9.8	5.3	5.9	5.7	4.3	3.3
15/16	15.8	10.2	5.5	6.3	6.1	4.4	3.6
16/17	16.3	10.5	5.8	6.5	6.5	4.6	3.8
17/18	16.4	10.5	5.9	6.5	6.4	4.8	3.9

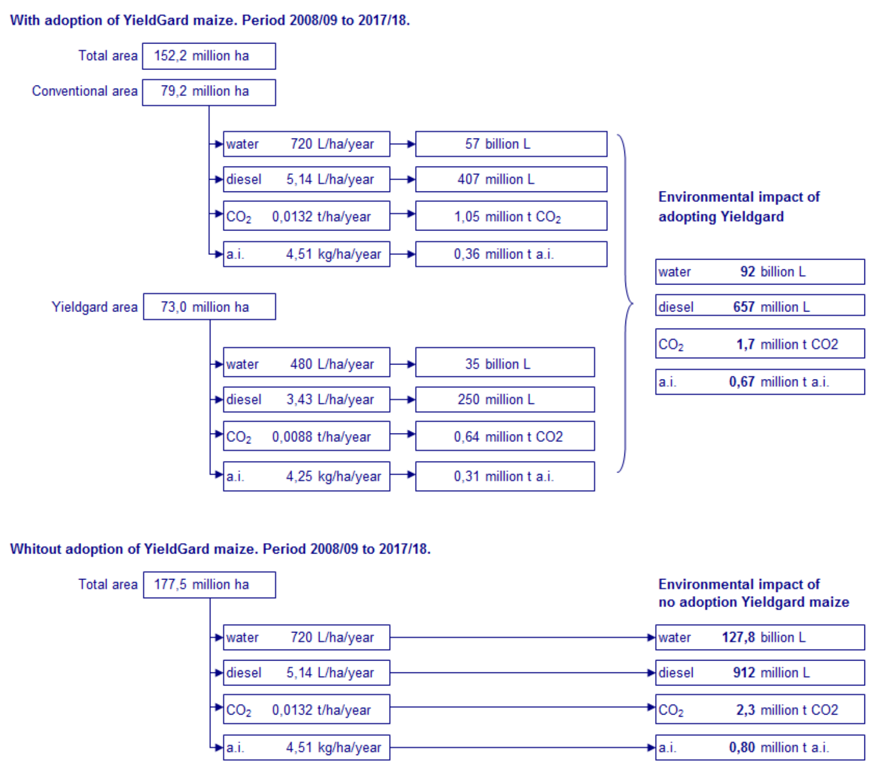
Source: CÉLERES. Based on own projections, figures in thousands of hectares

Taking into account an annual projection of corn planted over the next decade, assuming that YieldGard corn is adopted, and having already analyzed the expected impact of productivity, the total planted area with the cereal over this period is expected to reach 152.2 million hectares, being that out of this total, approximately 73.0 million hectares are expected to be planted with YieldGard corn and 79.2 million hectares with hybrids and conventional varieties. Considering such rate of adoption over the period under consideration, the average adoption rate of the YieldGard corn in Brazil is expected to reach 48.0% of the total area planted with the cereal.

On the other hand, supposing Brazil does not adhere to YieldGard corn in Brazil, for the purpose of calculating the net environmental benefit resulting from the adoption of this trait, circa 177.5 million hectares of planted area would be needed between 2008/09 and 2017/18. Such increase results from the fact that, as previously discussed, the hybrids and conventional hybrids are less potentially productive than YieldGard corn.

Bearing these two scenarios in mind, with and without the adoption of YieldGard corn, we initially projected the environmental impact on each one of the scenarios. For the analysis of the total environmental impact on the scenario of the adoption of the YieldGard corn crop, we took into consideration the remaining harvested area with the conventional crop. The same concept was applied to determine the environmental impact for conventional corn. At the end, the net benefit from the adoption of YieldGard corn in Brazil was estimated by difference, between 2008/09 and 2017/18.

Figure 5. Summary of environmental impacts from adopting YieldGard corn in Brazil. 2008/09 to 2017/18



Observation:

1/ To calculate the environmental impact, we only considered the diesel used in the sprayings of agrochemicals. We did not take into consideration the soil preparation or harvest operations.

2/ For conventional maize, we considered an average of 6 sprayings of agrochemicals applied with self-propelled sprayers of 2,000 liters. For YieldGard corn, we considered an average of 4 sprayings, based on field results derived from this study.

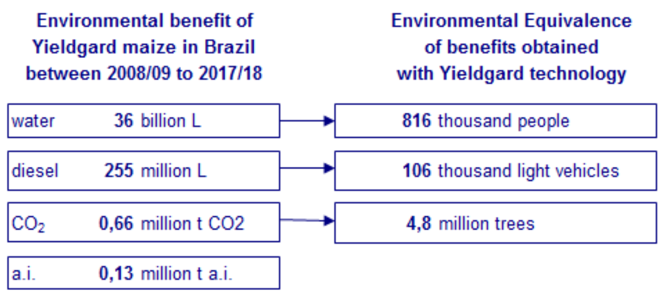
Source: Céleres Ambiental based on field survey.

As a premise for the gains resulting from the adoption of YieldGard corn, for diesel oil, water and CO_2 emission, we considered the results obtained in this study, through field interviews and summarized data.

Considering the difference between the environmental impact caused by both technologies, we could establish a net benefit for YieldGard corn of 36 billion liters in water savings (Figure 1.16), which volume would be enough to supply the demand for water of 816 thousand inhabitants in this period, using the UN recommendation as reference, which establishes 120 liters per inhabitant per day. This is a clearly considerable volume of water that is saved from being consumed by simply adopting a technology that is proven to be secure and efficient by different countries throughout the world.

The environmental benefit achieved with YieldGard corn is no less significant or considerable in reducing diesel oil use. We calculated this benefit amounts to 255 million liters of diesel, which will be saved over the upcoming decade, taking the adoption rates of this technology into account as previously discussed in this study. Such fossil fuel volume would be enough to supply nearly 106 thousand average-sized pick up trucks, such as the S-10 models, which travel 24 thousand kilometers annually, each.

Figure 6. Summary of the environmental benefits resulting from the adoption of YieldGard corn in Brazil



Observation:
UN recommendation for the water supply: 120 liters per capita per day
Calculation of kilometers: 24,000 km/year with a 10-km/liter yield
Coefficient used for conversion of trees: 7.38 trees/ton of CO_2 saved
Source: Céleres Ambiental based on in-house research

For the CO_2 emissions, the net benefit from the adoption of YieldGard corn, would enable a savings of almost 700 thousand tCO_2 over the next decade, which, in turn, corresponds to nearly 4.8 million trees being preserved. The botanical species considered for calculating the conversion were those found in the riparian forest.

Finally, the last environmental benefit examined in the study was the employment of active ingredients. Due to the decrease observed in the field in this research, the environmental benefit from this item reaches 134 thousand tons of chemical products which will be kept from being released into the environment over the next decade, which is, undoubtedly, a clear benefit from the adoption of YieldGard corn in Brazil.

FINAL CONSIDERATIONS

According to the observations made in this study, the non-adherence to the YieldGard trait implies various environmental losses, with a rise in corn planted areas over the upcoming years, which will consequently translate into the need to open up new planting areas.

The environmental benefits achieved from the adoption of biotechnology are clear. YieldGard corn allows for reducing the number of insecticide sprayings on the plantations, and warrants innumerable social-environmental benefits, such as: decreased consumption of water used in the sprayings, decreased fossil fuel usage(diesel oil), and, consequently, decrease in the quantity of carbon gas released into the atmosphere, soil protection and conservation, preservation of natural enemies, in addition to promoting the maintenance of local biodiversity.

The potential adoption of YieldGard corn allows for the reduction in the volume of active ingredients in the soil, which implies less agrochemicals will be used in the fields, favoring among other factors, the preservation of the environment with the decrease in volume of packages discarded in the environment and the rural worker's health.

The potential adoption of YieldGard corn, among other GM traits, will allow Brazil to face the growing domestic and international demand for corn, for traditional use and as input for biofuels in the countries chosen. The Brazilian rural producer is experiencing, in addition to economic gains, less dependency on conventional agrochemicals, perceiving the improvement in water, wildlife, soil and air quality, and particularly, in the health of the rural worker.

The adoption of the other biotechnological traits only tends to optimize the benefits set forth in this research, placing Brazil on equal conditions with its major competitors in the international market, and with an attitude of greater social-environmental responsibility.

About Céleres Ambiental

It is an environmental consulting firm that operates in the agricultural sector. With a view at better adapting itself to this market's requirements, it has further achieved proven competency in the environmental management of the sugar-alcohol sector related projects. It counts on a multidisciplinary team of highly qualified professionals who expediently respond to the needs of clients by executing different kinds of projects, among which are:

- Environmental Licensing
- Environmental Due Diligence (DDA)
- Site Feasibility Assessment
- Environmental Law Compliance

About the author

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