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# Food Security, Water Scarcity, the G-20 Agenda and the Strategic Role of Southern Cone Countries (Argentina, Brazil, Paraguay and Uruguay)

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Southern Cone Contributions to Food Security  
and Global Environmental Sustainability

**Marcelo Regúnaga & Pablo Elverdin**

Virtual Water in The Rural Sector of Argentina,  
Brazil, Paraguay and Uruguay and its Potential  
Impact on Global Water Security

**M. Florencia Ricard & Ernesto F. Viglizzo**

**JANUARY, 2017**



**GRUPO DE PAÍSES PRODUCTORES DEL SUR**

GROUP OF PRODUCING COUNTRIES FROM THE SOUTHERN CONE





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## Foreword

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The Group of Producing Countries from the Southern Cone (GPS by its Spanish acronym) is a Regional initiative organized by several non-public organizations of Argentina, Brazil, Paraguay and Uruguay, that have been working together to contribute to the construction of a South American platform that will be able to meet new food demands in a sustainable manner, while also generating wealth, employment and social capital in the region.

This effort builds on two premises. The first is that working jointly will give the four countries involved greater bargaining power, from a geopolitical standpoint, than if they worked individually. And the second is that prospects for consolidation in the region will unquestionably be better if such countries share a common development plan for the agroindustry as a whole.

For this purpose, GPS's work agenda focuses on three axes: a) Promote the regional integration; b) Improving the international presence of the region in the agroindustry area, and; c) Encourage the sustainable development with special emphasis in the climate change agenda.

Therefore, the present document is the result of the work and contributions of a large number of people, organized in a complex network, in response to

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their commitment to participate and contribute in the construction of a world that is capable of producing food for everybody in a sustainable manner.

In the next years, the importance of exports in order to satisfy the growing food demand, at reasonable prices and in a sustainable manner, will increase. The future food security will depend on trade and on the ability of net food exporters to locate their surpluses in the international markets without unjustified obstacles. Here is where the countries of the region play an important role, since they account for almost 30 percent of the total net food exports worldwide, and that contribution is expected to increase in the near future.

These concerns have also raised social and political awareness with respect to the growing economic scarcity of natural resources, the potential impacts of climate change and the difficult political economic issues that the world will face in the coming years by these reasons. These concerns have also led the International Community to propose specific mechanisms to improve global governance on environmental issues, and recently some compromises of singular magnitude have been achieved (as the commitment made in the COP21 shows).

In response to these concerns and proposals, GPS has organized a joint effort to analyze the potential contributions that the four countries can make to the global food supply and to environment sustainability and has put forward ideas and proposals concerning the major issues that are being considered in the international agenda in the areas of food security, agricultural natural resources and climate change.

GPS would not be possible without the efforts of the following persons and institutions: Eduardo Serantes and Luis Bameule (GPS Argentina); Luiz Cornacchioni and Juliana Monti (Asociacao Brasileira do Agronegocios-ABAG, Brazil); Héctor Cristaldo, Lilian Cabrera and Alfredo Molinas (Unión de Gremios de la Producción-UGP, Paraguay); Juan de la Fuente and Victoria Carballo (GPS, Uruguay).

This document is the result of a collective effort and builds on information and previous studies produced by GPS that were contributed by the participating organizations and individuals. The main authors of the papers have been Marcelo Regúnaga, Pablo Elverdin, Florencia Ricard and Ernesto Viglizzo, with substantial contributions by Martin Piñeiro, Eduardo Serantes, Luis Bameule and Paloma Ochoa.

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At the same time, the authors would like to express their special thanks to Nelson Illescas and Nicolás Jorge (INAL Foundation, Argentina) and to José Luis Tedesco (Asociación Argentina de Productores de Siembra Directa-AAPRESID, Argentina) for their individual contributions to the present paper; as well as to ABAG for providing the information included in Annex II.

The document is organized into two sections and deals with three main subjects: a) it describes the food production capacity of the region, its extraordinary potential and the significant progress made in technological and organizational matters; b) the contribution of the region to global food security implementing environmentally friendly production systems; and c) the regional export of virtual green water, and how it contributes to water security of the destination countries of its exports.

GPS would like to express its sincere appreciation to all those institutions which constitute our net.

**ARGENTINA:** CARI; AAPRESID; ACSOJA; ASAGIR; Argentrigo; ACTA; Bolsa de Cereales de Bs. As; CREA; FUNPEL; F.P.C; Irradia; Maizar.

**BRAZIL:** ABAG; FGV Agro; FIESP

**PARAGUAY:** UGP

**URUGUAY:** CURI; Cámara Mercantil de Productos del País.

Environmental Advisor: Ing. Agr. PH. D. Ernesto F. Viglizzo.

**Horacio A. M. Sánchez Caballero**

Project Coordinator



*Group of Producing Countries From The Southern Cone, Buenos Aires, January, 2017.*

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# Southern Cone Contributions to Food Security and Global Environmental Sustainability

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**Marcelo Regúnaga<sup>1</sup> & Pablo Elverdin<sup>2</sup>**

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<sup>2</sup> Consultant for IFPRI and a member of Grupo CEO in Buenos Aires. He is also member of GPS and advisor for the Chamber of Agricultural Machinery.

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## Summary

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### Addressing the challenge of food security, climate change and natural resources sustainability

Since the beginning of the 21st century, world food security has become a major concern of world leaders. The challenge of achieving world food security is more complex nowadays because such purpose should be reached while taking into account the impact of the production systems on climate change and natural resources sustainability.

The world is supposed to produce more food using available natural resources efficiently and sustainably while reducing the greenhouse gases emissions (GHGE) per unit produced. These purposes require a careful and integrated approach to the efficient use of land, water and energy, aimed at increasing productivity with production systems which are friendly with the environment.

Trade is also crucial to cope with such challenge, because regional production and consumption imbalances are, and will be, very relevant. Therefore, a smooth world food trading system should also be a major objective aimed at facilitating food security.

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The Southern Cone of South America and particularly Argentina, Brazil, Paraguay and Uruguay (ABPU Countries) has a proven track record of innovations to improve food production growth based on sustainable production systems. Projections show that these countries will increase its share in net food exports during the next decade

The region has already contributed significantly to addressing the growing world food and biofuels needs during the last two decades. Food and biofuels production in Argentina, Brazil, Paraguay and Uruguay (ABPU countries) grew at higher rates than in the rest of the world, increasing their share in world production. Moreover, food and biofuels production in ABPU countries grew at higher rates than local consumption, and currently the region is already the largest net food trade exporter in the world.

The mentioned Southern Cone countries also have a high production growth potential, based on their natural resources endowments and on proven technological innovations and competitive business models. The role of ABPU countries on future world food security is crucial because, in addition to the potential area and renewable water that could be devoted to food production, their institutional framework is well developed and farmers adopt very fast the improved technologies which are available in the market, as it has been the case during the last two decades.

Studies and simulation models conducted by regional and international specialized organizations show that the region's production growth rates projected for the next decade for most agricultural products are substantially higher than those projected for the world average. The information included in this study is based on the OECD-FAO 2015-2024 Agricultural Outlook. Such estimates were complemented with local studies in specific situations in which OECD-FAO baseline assumptions did not include recent policy changes, implemented in Argentina after the release of the Agricultural Outlook.

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Based on such projections, total grains ABPU countries production (cereals+oilseeds) should reach 422 million tons in 2024, growing at an annual average rate of 2.17% during the period 2015-2024, while the world total is estimated to grow at 1.2% per year. Within total grains, the regional oilseeds production is projected to grow at an annual average rate of 3.03%, being soybeans the main driving force, while world total oilseeds production is estimated to grow at 1.7% per year. The regional production dynamics is also high in vegetable oils and protein meals, which are projected to grow at 2.7% and 2.8% per year, respectively, during the period 2015-2024; while total world production of both commodities are projected to grow at 1.9% per year. As a result of the mentioned growth rates, ABPU countries' shares in world production of total grains and the oilseeds complex will increase substantially during the next decade.

In the case of total meats (beef, pork, poultry and sheep, as specified in OECD-FAO Agricultural Outlook) regional production is projected to grow at an annual average rate of 2.0% during the period 2015-2024, while total world production is projected to grow at an annual average rate of 1.2%. Similar to what has been mentioned for total grains and the oilseeds complex, ABPU countries' shares in world meats production will increase substantially during the next decade.

It should be noted that regional export shares of food products for the next decade are also expected to continue growing, increasing the ABPU countries' role in future food security and trade. In the case of meats' exports, projected annual ABPU countries growth rates are expected to reach 4.1% per year, while total world exports growth rates are projected at 1.8% per year; for such reason the region's total meats export shares will grow up to 31% of total world exports in 2024.

Regional exports of oilseeds are also projected to grow at much higher rates than total world exports, increasing the leadership that ABPU countries already have in world trade; it is projected that regional shares in total oilseeds trade will grow up to 52% in 2024. ABPU countries exports of protein meals are projected to grow during the next decade at an annual average rate of 2.0%, while world averages are projected to grow at 1.3% per year; as a result regional shares in total world trade of protein meals will grow up to 61%. ABPU countries export shares are currently very high also in sugar: estimates show

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that regional market share reached 40.7% in 2015; and it is projected to grow up to 42.2% in 2024.

The region's export leadership is not limited to the products detailed above but encompasses other food products, such as coffee, fruits, juices, tobacco, and other food preparations.

## A smooth world food trading system should be a major objective aimed at facilitating food security and natural resources sustainability

Regional production and consumption imbalances are very relevant today, and it is expected that such situation will continue in future decades. Many emerging countries are facing serious limitations on area and renewable water availabilities to sustain food production growth at high rates during future decades; and they will rely more on imports from net exporting countries.

However, world trade of agricultural products is seriously limited by trade policies currently implemented by most developed and developing countries. Such obstacles are inconsistent with global food security purposes, as well as with the need to tackle natural resources deterioration and global warming.

These issues have not been considered seriously enough in international trade negotiations in WTO during the last decades. Therefore, world leaders should give more attention to considering to what extent trade barriers that are not based on science are affecting food security and global warming. The G20 could play an important role to promote future global food security based on a more open trading system.

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The Southern Cone countries' production systems and business models are economically efficient and environmentally friendly. They could be an interesting alternative to cope with global food security and sustainability in the rest of the world

The challenge of achieving world food security is more complex nowadays because such purpose should be reached taking into account the impact of the production systems on climate change and natural resources sustainability. The world is supposed to produce more food using available natural resources efficiently and sustainably while reducing the greenhouse gases emissions (GHGE) per unit produced.

However, most of current world crop production is conducted under production systems which are not environmentally friendly. During the last four decades, increases in production and productivity in most regions have been based on the use of high amounts of fuels and fertilizers that have deteriorated the natural resources and are contributing excessively to global warming. Most of the agriculture conducted in Europe, Asia and North America is based on such input intensification process. It is estimated that more than 90% of world crop production in such regions is conducted under input intensive production systems, which are supposed to be revised.

By contrast, during the last two decades ABPU countries have massively implemented interesting structural and technological innovations that have increased competitiveness and productivity with production systems which are environmentally friendly. This process has been called "the sustainable intensification strategy". Most of the extensive crop production (cereals and oilseeds) currently conducted in ABPU countries is based on such sustainable intensification strategy, which is also associated with rotations including pastures for extensive livestock production.

This new agriculture is based on the convergence of various technological innovations implemented gradually in the region: no-till strategy, crop rotations and sanitation; precision farming; improved seeds including genes for herbicides, insects, and diseases resistances (which imply a lesser use of agrochemicals); new chemical

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molecules in agrochemicals; integrated plague control; intensive use of information and communication technology; satellite-image support; logistic innovations like silo bags; post-harvest management; precision nutrition; etc.

The no-till strategy (which is the core of the innovation package) integrates a production system that reduces soil erosion and improves rainwater storage in the soil (strategic water management). It is a production system designed at maximizing productivity in a sustainable manner, by improving the use of natural resources, minimizing the number of tilling operations, and reducing oil consumption and GHG emissions. The soil is covered by stubble; a carbon management strategy is implemented (fostering carbon sequestration), and a crop fertilization strategy is adopted that is based on a soil nutrition and structuring concept, rather than on the soil fertilization approach. This approach improves the soil biotic load and its sanitary conditions. After several years of implementation of such strategy, the soil conditions improve substantially.

Less than 10% of total world crop production is under the “no-till management strategy”, and most of the area planted with no-till systems is located in South America. The massive adoption in ABPU countries of such productive and soil conservation strategy coincided with the increases in yields of the main annual crops, registered also in the region during the last two decades.

Summing up, during the last two decades the ABPU countries increased substantially their food and biofuels production and world market shares, while massively adopting environmentally friendly production systems. These very positive results of the “sustainable intensification strategy” implemented during the last decades in the region provide an interesting experience for the challenge of producing more food using efficiently and sustainably the available natural resources, while reducing the greenhouse gases emissions (GHGE) per unit produced.

The focus to tackle food security, natural resources sustainability and global warming should not be limited to trade: it is necessary to revise all the production systems conducted in the main producing countries. Taking into account the valuable experience of the Southern Cone countries, a pragmatic alternative to cope with global food security and sustainability is to move from input intensive production systems widespread in main producing countries towards the “sustainable intensification strategy”, that promotes production

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growth while preserving natural resources and reducing the greenhouse gases emissions (GHGE) per unit produced. This is a better alternative than the “greening agriculture” strategies promoted by several NGOs, which reduce dramatically food supply and seriously challenge the purpose of world food security.

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# Introduction

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Since the beginning of the 21st century, world food security, resources' sustainability and climate change have become major concerns of world leaders. Economic growth in developing countries and the emergence of an expanding middle class in many of them resulted in the increase of their purchasing power and in demand growth for energy, for food and for other agricultural processed products. These trends coincided with the increase in demand of bio-fuels and other non-food uses of agricultural products processed in bio-refineries, aimed at reducing the use of fossil fuels ("the bio-economy approach").

These consumption increases have made evident a growing demand for natural resources including fossil energy, agricultural natural resources (arable land, water and forests) and minerals, and have brought back the specter of food insecurity for the next decades. Global warming also emerged as a major challenge for the near future, and food production systems could play an important role in reducing (or increasing) global greenhouse gases emissions.

Therefore, the challenge of achieving world food security is more complex nowadays, because such purpose should be reached taking into account the impact of the production systems on climate change and natural resources

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sustainability. The world is supposed to produce more food using available natural resources more efficiently and sustainably, and reducing the greenhouse gases emissions per unit produced. These purposes require a careful and integrated approach to the efficient use of land, water and energy, aimed at increasing productivity with production systems which are friendly with the environment. This is not the case of most production systems implemented in Asia, Europe, Africa and some American countries.

The food security outlook varies substantially in different regions. Most of the dynamism of food demand growth in recent decades has been driven by developing countries of Asia, Africa and Latin America. However, production growth rates in some of these regions have not reached the necessary levels to achieve self-sufficiency, and they rely on net imports from other regions. Furthermore, some of the main net importing countries face relevant limitations associated with the progressive deterioration and scarcity of their natural resources, and they will need to implement new less intensive and more sustainable approaches to their current production systems.

Therefore, a smooth world food trading system should be a major objective aimed at facilitating food security. However the world trade scenario shows very high import taxes on food products and increasing adoption of non-tariff barriers, particularly private measures, in many relevant importing countries. Therefore, world leaders should give more attention to promote trade as a key component of the food security global strategy.

South America, and particularly the Southern Cone countries (Argentina, Brazil, Paraguay and Uruguay-ABPU countries) have a proven track record of growth and innovation based on production systems which are environmentally friendly; and they could be strategic contributors to addressing the growing world food needs in a sustainable manner. The Region has already contributed significantly to addressing the growing world food demand during the last two decades, increasing food and feed production at annual rates that almost doubled the respective world averages, based on its resources' endowments and on sustainable and innovative business models.

The purpose of this document is to analyze the potential contributions that the four countries can make in the future decades to the global food and biofuels supply, based on environmentally friendly production systems; and to

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also share the regional experience of alternatives to implementing productive and sustainable production systems.

The present and increasing future importance of Argentina, Brazil, Paraguay and Uruguay as net food and biofuels exporters in world trade, highlights the relevance of regional views on the best approaches to produce more food using more efficiently and sustainably the available natural resources, while reducing greenhouse gases emissions per unit produced.

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# Southern Cone Contributions to Global Food Security

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As it has been described in previous studies<sup>3</sup> South America, and particularly the countries of the Southern Cone, Argentina, Brazil, Paraguay and Uruguay (ABPU countries), have already contributed significantly to addressing the growing world food and biofuels' needs during the last two decades (GPS - Regúnaga, 2013). During such period, food and biofuels' per capita productions in the mentioned countries grew almost twice than the world averages, and also at higher rates than local consumption, and the region became the largest net food and biofuels' exporter of the world.

The international role of ABPU countries in food security will continue to increase in future decades. Regional agricultural production can still grow at high rates, both by increasing the area being farmed in environmentally sustainable production systems, and by improving productivity. Natural resources endowment (abundant additional land and renewable water sources), and innovative human capital are the basic fundamentals for such projected growth, as it has been also the case during the last two decades.

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<sup>3</sup> GPS- Regúnaga, 2013; Diaz Bonilla, E. et al. 2012.

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ABPU countries have the resources and the capabilities to confirm their future role as the most dynamic foodstuff and processed food supplier of the world. The following projections for potential production growth confirm this outlook. Baseline OECD-FAO production and trade projections for selected food products and biofuels for the next decade show that the four countries of the region are expected to grow at substantially higher rates than the world average.

## Production projections for next decade

Table 1 includes the baseline production projections for ABPU countries during the period 2015-2024 and the respective annual growth rates for the main products, as they have been specified in the OECD-FAO Agricultural Outlook.

**Table 1. Baseline production projections for ABPU countries. Period 2015-2024**  
(million tons, annual growth in %)

Products*	2015 A (million ton)	2024 B (million ton)	Total growth B-A (million ton)	Annual growth 2015-2024 (%)**
Cereals	176.1	200.3	24.2	1.30%
Oilseeds	164.8	222.1	57.3	3.03%
Total Grain	340.9	422.4	81.5	2.17%
Vegetable Oils	19.0	24.8	5.9	2.73%
Protein Meals	71.7	94.4	22.7	2.79%
Sugar	36.1	44.3	8.2	2.08%
Meats	33.1	40.2	7.1	1.97%
Milk	43.9	54.5	10.7	2.21%
Biofuels***	36.7	42.9	6.2	1.58%

**Source:** OECD-FAO 2015-2024 Agricultural Outlook. In the case of Argentina the projections were corrected with INAI projections<sup>4</sup> including recent changes in agricultural policies, not considered in the baseline OECD-FAO 2015-2024 Agricultural Outlook.

**Notes:** \* Products as specified in OECD-FAO Agricultural Outlook. Total grains include cereals and oilseeds. Meats include beef, pork, poultry and sheep. Biofuels include ethanol and biodiesel.

\*\* Cumulative annual growth rates. \*\*\* Thousands of million litres.

Total grains ABPU countries production (cereals+oilseeds) are projected to reach 422 million tons in 2024, growing at an annual average rate of 2.17% during the period 2015-2024. Within total grains, the oilseeds are projected to grow at an annual average rate of 3.03%, being soybeans the main driving force. Vegetable oils and protein meals are projected to grow at 2.7% and 2.8% annual average rates, respectively, during the period 2015-2024. In the case of total meats regional production is projected to grow at an annual average rate of 2.0 % during the mentioned period. Annual average growth rate for milk is 2.2% for the decade.

It is interesting to note that the highest production growth rates projected for ABPU countries are for the oilseeds complex, meats and milk, which are the food products with higher world consumption growth rates projected for next decades, associated mainly to the urbanization process and the change in consumers' preferences of the emerging middle classes in developing countries<sup>5</sup>.

Projected production growth rates for ABPU countries are higher than the OCDE-FAO average projections for the world. Similarly to what happened during previous decades, ABPU countries' annual growth rates estimates for the next decade are, for most products, substantially higher than those projected for the world average in the OECD-FAO Agricultural Outlook 2015-2024 (Figure 1). Regional growth rates result from increases both in productivity and in cultivated areas; the last factor being the major factor explaining the differences with the rest of the world.

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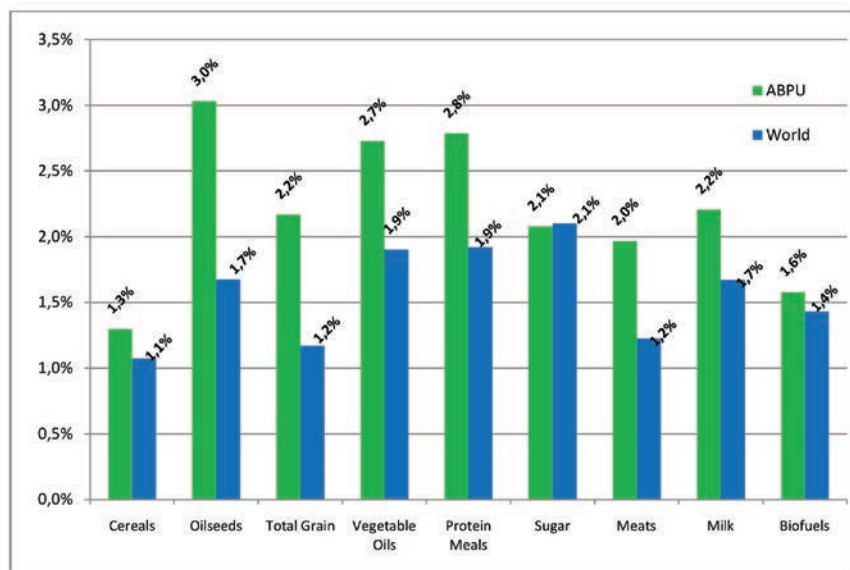
<sup>4</sup> GPS- Regúnaga, 2013; Diaz Bonilla, E. et al. 2012.

<sup>5</sup> Aquaculture products are projected to grow at higher rates than the mentioned food products, but the size of the market is still less relevant.

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**Figure 1. Total world and ABPU countries annual averages production growth projections for selected products\* during the period 2015-2024**

(annual growth rates in %\*\*)



**Source:** OECD-FAO 2015-2024 Agricultural Outlook. In the case of Argentina the projections<sup>6</sup> were corrected with INAI projections including recent changes in agricultural policies, not considered in the baseline OECD-FAO 2015-2024 Agricultural Outlook.

**Notes:** Products as specified in OECD-FAO Agricultural Outlook. Total grains include cereals and oilseeds. Meats include beef, pork, poultry and sheep. Biofuels include ethanol and biodiesel.

\*\* Cumulative annual growth rates.

## Trade projections for next decade

Table 2 and Figure 2 include the total export projections for ABPU countries and

<sup>6</sup> INAI projections use the PEATSim-Ar simulation model, adapted from the PEATSim model developed by Pennsylvania University and ERS-USDA ([www.inai.org.ar](http://www.inai.org.ar)).

for the world for the period 2015-2024. Annual averages export growth rates for ABPU countries are substantially higher than those projected for the world, particularly in meats, dairy products and the oilseed complex (oilseeds, oils and protein meals).

**Table 2. Total world and ABPU countries export projections for selected products during the period 2015-2024** (million tons; annual growth in %)

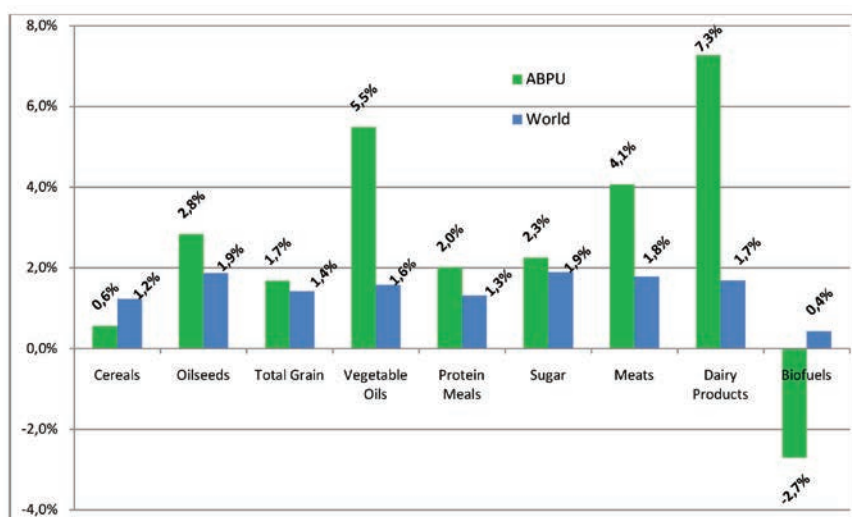
Products*	ABPU Countries			
	2015 A (million ton)	2024 B (million ton)	Total growth B-A (million ton)	Annual growth 2015-2024 (%)**
Cereals	80.5	85.1	4.6	0.56%
Oilseeds	70.0	92.7	22.6	2.84%
Total Grain	150.5	177.8	27.3	1.68%
Vegetable Oils	8.3	14.2	5.9	5.49%
Protein Meals	49.2	60.0	10.9	2.01%
Sugar	23.4	29.3	5.9	2.26%
Meats	8.0	11.9	3.9	4.07%
Dairy Products	0.4	0.8	0.4	7.28%
Biofuels***	2.1	1.6	-0.5	-2.70%
Products*	WORLD			
	2015 A (million ton)	2024 B (million ton)	Total growth B-A (million ton)	Annual growth 2015-2024 (%)**
Cereals	363.5	410.8	47.3	1.23%
Oilseeds	147.2	177.3	30.0	1.87%
Total Grain	510.7	588.1	77.4	1.42%
Vegetable Oils	77.2	90.3	13.1	1.58%
Protein Meals	85.4	97.3	11.9	1.31%
Sugar	57.2	69.0	11.8	1.89%
Meats	31.7	37.8	6.1	1.78%
Dairy Products	8.1	9.5	1.5	1.69%
Biofuels***	9.6	10.0	0.4	0.43%

**Source:** OECD-FAO 2015-2024 Agricultural Outlook. In the case of Argentina the projections were corrected with INAI projections<sup>7</sup> including recent changes in agricultural policies, not considered in the baseline OECD-FAO 2015-2024 Agricultural Outlook.

**Notes:** Products as specified in OECD-FAO Agricultural Outlook. Total grains include cereals and oilseeds. Meats include beef, pork, poultry and sheep. Biofuels include ethanol and biodiesel.

\*\* Cumulative annual growth rates. \*\*\* Thousands of million litres.

**Figure 2. Total world and ABPU countries trade growth rate projections for selected products\* during the period 2015-2024 (annual growth rates in %\*\*)**



**Source:** OECD-FAO 2015-2024 Agricultural Outlook. In the case of Argentina the projections were corrected with INAI projections including recent changes in agricultural policies, not considered in the baseline OECD-FAO 2015-2024 Agricultural Outlook.

**Notes:** \* Products as specified in OECD-FAO Agricultural Outlook. Total grains include cereals and oilseeds. Meats include beef, pork, poultry and sheep. Biofuels include ethanol and biodiesel.

\*\* Cumulative annual growth rates.

<sup>7</sup> INAI projections use the PEATSim-Ar simulation model, adapted from the PEATSim model developed by Pennsylvania University and ERS-USDA ([www.inai.org.ar](http://www.inai.org.ar)).

It should be noted that in the case of meats' exports, projected annual ABPU countries growth rates reach 4.1% per year, while total world exports growth rates are projected at 1.8% per year; for such reason the region's total meats export shares will increase substantially during next decade. Similar comments could be mentioned for dairy products: the projected annual ABPU countries growth rates reach 7.3% per year, while total world exports growth rates are projected at 1.7% per year. ABPU countries exports of vegetable oils are projected to grow during the next decade at annual growth rates of 5.5% while world averages are projected to grow at 1.6% per year. Regional exports of oilseeds are also projected to grow at much higher rates than the world's, increasing the leadership that ABPU countries already have in world trade. On the other hand, regional exports of cereals decline, despite the increase in projected production; the main reason for this trend is that most of the cereals' regional growth is expected to be processed locally to produce meat and dairy products.

Table 3 and Figures 3 to 11 show the evolution of projected ABPU countries' exports growth of selected products during the period 2015-2024, and the evolution of their respective market shares. ABPU countries production growth projected for the next decade contribute to increase significantly their exports and their market shares in the oilseeds complex (oilseeds, meals and oils), in meats (beef, poultry and pig meat), sugar and dairy products.

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**Table 3. ABPU countries' net food exports and exports shares for selected products in 2015 and 2024** (million tons and %)

Products*	ABPU Net Exports million ton		ABPU countries' exports share (%)		ABPU Shares Growth (%)
	2015 A	2024 B	2015 C	2024 D	2015-2024 ((D-C)/C)
Cereals	72.5	76.2	20.0%	18.5%	-7.09%
Oilseeds	69.2	91.8	47.0%	51.8%	10.27%
Total Grain	141.7	168.0	27.7%	28.6%	2.96%
Vegetable Oils	7.7	13.5	9.9%	15.0%	50.51%
Protein Meals	48.9	59.8	57.3%	61.4%	7.24%
Sugar	23.3	29.1	40.7%	42.2%	3.73%
Meats	7.8	11.7	24.7%	31.0%	25.56%
Dairy Products	0.3	0.7	3.9%	7.5%	92.36%
Biofuels***	1.6	1.6	16.2%	15.6%	-3.95%

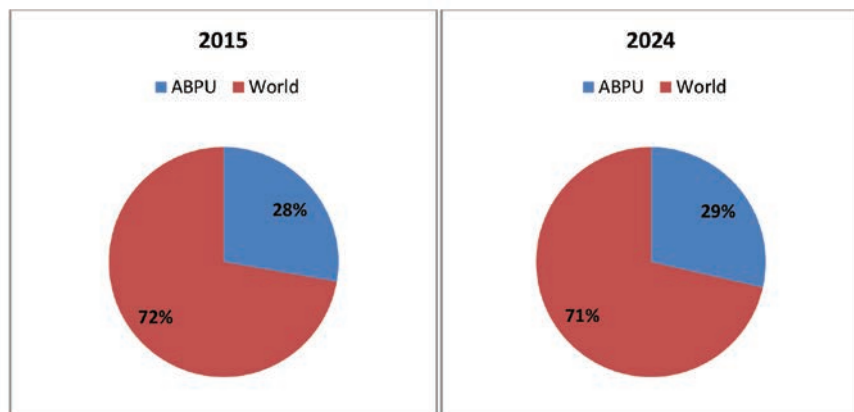
**Source:** OECD-FAO 2015-2024 Agricultural Outlook. In the case of Argentina the projections were corrected with INAI projections including recent changes in agricultural policies, not considered in the baseline OECD-FAO 2015-2024 Agricultural Outlook.

**Notes:** \*Products as specified in OECD-FAO Agricultural Outlook. Total grains include cereals and oilseeds. Meats include beef, pork, poultry and sheep. Biofuels include ethanol and biodiesel.

\*\*Thousands of million litres.

ABPU countries exports market shares are already very high in oilseeds and protein meals: in 2015 they represented 47.0% of total oilseeds exports, and 57.3% of protein meals exports. And the projections for 2024 show that the region is expected to increase the respective export shares to 51.8% in the case of oilseeds and to 61.4% in protein meals. The projected high growth rates for regional vegetable oils exports result in a significant increase in the ABPU countries market share, from 10% in 2015 to 15% in 2024 (Figures 4, 5 and 6).

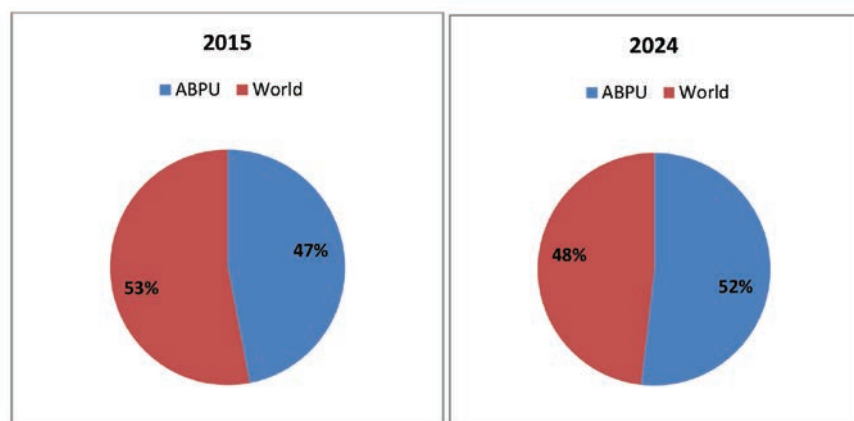
**Figure 3. Total grains. ABPU countries' exports shares in 2015 and 2024**



**Source:** OECD-FAO 2015-2024 Agricultural Outlook. In the case of Argentina the projections were corrected with INAI projections including recent changes in agricultural policies, not considered in the baseline OECD-FAO 2015-2024 Agricultural Outlook.

**Note:** Total grains include cereals and oilseeds.

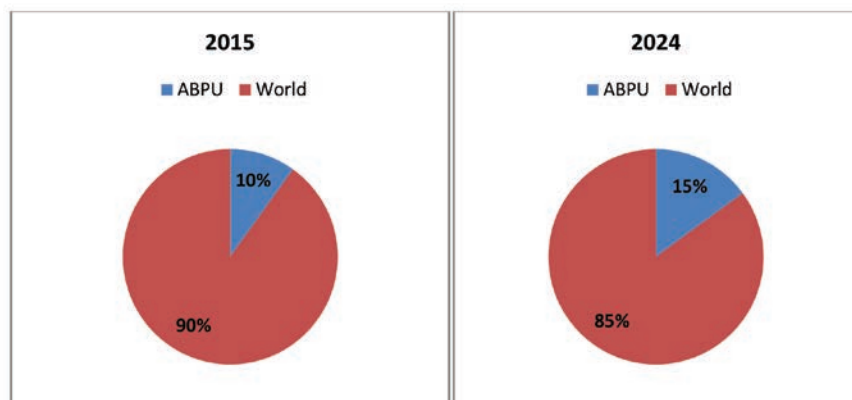
**Figure 4. Oilseeds. ABPU countries' exports shares in 2015 and 2024**



**Source:** OECD-FAO 2015-2024 Agricultural Outlook. In the case of Argentina the projections were

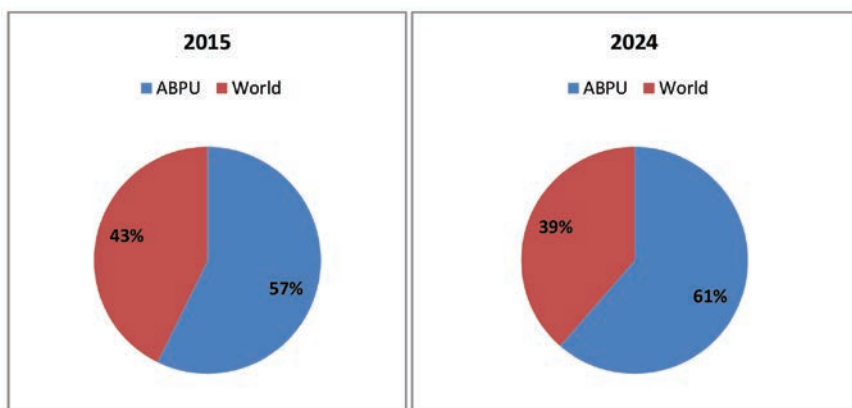
corrected with INAI projections including recent changes in agricultural policies, not considered in the baseline OECD-FAO 2015-2024 Agricultural Outlook.

**Figure 5. Vegetable Oils. ABPU countries' exports shares in 2015 and 2024**



**Source:** OECD-FAO 2015-2024 Agricultural Outlook. In the case of Argentina the projections were corrected with INAI projections including recent changes in agricultural policies, not considered in the baseline OECD-FAO 2015-2024 Agricultural Outlook.

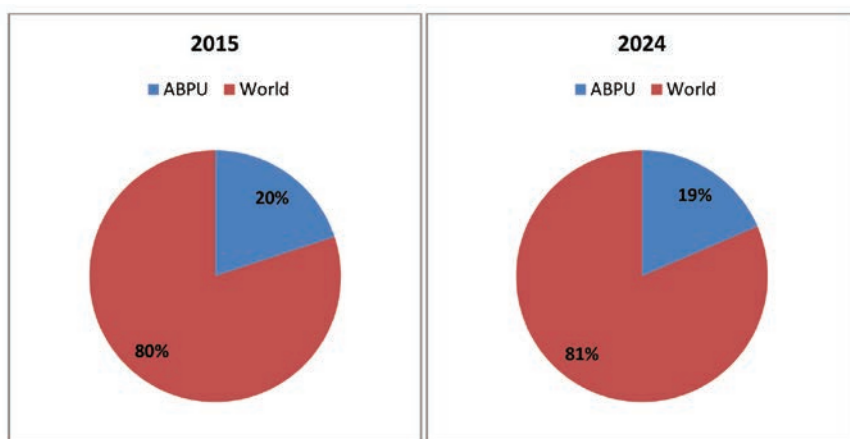
**Figure 6. Protein meals. ABPU countries' exports shares in 2015 and 2024**



**Source:** OECD-FAO 2015-2024 Agricultural Outlook. In the case of Argentina the projections were corrected with INAI projections including recent changes in agricultural policies, not considered in the baseline OECD-FAO 2015-2024 Agricultural Outlook.

As it has already been mentioned, most of the ABPU countries production growth of cereals is projected to be devoted to meats and milk production in the region (mainly to be exported as meats and dairy products). Therefore the region is expected to reduce its cereals trade market share, from 20% of total exports in 2015 to 19% in 2024.

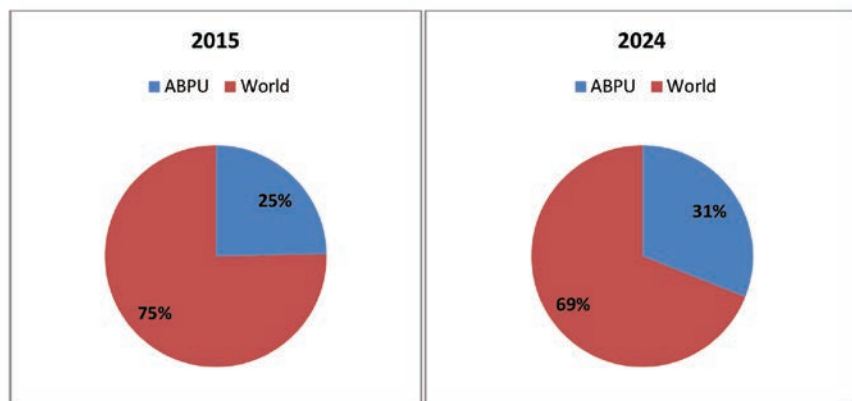
**Figure 7. Cereals. ABPU countries' exports shares in 2015 and 2024**



**Source:** OECD-FAO 2015-2024 Agricultural Outlook. In the case of Argentina the projections were corrected with INAI projections including recent changes in agricultural policies, not considered in the baseline OECD-FAO 2015-2024 Agricultural Outlook.

The region is also a very relevant meat exporter: in 2015 the market share was 24.7% of total meats exports, and it is projected to grow to 31% in 2024.

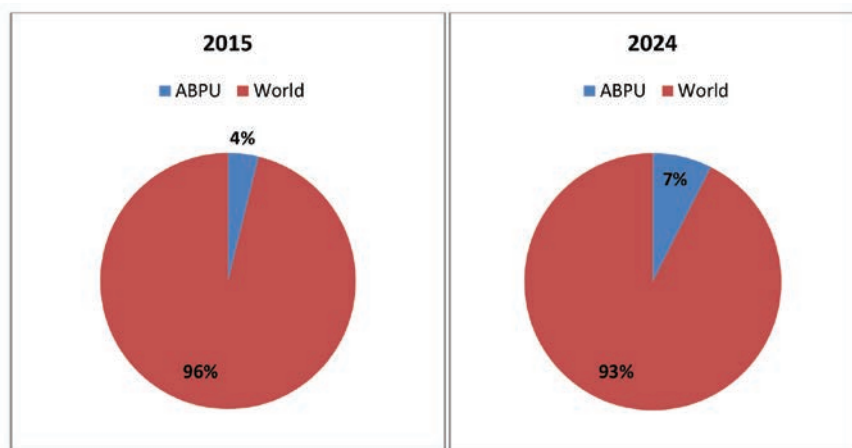
Figure 8. Meats. ABPU countries' exports shares in 2015 and 2024



**Source:** OECD-FAO 2015-2024 Agricultural Outlook. In the case of Argentina the projections were corrected with INAI projections including recent changes in agricultural policies, not considered in the baseline OECD-FAO 2015-2024 Agricultural Outlook.

**Note:** Meats include beef, pork, poultry and sheep.

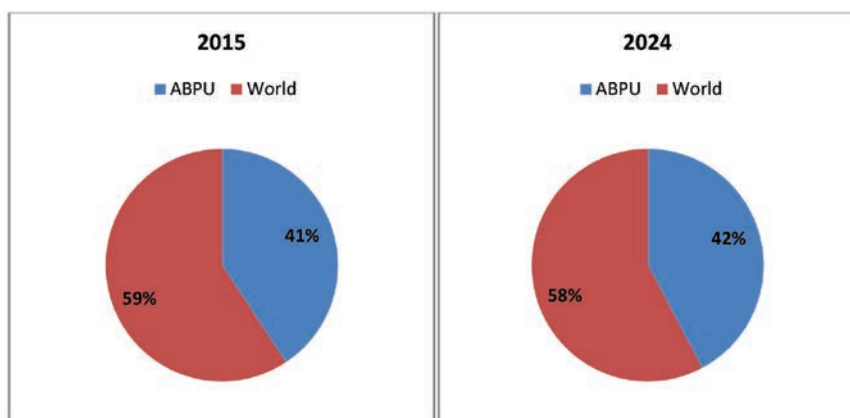
Figure 9. Dairy products. ABPU countries' exports shares in 2015 and 2024



**Source:** OECD-FAO 2015-2024 Agricultural Outlook. In the case of Argentina the projections were corrected with INAI projections including recent changes in agricultural policies, not considered in the baseline OECD-FAO 2015-2024 Agricultural Outlook.

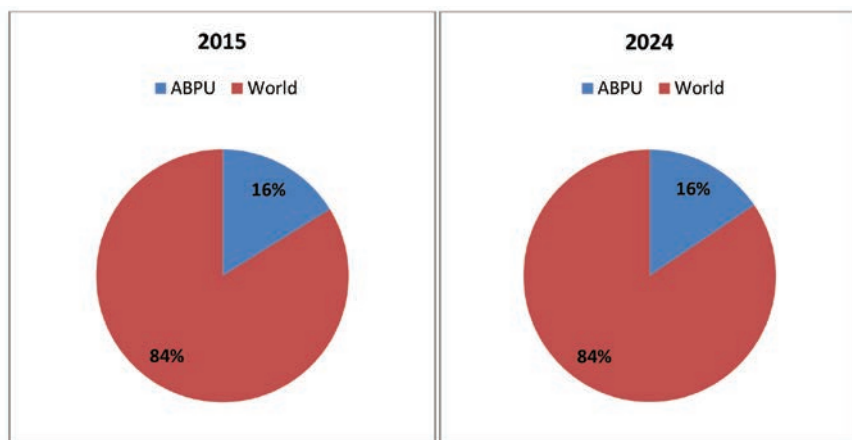
ABPU countries export shares are currently very high in sugar: estimates show that the regional market share reached 40.7% in 2015; and it is projected to grow up to 42.2% in 2024.

**Figure 10. Sugar. ABPU countries' exports shares in 2015 and 2024**



**Source:** OECD-FAO 2015-2024 Agricultural Outlook. In the case of Argentina the projections were corrected with INAI projections including recent changes in agricultural policies, not considered in the baseline OECD-FAO 2015-2024 Agricultural Outlook.

**Figure 11. Biofuels. ABPU countries' exports shares in 2015 and 2024**



**Source:** OECD-FAO 2015-2024 Agricultural Outlook. In the case of Argentina the projections were corrected with INAI projections including recent changes in agricultural policies, not considered in the baseline OECD-FAO 2015-2024 Agricultural Outlook.

**Note:** Biofuels include ethanol and biodiesel.

ABPU countries are also very relevant producers and exporters of many other food products, such as coffee, fruits, juices, vegetables, tobacco, cotton, etc. They have not been included in Table 2 and Figure 2 because most of them are not specified in the OECD-FAO agricultural outlook projections, limiting the comparisons between the region and the world averages for specific products<sup>8</sup>. To provide additional background Table 4 lists the main products in which the region is the leading exporter or the second one.

<sup>8</sup> Table 2 and Figure 2 compare regional and world production information based on the products as specified in the OECD-FAO Agricultural Outlook.

Table 4. Main food products in which ABPU countries were leading exporters in 2010

Product	First exporter	Second exporter
Bovine meat	x	
Poultry meat	x	
Meat preparations		x
Canned meat	x	
Soybean	x	
Groundnuts shelled		x
Soybean oil	x	
Sunflower seed oil		x
Groundnut oil	x	
Oilseeds cake meals	x	
Maize		x
Sugar	x	
Coffee	x	
Orange juice	x	
Lemon juice	x	
Pears	x	
Pulp fruit feed	x	
Garlic	x	
Honey	x	
Tobacco	x	

Source: FAO. FAOSTAT data.





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## Production Systems Implemented in the Region are Sustainable and Environmentally Friendly

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The challenge of achieving world food security is more complex nowadays because such purpose should be reached while taking into account the impact of the production systems on climate change and natural resources sustainability. The world is supposed to produce more food using available natural resources efficiently and sustainably, and reducing the greenhouse gases emissions (GHGE) per unit produced. These purposes require a careful and integrated approach to the efficient use of land, water and energy, aimed at increasing productivity with production systems which are friendly with the environment.

It should be highlighted that most of current world crop production is conducted under production systems which are not friendly with the environment. During the last four decades, increases in production and productivity in most regions have been based on the use of high amounts of fuels and fertilizers, which have deteriorated the natural resources and are contributing excessively to global warming.

Most of the agriculture conducted in Europe, Asia and North America is based on such input intensification process. It is estimated that more than 90% of world crop production in those regions is conducted under input intensive

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production systems, which are supposed to be revised<sup>9</sup>. Currently, in some developed countries several influential NGOs are promoting alternative agro-ecological production systems aimed at “greening agriculture”. However, most of these alternatives limit production and therefore challenge the purpose of achieving food security.

By contrast, during the last two decades ABPU countries have massively implemented interesting structural and technological innovations that have increased productivity with production systems which are friendly with environment. This process has been called “the sustainable intensification strategy”. Most of the extensive crop production (cereals and oilseeds) currently conducted in ABPU countries is based on such sustainable intensification strategy, which is also associated with rotations including pastures for extensive livestock production.

This new agriculture, based on the knowledge provided by the bio-economy approach, includes the integration of different scientific disciplines such as ecology, eco-physiology, genomics, biotechnology, nutritional science, etc. In such context, good agricultural practices have a strategic relevance, because they are the tools that make it possible to adapt and implement agricultural knowledge and innovations.

The mentioned production strategy is based on the convergence of various technological innovations implemented gradually in the region: no-till strategy, crop rotations and sanitation; precision farming; improved seeds including genes for herbicides, insects, and diseases resistances (which imply a lesser use of agrochemicals); new chemical molecules in agrochemicals; integrated plague control; intensive use of information and communication technology; satellite-image support; logistic innovations like silo bags; post-harvest management; precision nutrition; etc.

The no-till strategy (which is the core of the innovation package) integrates a production system that reduces soil erosion and improves rainwater storage in the soil (strategic water management). It is a production system designed at maximizing productivity in a sustainable manner, by improving the use of

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<sup>9</sup> In the USA less than 20% of cultivated area was planted with no till systems in 2010 (FEBRAPDP [www.febradp.org.br](http://www.febradp.org.br)). Shares in Europe and Asia were substantially lower (less than 2%).

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natural resources, minimizing the number of tilling operations, and reducing oil consumption and GHG emissions per unit produced. The soil is covered by stubble; a carbon management strategy is implemented (fostering carbon sequestration); and a crop fertilization strategy is adopted, that is based on a soil nutrition and structuring concept, rather than on the soil fertilization approach. This approach improves the soil biotic load and its sanitary conditions. After several years of implementation of such strategy the soil conditions improve substantially, a totally different result to what happens with the widespread input intensive agriculture.

Annex I includes more detailed information on the main characteristics and impacts of the no-till strategy implemented in Argentina, as well as a certification system designed and implemented by AAPRESID<sup>10</sup> (the Argentine association of no-till farmers). Figures A6 and A7 in Annex I include photos showing the impact on soil conservation and its improvement of the no-till strategy in Argentina, and the impact on energy use and on soil destruction of the intensive European production system (in Italy).

Less than 10% of world crop production is under the “no-till management strategy” and most of the area planted with no-till systems is located in South America. Figures 12, 13 and 14 are a “proxy” to show the massive adoption of such productive and soil conservation strategy in Argentina and Brazil. Similar comments could be done for the massive adoption of such strategy in extensive crops production in Uruguay and Paraguay.

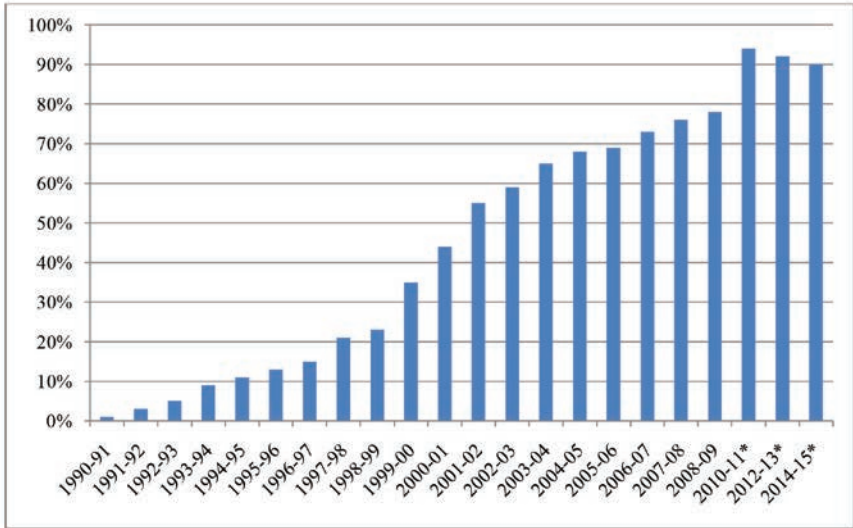
Figures 12 and 13 show the massive adoption of no-till planting in the main annual extensive crops of Argentina. Such process coincided with the increases in yields of the main annual crops, also registered in the country during the last two decades.

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<sup>10</sup> AAPRESID. [www.org.ar](http://www.org.ar).

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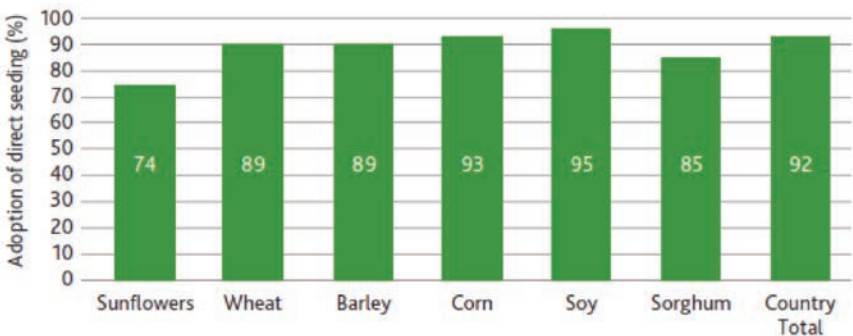
**Figure 12. Massive adoption of no-till planting in Argentina**  
(percentage of total cultivated land under no-till)



**Source:** AAPRESID and ReTAA-Bolsa de Cereales.

**Note:** \* Preliminar.

**Figure 13. Use of no-till planting in Argentina in the main annual crops in 2012/13**  
(% of total planted area with each crop)



**Source:** ReTAA-Bolsa de Cereales, 2015.

Table 5 shows the increase in yields of major annual crops in ABPU countries during the last decades, while massively adopting environmentally friendly production systems.

**Table 5. Evolution of major annual crops' yields in ABPU countries** (tons per hectare)

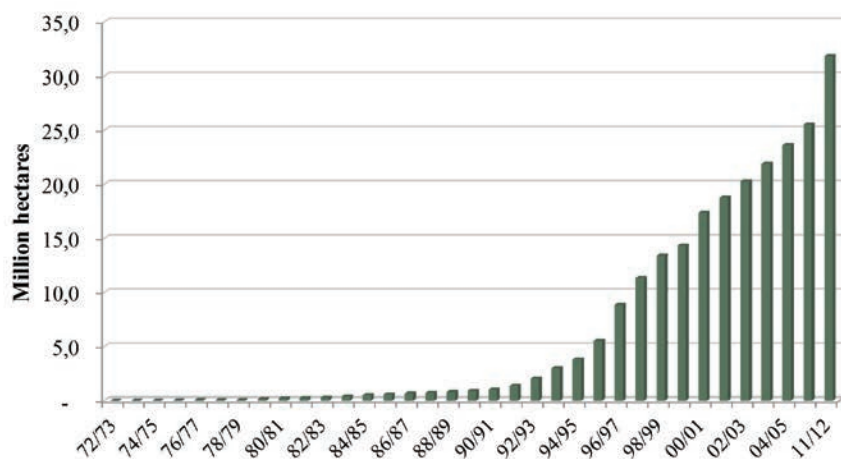
Time	Maize				Soybean			
	Argentina	Brazil	Paraguay	Uruguay	Argentina	Brazil	Paraguay	Uruguay
1989/1990	3.06	1.84	1.46	1.97	2.17	1.76	1.61	1.18
1990/1991	4.05	1.80	1.65	1.79	2.42	1.62	1.46	1.18
1991/1992	4.42	2.20	1.65	1.56	2.37	1.99	1.44	1.54
1992/1993	4.16	2.36	1.76	1.94	2.32	2.12	1.79	1.54
1993/1994	4.17	2.41	2.12	1.64	2.30	2.16	1.71	1.54
1994/1995	4.52	2.64	2.47	2.44	2.19	2.22	2.00	1.55
1995/1996	4.11	2.36	2.01	2.17	2.09	2.21	2.51	1.78
1996/1997	4.56	2.57	2.60	2.66	1.81	2.31	2.64	1.75
1997/1998	6.08	2.65	2.29	3.38	2.80	2.50	2.60	1.63
1998/1999	5.37	2.68	1.95	4.10	2.45	2.43	2.48	2.11
1999/2000	5.55	2.52	2.33	1.55	2.47	2.55	2.43	0.78
2000/2001	5.45	3.20	2.34	4.31	2.67	2.84	2.59	2.33
2001/2002	6.08	3.00	2.38	3.33	2.63	2.66	2.46	2.31
2002/2003	6.33	3.44	2.55	4.56	2.82	2.82	2.92	2.37
2003/2004	6.39	3.38	2.08	4.96	2.36	2.37	2.02	1.53
2004/2005	7.36	3.03	2.68	4.12	2.71	2.31	2.02	1.72
2005/2006	6.48	3.23	4.65	4.18	2.66	2.56	1.50	2.05
2006/2007	8.04	3.64	4.00	5.75	2.99	2.85	2.30	2.14
2007/2008	6.45	3.99	2.40	4.14	2.82	2.86	2.26	1.67
2008/2009	6.20	3.62	3.38	3.07	2.00	2.66	1.44	1.80
2009/2010	8.33	4.34	4.75	5.51	2.93	2.94	2.41	2.11
2010/2011	6.72	4.16	4.24	3.53	2.68	3.11	2.48	1.79
2011/2012	5.83	4.80	3.95	4.26	2.28	2.66	1.37	2.48
2012/2013	6.75	5.16	4.00	5.63	2.50	2.96	2.60	2.81
2013/2014	7.65	5.06	4.95	4.31	2.77	2.88	2.52	2.52
2014/2015	8.50	5.40	4.40	5.78	3.18	3.03	2.50	2.47
2015/2016	8.29	4.19	4.50	4.74	2.91	2.90	2.76	1.96

Source: USDA.

The massive growth of no-till planting has also been registered in Brazil during the last two decades (Figure 14) while the country's average yields of main extensive crops substantially grew (at higher rates than in Argentina and other developed countries). Information provided in the 2016 National Meeting of the Brazilian National Federation of No-tillage (15º Encontro Nacional de Plantio Direto na Palha-FEBRAPDP) shows that approximately 70% of cultivated

area with the main extensive crops in 2014/15 was with no-till planting. Annex II includes more detailed information on the main characteristics and impacts of the no-till strategy implemented in Brazil.

**Figure 14. Massive adoption of no-till planting in Brazil** (million hectares)



**Source:** Markestrat, with National Federation of No-tillage in the Straw (FEBRAPDP) and CONAB data (2012).

Summing up, during the last two decades the ABPU countries substantially increased their food and biofuels production, while massively adopting environmentally friendly production systems. These very positive results of the “sustainable intensification strategy” implemented during the last decades in the region provide an interesting experience for the challenge of producing more food using efficiently and sustainably the available natural resources and, at the same time, reducing the greenhouse gases emissions (GHGE) per unit produced.

Taking into account such valuable regional experience, a pragmatic alternative to cope with global food security and sustainability is to move from input intensive production systems widespread in main producing countries towards the “sustainable intensification strategy”, that promotes production growth while preserving natural resources and reducing the greenhouse gases

emissions (GHGE) per unit produced. We believe this is a better alternative than the “greening agriculture” strategies promoted by several NGOs, which dramatically reduce food supply and seriously challenge the purpose of world food security.

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## Final Remarks

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### Food security and world trade

Trade undoubtedly plays an important role in food security. Regional production and consumption imbalances are very relevant today, and it is expected that such situation will continue in future decades. Moreover, many emerging countries are facing serious limitations on area and renewable water availabilities to sustain food production growth at high rates during future decades; and most of developed countries are also supposed to move from their input intensive production systems to approaches that should be more friendly with the environment, to cope with natural resources deterioration and global warming.

However, world trade of agricultural products is seriously limited by trade policies currently implemented by most developed and developing countries. Tariff and non-tariff barriers in agricultural products are substantially higher than in other goods and services. Such obstacles are inconsistent with global food security purposes as well as with the need to tackle natural resources deterioration and global warming. The result of such measures is that in many net importing countries food prices are much higher than they could be, affecting the access of low income population, which is a key component of food security.

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These issues have not been considered seriously enough in international trade negotiations in WTO. On the contrary, the world trade scenario shows increasing adoption of non-tariff barriers, particularly private measures, in many relevant importing countries. Most of them are not based on scientific evidence as it should be the case under WTO rules. Therefore, world leaders should give more attention to considering to what extent trade barriers that are not based on science are affecting food security and global warming.

A smooth world food trading system should be a major objective aimed at facilitating food security. This purpose has not been included in the international agenda during the last decades, and it highlights the importance of the G20 future leadership to promote global food security based on a more open trading system.

In previous proposals issued by GPS (Regúnaga, M. 2013; Piñeiro, M. et al 2015; Perez del Castillo, C. 2015; MeléndezOrtiz, R. 2015) the need of finding alternatives to promote global food security based on a more open trading system are analyzed. They are available at [www.grupogpps.org](http://www.grupogpps.org).

## The world should move to production systems that are more friendly with the environment

As it has been highlighted in previous chapters, most of the world food production and productivity growth has been based on the use of high amounts of fuels and fertilizers, which have deteriorated the natural resources and are contributing excessively to global warming.

Such strategy should be revised. The world is supposed to produce more food to cope with food security, but using available natural resources sustainably, and reducing the greenhouse gases emissions (GHGE) per unit produced. In many developed countries such production systems are being challenged by NGOs usually concerned with environmental issues. However, most of the alternatives promoted to “greening agriculture” are inconsistent with world food demand growth, and particularly that of the emerging countries.

At the same time other trade barriers are being imposed by the private sector of some relevant importing countries aimed at reducing the Carbon Footprint and, more recently, the Product Environmental Footprint. Such approaches are

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biased in terms of the total world production system, because they are merely putting the focus on trade, while failing to consider the impact on climate change of the main world's production systems.

Our view is that most of the world production systems are supposed to move towards alternatives which are productive and friendly with the environment. Taking into account the valuable experience of last decades innovations as implemented in the Southern Cone, a pragmatic alternative to cope with global food security and sustainability is to move from input intensive production systems widespread in main producing countries towards the "sustainable intensification strategy", that promotes production growth while preserving natural resources and reducing the greenhouse gases emissions (GHGE) per unit produced.

Such discussions should also be included in the international innovation, production and trade agenda.

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## References

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AAPRESID. *Agricultura Certificada*. [www.aapresid.org.ar](http://www.aapresid.org.ar)

Díaz-Bonilla, E. et al. *Better to be foresighted than myopic: a foresight exercise related to agriculture, food security, and R&D in Latin America and the Caribbean*. CIAT Policy Brief, August 2012.

FAOSTAT. *FAO Statistics database*. 2016 Available at <http://faostat.fao.org/beta/en/#home>

FEBRAPDP. *15° Encontro Nacional de Plantão Direto na Palha*. Goiania, Brazil, September 20-22, 2016.

INAI Foundation. *ERAMA 2024. Agroindustrial Reference Scenario for Argentina and the World up to 2024*. Buenos Aires, December 2015.

Meléndez Ortiz, Ricardo. *Addressing Global Food Demand through Multilateral Trade*. The DIALOGUE and GPS, Washington, 2015.

OECD-FAO. *OECD-FAO Agricultural Outlook 2016-2025 statistics*. 2016 Available at <http://www.agri-outlook.org/database/>.

Pérez del Castillo, Carlos. *Achieving Food Security: The Opportunities and Responsibilities of Large Net Exporters*. The DIALOGUE and GPS, Washington, 2015.

Piñeiro, Martín, Margaret Myers, and Laura Uzquiza. *Securing Global Food Supply: What Role for Latin America's Net Agricultural Exporters?* The DIALOGUE and GPS, Washington, 2015.

Piñeiro, Martín and Margaret Myers. *Achieving Food Security: The Dilemmas and Strategies of Large Net Importers*. The DIALOGUE and GPS, Washington, 2015.

Regúnaga, M. (ed). *Global Food Security and Agricultural Natural Resources: Role and Views of Argentina, Brazil, Paraguay and Uruguay*. Group of Producing Countries of Southern Cone -GPS-, Buenos Aires, September, 2013.

Regúnaga, M. and Agustín Tejeda Rodríguez. *Argentina's Agricultural Policies, Trade and Sustainable Development Objectives*. ICTSD Issue Paper Nº 55. Geneva, 2015.

ReTAA. *Relevamiento de Tecnología Agrícola Aplicada: Campaña 2012-2013*. Bolsa de Cereales. Buenos Aires, October, 2015.

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# Annex I

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## Good Agricultural Practices and its Certification as Instrumented by Aapresid in Argentina

**Jose Luis Tedesco<sup>11</sup>**

### *1. Good agricultural practices and sustainable production practices*

Good Agricultural Practices and Sustainable Production Practices imply considerable cultural changes and these have been implemented gradually but steadily by Argentinean producers in their customs and habits.

The pillars for the implementation of Sustainable Production Practices are based on the following activities in the No-Till Production System:

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<sup>11</sup> Agronomist of University of La Plata, Member of Commission Directive AAPRESID and Agricultural Producers

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- a) No-tilling and crop residue presence.** This practice contributes to a more efficient use of water, minimizes soil erosion and the use of fossil fuels. As a result, carbon emissions are reduced and a greater capture of carbon is achieved through crops and crops residues; these facts promote a more diverse and active biological life in the environment in general and in the soil in particular. The increase in biological activity is key to promoting soil fertility which then provides more stability in the productions and yields per surface unit. This virtuous circle maintained over time also results in costs cuts.
- b) Crop rotation.** It consists in alternating different crops both in time and space. Crop rotation is made up of plant species aimed at harvesting its grains but there are other plant species, so-called cover crops, which are not destined to be harvested but whose presence in the rotation scheme fulfils a critically important role for the agroecosystem, such as the biological nitrogen fixation and weed competition. Crop rotation presents advantages from an agronomic point of view such as the inhibiting effect on pathogens and the balanced use of nutrients present in the soil alongside the gradual improvement of the physical, chemical and biological soil conditions; it also stimulates business management through the diversification of production risks.
- c) Integrated plague, weed and disease management (IPM).** The IPM practice seeks to optimize weed, disease, insect and other plagues through diverse strategies in order to protect crops while taking into account economic, social and environmental factors. It requires a thorough knowledge of the plague's biology and ecology as well as that of its environment. In this practice one does not set out to eliminate a crop plague in particular but rather keep it in check below the level of economical damage. IPM also takes into account the benign agents already present in the ecosystem; this is why it becomes paramount to identify the natural enemies for each adversity so as to evaluate its population and capacity to control the crop plague. Carrying out an adequate IMP implies lowering the environmental impact and increased efficiency in business management.
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- d) Efficient and responsible plant protection management.** As a result of a responsible IMP's application the plant protection treatment prescription must come from an agronomic decision with technical back up while it is necessary to achieve a high efficiency and efficacy in said application. This involves 1) choosing less toxic products and/or greater selectivity, that is, choosing those products that control the aimed plagues and have a very low or zero impact in the rest of the agro-ecosystem components; 2) taking into account the minimum time that must pass between the application and the harvest, technically known as the "pre harvest interval;" 3) safely storing and transporting phytosanitary products; 4) looking after workers' and machinists' health; 5) correct management of used packaging and waste water.
- e) Nutritional Strategy.** This practice implies the incorporation of a rational fertilization plan funded in scientific certainties that contemplates not only the number of nutrients to be applied but also their efficient use in crops. This premise must be fulfilled over time while aiming to reach an environmentally sustainable production as a result of achieving or maintaining balancing parameters and indicators that make up the soil's chemical "health." One of the methods contemplated to evaluate it is the nutrients' balance under production strategies with an holistic approach, an action that lays bare the importance of periodical soil analysis.

The integrated application of all these practices within the No-Till Farming System guarantee the Productive System's sustainability and the conservation of its potential without compromising the environment's current and future's condition.

## *2. Good agricultural practices certification through a quality management system*

Certified Agriculture is a Quality Management system designed by AAPRESID (Asociación Argentina de Productores en Siembra Directa: Argentinean Association of No-Till Rural Producers) that has been continuously developing for a decade. The AC production processes Standard Certification guarantees Sustainable

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Production Practices in the application of No-Till Farming that implies no soil removal in addition to applying Good Agricultural Practices (GAP) through time.

It comprises all those actions developed in agricultural production aimed at avoiding or mitigating environmental damages, ensuring an adequate productivity and obtaining innocuous products for human consumption; that is, it addresses food security from three fundamental topics:

- Sustainable food production
- Guaranteed food availability in sufficient quantities over time,
- Production of intrinsically innocuous products.

The certification provides certainties regarding the production processes, the traceability of each activity implied in producing through a compilation of registers that generate transparency and a continuous improvement in the whole productive system.

### *3. FEFAC'S acknowledgement of certified agriculture*

In September 2015, in the city of Rosario, Argentina, an exchange meeting was held between AAPRESID and FEFAC's (European Feeds Manufacturers' Federation) representatives in order to construct a direct link between the two institutions based on a common interest: sustainable production.

The meeting's aim was to establish a physical flow of raw materials with a sustainable origin between Certified Producers under AAPRESID's Certified Agriculture Standard and buyers from the European market as a response to the ever increasing requirements of the demanding countries interested in knowing where and how is its food originated.

The European Feeds Manufacturers' Federation (FEFAC) represents 24 national associations from 23 European Union member state countries whose associated companies process 156 million tonnes of balanced food per year.

After this meeting, the Certified Agriculture Standard Certification was included in a tool known as Standards Map ([www.standardsmap.org/fefac](http://www.standardsmap.org/fefac)) where FEFAC recognises certain quality standards that serve as guidelines for its members when it comes to acquiring sustainable certified products in the

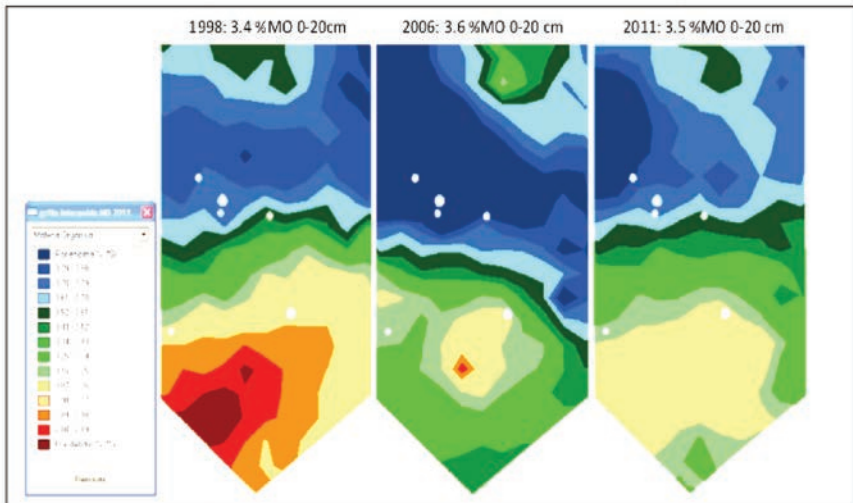
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productive process. Within this outline Certified Agriculture emerges as one of the more complete and strict standards at global levels and offers real sustainable guarantees from a social, environmental and economic standpoint.

#### 4. *The certified system and its indicators*

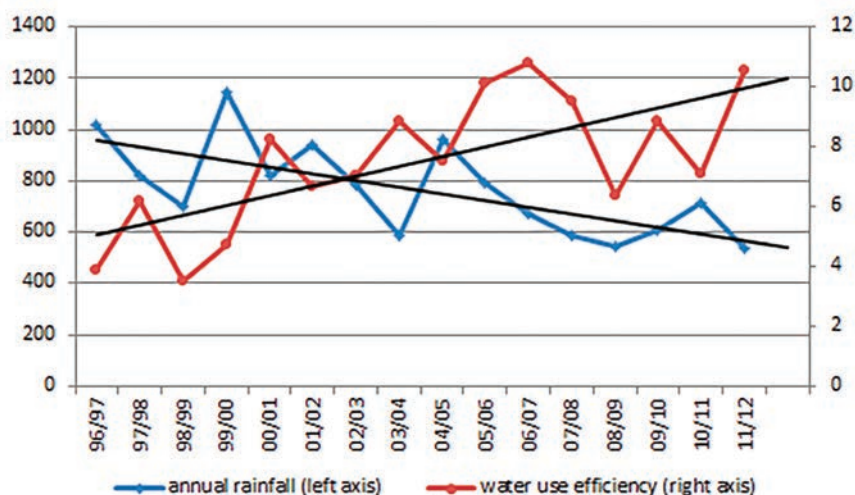
**a) Fertility.** What follows are Tecnocampo's (a Company located in central Córdoba, Argentina) indicators. Tecnocampo has been applying the No-Till System for 24 years and has been certified for the past 6 years (<http://tecnocampo.com/>). The indicators are gathered and calculated based on the registers that the certified company has in each of the activities that are involved in the production system; what we see in the first image is the evolution of organic matter in the soil (the percentage of Organic Matter) with data taken for a period of almost 20 years. In Figure A.1. a stable tendency is observed in the OM % indicator's evolution with a slight increment in the productive cycles that the crop rotation use allowed to intensify.

**Figure A.1. Evolution of fertility implementing the no-till strategy**



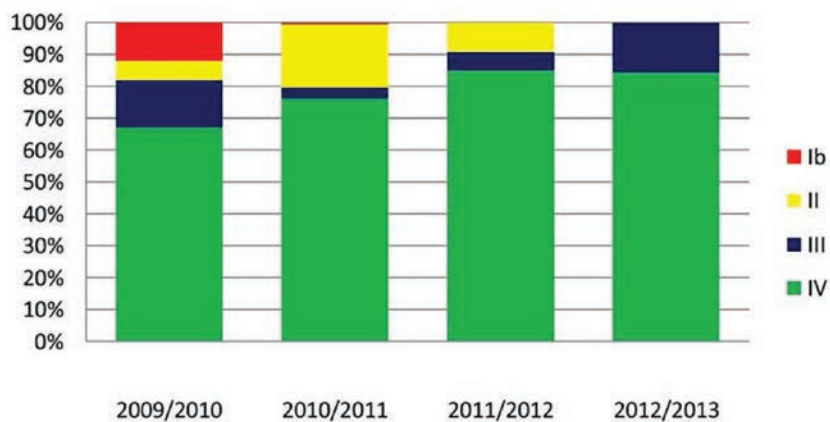
- b) Water use efficiency.** Figure A.2. shows the inverse correlation between the rainfall reduction tendency in the last two decades in the centre of the Province of Córdoba, Argentina, and the increment in the efficient use of water during the same period as a result of applying the No-Till System and intensifying crop rotations.

**Figure A.2. Increase in the efficiency of water use implementing the no-till strategy: Annual rainfalls/ Efficient use of water**



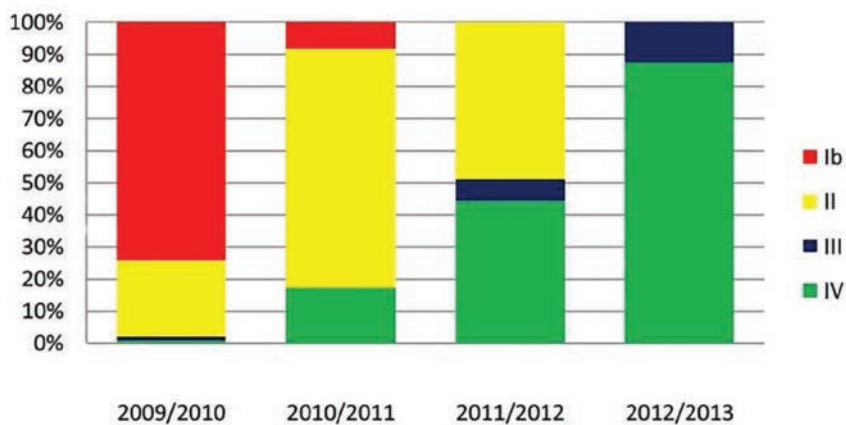
- c) Responsible Plant Protection Management.** In Argentina phytosanitary products labels use the WHO classification for toxicological class identification. The red badge products present the lowest lethal dose .50, which means they are the most toxic ones because even a small product amount can be lethal. In decreasing order are the yellow badge, blue badge and finally the green badge ones which present the least toxicity. Figures A.3 and A.4 present the indicators that show phytosanitary use evolution where the gradual elimination of red and yellow badge products can be seen until only blue and green badge products are used. This change implies a significant improvement in the management of phytosanitary products and a decrease in environmental impact.

Figure A.3. Evolution of use of different kinds of herbicides implementing the no-till strategy



Source: Tecnocampo. (<http://tecnocampo.com>)

Figure A.4. Evolution of use of different kinds of insecticides implementing the no-till strategy



Source: Tecnocampo. (<http://tecnocampo.com>)

## 5. *Biospas*

**Soil Biology and Sustainable Agrarian Production** (<http://www.proyectobiospas.org/>). Since 2007, organized by The Strategic Projects Area in Argentina's Technological Science and Productive Innovation Ministry, a Research Project has been developing which integrates the participation of scientists working in the public sphere with AAPRESID alongside with two private sector companies: La Lucía S.A. from the Romagnoli Group and Rizobacter S.A.

The Project's goal consists in generating the knowledge to understand the soil's biological processes under the No-Till System. A sustainable and efficient productivity of agricultural commodities can be developed in a more environmentally friendly way on the basis of an ever more profound, detailed and integral knowledge of the agro system being managed. To that end, the Project seeks the creative input and action of academic institutions, technical and business entities by fostering their capacities for the development and generation of wealth and value. One of the Project's prominent characteristics is its proposal for developing several coordinated projects to take a comprehensive approach to the same subject of study.

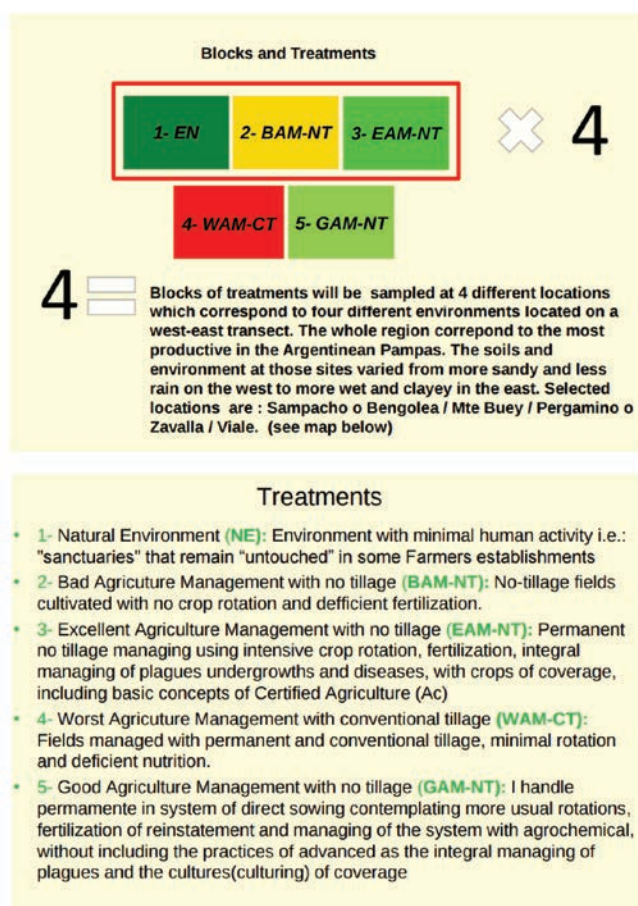
The BIOSPAS's Project main goal is the holistic study of the functioning of the soil through a description of physical, chemical and biological parameters and their interactions with productivity under different conditions of agricultural management in No-Till Farming with the aim to generate knowledge that allows a better understanding of the biological processes that take place in the soil related to productivity and the different No-Till managements. The different biological, biochemical, chemical and physical aspects are characterized simultaneously, both qualitatively and quantitatively, over the same samples.

Three systems or soil uses were compared:

- a) No-Till System with the Sustainable Production Practices previously mentioned including a history of crop rotation according to the region plus nutrition reposition
  - b) Its counterpart, monoculture or minimum crop rotation or without nutrient reposition, which is definitely not sustainable,
  - c) A pristine or virgin environment such as ranch house premises where agriculture was never practiced before.
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The experimental design, the discussion of its results and the Project's general management was carried out in an integrated manner between all the actors whether they belonged to the private or public sector. In turn, the parameters were defined taking into account a series of work definitions regarding soil management in accordance with a group of descriptions provided by AAPRESID's Certified Agriculture (<http://www.aapresid.org.ar/ac/>). Figure A. 5.

**Figure A. 5. Blocks and treatments based on AAPRESID Certified Agriculture**





The development of this new and genuine knowledge about soil biology allows the construction of quality biological soil indicators that are indispensable guides for the farm producer and a factual basis to tune scientific knowledge and research. The new indicators will contribute to strengthen and improve the Sustainable Production Certification Practices' processes.

Twice a year, within the Project's framework, samples were taken alongside an East-West transect located in the most productive areas of Córdoba, Buenos Aires and Entre Ríos Provinces, Argentina. Diverse study and technical approaches were used starting with the environmental variables determination and analysis and the soil's physical measurements to the metagenomics molecular analysis of certain functions in the soil's biology through to more classical microbiological, biochemical, chemical and agronomic techniques.

The joint efforts in this Project placed under analysis the diversity of the obtained data to define the existence of correlations that allow building new soil and productivity quality indicators and generate knowledge and courses of action to foster development and wealth generation in our communities. In addition, a more in depth knowledge of the soil's biology contributes to generating conscience about our country's natural resources patrimony.

The obtained results confirm that, through the application of Sustainable Production Practices it is possible to go from a degrading tendency in soils to an inverse tendency that is a clear improvement. The soils under monoculture have nothing in common with the pristine soils whereas the soils under the No-Till System share many characterizations with the pristine grounds regarding the soil's diversity and its population of macro and micro fauna. This information is of vital importance for the sustainability of the productive systems, the conservation of our country's condition as a surplus producer and to boost policies that allow us to sustain this goal over time.

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*6. Additional photos showing impacts of argentine and European alternative production systems*

**Figure A.6. Argentine Production System with Low Use of Inputs and Energy (Direct Seeding)**



*Source:* Regúnaga, M. (2012). Photos of the Pampean Region, Argentina.

**Figure A. 7. European Production System with High Use of Inputs and Energy**



*Source:* Regúnaga, M. (2012). Note: Photos of Tuscany, Italy.



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## Annex II

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### The Transformation of Agriculture in Brazil through Development and Adoption of Zero Tillage Conservation Agriculture<sup>12</sup>

**P. L. de Freitas<sup>13</sup> and J. N. Landers<sup>14</sup>**

#### *Abstract*

The soil conservation movement in Brazil has been a major driving force in the continuing search for agricultural farming systems that are more sustainable than what we have today, particularly in tropical and subtropical areas. The

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development and adoption of Zero Tillage Conservation Agriculture (ZT/CA) was the key to the success of this movement, generating agricultural, environmental, and societal benefits.

Adoption of the ZT/CA philosophy and technologies is currently practiced on more than 50% of the annual crop area. This is due to the work and innovations of pioneering farmers, agronomists, researchers, and consultants that were and are involved in these efforts. This extensive adoption of ZT/CA occurred after many unsuccessful efforts to mitigate against the devastating effects of soil erosion that were threatening the entire agricultural industry in Brazil. Technicians and farmers realized that erosion control required continual cover of the soil to guard against the torrential rain storms common to these regions. This triggered the efforts of soil conservation pioneers at different points in time and regions of Brazil.

In southern Brazil, Herbert Bartz, watched his topsoil eroding away in torrents of runoff. This set him thinking and searching for alternatives, resulting in his adoption of ZT/CA farming in 1972. Ten years later in Brazil's centre-western savannah (Cerrado biome), farmers, researchers, crop consultants and agro-industry initiated efforts to expand cultivation into the very difficult production region of the Cerrados. This was successfully achieved through the pioneering work of agronomist John Landers, bringing experience from the ZT/CA farmer association networks in the south.

These were the turning points in the sustainable development of annual crop farming in Brazil. Today, society recognizes the role of these pioneers as key to achieving social, economic and environmental sustainability. ZT/CA reversed the historically accelerating degradation of soil organic matter and soil structure by abandoning conventional tillage, thus improving soil physical and chemical characteristics. This was achieved by promoting cover cropping and permanent soil cover with crop residues, crop rotations, and complementary, environmentally suitable soil management technologies.

## *Introduction*

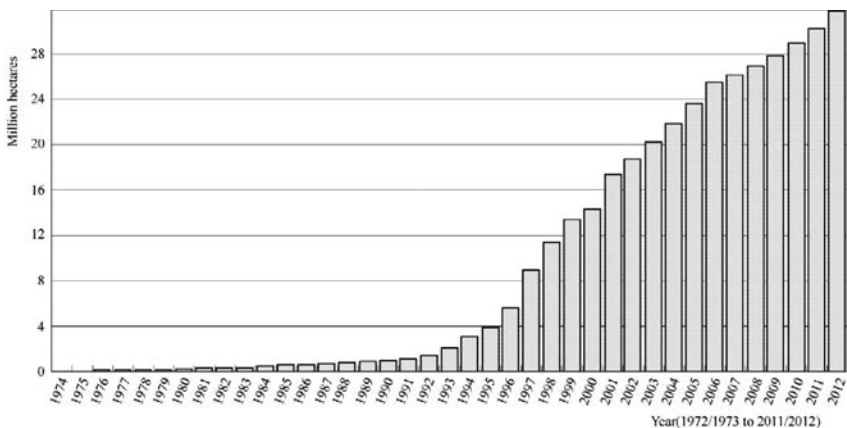
The soil conservation initiative in Brazil is closely linked with continuing efforts to develop agricultural systems that are more sustainable, profitable,

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and environmentally friendly than those of today. Soil conservation was the foundation for these efforts, with zero tillage as a central pillar.

The adoption of Zero Tillage Conservation Agriculture (ZT/CA) in Brazil has been based on principles of sustainability, with social, economic and environmental dimensions. It integrates the objectives of high productivity, low consumption of fossil fuels, increased carbon sequestration, and mitigation of water and wind erosion. The success of these efforts is illustrated by the fact that these procedures are used in over 50% of the area cropped for annual crops. It is also illustrated by the major shift away from traditional tillage to more environmentally friendly practices. This has revolutionized the entire production chain in tropical and subtropical regions of Brazil.

**Fig. 1 Evolution of ZT/CA management systems in Brazil**

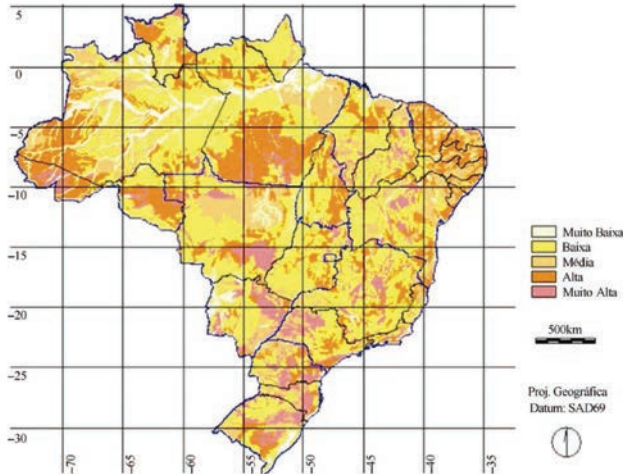


**Source:** Authors based on FEBRAPDP, 2013.

This did not happen easily or quickly. As in most other countries, agriculture in Brazil was initiated using traditional inversion tillage based on experience from temperate regions in Europe. The adoption of management systems not adapted to the specific pedoclimatic conditions, the devastation of soil erosion, and market pressure from poor commodity prices promoted expansion of these technologies, particularly in areas highly vulnerable to erosion, as shown in Fig. 2 (Ramalho-Filho et al., 2009).

**Fig. 2 Soil vulnerability to water erosion in Brazil (based on Hernani et al., 2002)**

(The legend represents five levels of vulnerability: MuitoBaixa is Very Low; Baixa is Low; Media is Average; Alta is High; Muito Alta is Very High.)



**Source:** Authors based on Hernani et al., 2002.

The control of erosion in highly vulnerable tropical soils requires, first of all, that land uses are in accord with the ecological conditions and suitability of the land (Ramalho-Filho; Beek, 1995). Evaluations based on Brazilian soil information, indicate that over 5.5 million km<sup>2</sup> (65% of the territory) are suitable for agriculture (Manzatto et al., 2002). The adoption of land management technologies in harmony with the ecosystem characteristics of these areas is a key measure to avoid extensive degradation on the fragile Amazon and Pantanal Biomes (Freitas et al., 2007).

In the agricultural development of Brazil, various attempts to control massive soil erosion were tried, including traditional mechanical terraces and contour channels. However, by the 1970s, it became obvious that these procedures were not working and some major changes were necessary. The major problems were due to the intense, erosive rains that occur normally at the start of the planting season, resulting in incredible soil losses.

Hernani et al. (2002) estimated an annual soil loss of 833 million tons in areas with annual and perennial crops and in natural and planted grasslands. Annual on-farm cost of erosion, based on the additional requirements for fertilizers, limestone and organic fertilizers, was estimated to be more than \$US 2.6 billion (Hernani et al., 2002).

**Table 1 A first approximation of the economic impacts of ZT adoption in Brazil**  
(re-calculated from Landers et al., 2001a)

Categories of Impacts	Economic Impact (USD)
<b>A. On-farm benefits (direct benefit to farmers)</b>	<b>943.7</b>
Incremental net benefits due to the adoption of ZT in relation to conventional systems due to land value appreciation	882.2
Economy in irrigation water pumping energy	61.5
<b>B. Off-farm reductions in public spending</b>	<b>164.6</b>
Maintenance of rural roads	128.3
Municipal water treatment	1.3
Incremental reservoir life	24.4
Reduced dredging costs in ports and rivers	10.6
<b>C. Off-farm environmental benefits to society</b>	<b>487.9</b>
Increase in water availability due to greater aquifer recharge	303.2
Carbon credits for reduced diesel fuel use	1.6
Reduced use of Irrigation water	17.5
Carbon credits for the decrease in CO <sub>2</sub> emission from lower fuel consumption, sequestration in soil, and from soil and biomass C sequestration	165.7
<b>D. Benefits for mitigating de-forestation through the adoption of integrated ZT and livestock systems</b>	<b>2,077.6</b>
<b>Total benefits on an annual basis</b>	<b>3,673.7</b>

\* Calculated in relation to the total cultivated area, 31.8 million ha.

## *The Break Through*

The first requirement was that researchers and farmers accept the principle that mechanical practices alone were not adequate to control water erosion in tropical and subtropical areas. It was realized that effective control can only be achieved through integration of mechanical practices with biologic technologies including vegetative cover and crop rotations, and that intensive tillage be avoided. This was the first approach to ZT/CA.



Concepts such as integrated farming systems (Muzilli, 1988; Norman, 1980) and integrated watershed management (BRASIL, 1987; Shaxson, 1988; Bragagnolo et al., 1997) were tried. Eventually, these concepts were integrated with principles of agroecology and the preservation of soil, water, and biodiversity.

The evolution and dissemination of these ideas occurred in different places and in different times. It started near the end of the 1960s in Rio Grande do Sul, using an American no till planter called "Buffalo" to seed sorghum (Borges, 1993). Following this, many trials were started in experimental stations such as the ones supported by FECOTRIGO (Brazilian Wheat and Soya Cooperative Federation) and the Ministry of Agriculture. These trials were extended to the State of Paraná at the beginning of the 1970s.

In 1971 research was initiated by IPEAME (a predecessor of EMBRAPA) with German technical assistance and the successes achieved were a major turning point. The interest and acceptance of the technologies in Paraná were driven by necessities to control soil erosion as well as restrictions in availability of farm credit (Landers, 1999). Among the different farmers and researchers involved in this effort, it was the dedication, perseverance, and pioneering work of a farmer, Herbert Bartz, which stands paramount (Saturnino, 1998; Saturnino, 2001). His efforts and innovations were fundamental in overcoming the initial difficulties of this new technology.

Following this, researchers and farmers had the support of IAPAR, a research institute inaugurated in the early 1970s in Londrina, Paraná, and the support of technicians from ICI BRASIL & the UK. By 1975, data from the trials were available, showing a reduction of 90% in soil loss and over 50% in water loss (IAPAR, 1981). These breakthroughs established the modern basis of soil conservation consciousness in Brazil, and provided the foundation for a revitalized and sustainable agriculture.

Following the successes of Herbert Bartz, other farmers began adopting ZT/CA in the southern states of Brazil. Pioneers in the region of Campos Gerais (State of Paraná) included Manoel Henrique Pereira, Frank de Jikstra, and Wibe de Jagger.

In 1978, the development of no till planters for tropical conditions was initiated by researchers at EMBRAPA (Brazilian Enterprise for Agricultural Research, Ministry of Agriculture) in Passo Fundo (Rio Grande do Sul), with support from ICI Brazil. At the same time, trials of a lagged double disc system were initiated with

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cooperation from Canada. Also, by this time herbicides based on glyphosate were introduced, and the first equipment for simultaneous planting and fertilizing were introduced. In addition, field studies with covercrops and crop rotations were intensified, all with the result that ZT/CA became established as a feasible management system for tropical and subtropical areas (Derpsch et al., 1991; Derpsch and Calegari, 1985). These procedures ultimately spread to other regions in Brazil.

At the same time, the ZT/CA practices and processes developed for the subtropical region were brought to the Centre-west, tropical region as farmers migrated into these areas because of cheap land and government incentives. A period of rapid expansion in this region started in the late 1970s, with a significant increase in area of improved pastures and annual crops, triggered by the breakthrough on soil treatment with lime and fertilizers. In only a decade the area under no-till in Brazil increased from about 1,000 ha in 1973/1974 to 400,000 ha in 1983/1984 (Derpsch, 1984).

### *The evolution of farmer associations to promote ZT/CA agriculture*

Farmer's associations played a central and crucial role in adoption and dissemination of ZT/CA technologies in Brazil. The first of these, founded in the region of Campos Gerais (State of Paraná), was named "Clube da Minhoca" (literally "The Earthworm Club"). Pioneer farmers, supported by COOPERSUL and agribusiness components, organized three national meetings (1981, 1983 and 1985) where they discussed the main technological difficulties in initiating ZT/CA system, supported by experienced researchers and technicians.

Other farmer organizations were organized in the State of Rio Grande do Sul but these were called "Clube Amigos da Terra" (Friends of the Land Clubs). The objectives were to promote awareness, training, and technical development for adoption and refinement of ZT/CA (Borges, 1993). After the successful experience in Rio Grande do Sul, the concept of "Clube Amigos da Terra" was extended to other regions to help farmers promote and develop new technologies related to herbicide management, spraying techniques, fertilization and liming, erosion

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control, and rotation of annual crops with pasture. These farmer's organizations propelled Brazil to becoming a world leader in tropical and subtropical ZT/CA systems (Freitas et al., 2001).

These successes ultimately culminated in the creation of the Brazilian Federation of Zero Tillage in Crop Residues (FEBRAPDP) in July 1992, and finally in the creation of the American Confederation of Farmers Organizations toward a Sustainable Agriculture—CAAPAS. The latter included institutions such as AAPRESID (Asociación Argentina de Productores en Siembra Directa), SOCOSCHI (Sociedad de Conservación de Suelos de Chile), FEPASIDIAS (Federación Paraguaya de Siembra Directa para una Agricultura Sustentable), AUSID (Asociación Uruguaya de Siembra Directa), AMLC (Asociación Mexicana de Labranza de Conservación), ANAPO (Asociación de Productores de Oleaginosas y Trigo de Bolivia), CTIC (Conservation Technological Information Center—West Lafayette, Indiana, USA). CAAPAS later expanded with membership from Mexico and Canada.

The Farmer Association for the Cerrado Region (APDC) was organized in 1992, headquarters in Goiânia (State of Goiás), with the objective to promote ZT/CA following two successful short courses organized by John Landers (with agribusiness support). It later expanded its network to 47 "Clube Amigos da Terra", foundations and other farmer organizations. With APDC acting as a facilitator for ZT/CA, the result was an increased adoption to more than 5 million ha by 2001/2002. Farmer-to-farmer extension with integrated support from the private sector, NGO, government and some international agencies was the prime factor in dissemination. Farmer involvement has led to substantial improvements in technology delivery to the farm sector, but government support to research and extension has also been essential.

### *ZT/CA in the Brazilian "Cerrados"*

In the 1980s, and based on the successes from the south, ZT/CA was attempted in the Brazilian Cerrado region, a wet/dry tropical savannah biome concentrated in the central high-plateau and covering 207 million ha. This region is one of the "major agricultural frontiers" in the country, but one where special care is required

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to protect the environment (Sade, 2000). The Cerrados is one of the most difficult production areas on earth, being dominated by low fertility soils, predominantly Ferralsols (Oxisols, Latossolos), Arenosols (Entisols, "Neossolos quartzarênicos") and Acrisols (Ultisols, Argissolos). Annual rainfall (summer rains) varies from 1,200 to 1,700 mm spread over 5-7 months. However, the elevated tablelands and wide interfluvies with gentle topography are well-suited to mechanized agriculture.

Several trials were initiated in the early 1980's by Eurides Penha, a pioneer farmer in Rio Verde (State of Goiás). In 1982, ZT/CA was attempted by Ricardo Merola for seed production in Santa Helena (Goiás). Of special note, however, are the trials started by John Landers in Morrinhos (State of Goiás) after 1992.

By the early 1990s, the evolution of ZT/CA involved the integration of annual cropping with livestock production, improving the profitability of the system and mitigating crop failures.

### *The Process of ZT/CA Adoption*

The process of adoption of ZT/CA in the southern states (subtropical region) and Centre-western and south-east states (tropical region) for high intensive mechanized agriculture and for small farms, are shown in Table 2, as described by Landers (1999). In the Cerrado region, ZT/CA adoption was based on (i) farm-tested and cost-effective technology, (ii) awareness of financial benefits, (iii) technical training, (iv) removal of serious soil physical and chemical constraints and problem weeds, and (v) availability of cover crop seeds.

Experience has shown that an important change in paradigm is often associated with ZT/CA adoption. This includes higher awareness of environmental responsibility and enhanced management capabilities. The idea of working with nature rather than exploiting nature imparts a profound change of thinking to the ZT/CA farmer.

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**Table 2 The phases of ZT/CA development in Brazil** (Adapted from Landers, 1999)

ZT/CA development phases	Sub-tropical Region (southern states)		Tropical Region (Centre-western and south-eastern states)	
	Mechanized	Small Farms	Mechanized	Small Farms
<b>PIONEER PHASE</b> On-farm technology development by few farmers. Little expansion. Beginning of research. No extension, some private sector or international support. Testing of cover crops. Beginning of ZT farmer organization and dissemination events.	1971-1984	1985-1991	1981-1986	1996-2004
<b>CONSOLIDATION PHASE</b> Improvements in technology, better planters, more weed control and cover crop options. Early fertilizer lime recommendation under ZT. Costs approaching CT. Expansion slow, little extension and formal teaching.	1985-1990	1992-1996	1987-1992	2004-2008
<b>MASS ACTION PHASE</b> Costs below CT. Increasing adoption by extension in teaching curricula. Technology refinements and wide range of research recommendations. Incentives limited to small/medium farmers. Significant private sector support. Rapid expansion-NGO network with private and public sector.	1991-2000	1997-2010	1993-2000	2009-2015
<b>DOMINANT PHASE</b> ZT as the norm. Full research priority to avoid second generation problems. NGO network active in on-farm R&D and professional ZT training. Widespread adoption by extension and teaching establishments. Incentives to intensification in ZT	2001-2100	2011-2100	2001-2100	2016-2100

<sup>3</sup> FAO/UNESCO Soil Classification (USA Soil Taxonomy, Brazilian Soil Classification).

### *Technological development of ZT/CA*

No-tillage, crop rotation, cover cropping, and permanent soil cover are the technological pillars of ZT/CA. Application of these principles reverses the devastating impacts of accelerated soil erosion, degradation of soil organic matter, and destruction of soil structure. It also increases soil biology and biodiversity by 2 to 4 times (Landers et al., 2013).

The adoption of ZT/CA represents a radical change in agronomical practices, eliminating soil tillage, promoting agrobiodiversity (crop rotations), and keeping the soil surface covered with crop residues (Machado et al., 2004; Landers et al., 2001c). The agronomic evolution under ZT/CA goes beyond the erosion control, soil compaction mitigation and/or reduced production costs. It is recognized as an

example of technological integration driven by farmers, complying with personal and social desires for improved sustainable development and environmental quality (Landers et al., 2001b).

In 2000/2001 a technological platform on ZT/CA was carried out by EMBRAPA, FEBRAPDP and APDC to prepare the basis for research on improvements in efficiency and efficacy of ZT. The objectives were to promote environmental sustainability, economic competitiveness, and social equity (Freitas, 2001). Countrywide research priorities were ranked after considering socio-economic, political and cultural priorities as: (i) the high initial cost of adoption (including the high cost of specialized ZT/CA machinery), (ii) lack of low-interest specific ZT/CA credit lines, (iii) high cost of inputs (per se and in soil pest control), (iv) unemployment of tractor drivers and (v) the need for employee training in ZT technology. Other problems cited were in relation to extension of ZT: (i) lack of promotion of the new concepts, (ii) lack of information on herbicides and (iii) lack of basic technical knowledge of ZT principles.

The major result of the ZT/CA Platform has been the multiplication of cooperative research, development and diffusion projects between farmer organizations and individual farmers, private sector and government agencies. The topics covered are wide-ranging, including integrated pest, disease and weed management, alternative crop rotations, biomass generation for soil cover, indicators for soil nutrients, soil physical properties and soil biological activity, modifications of farm machinery for higher efficiency under ZT conditions, and a conscious effort to reduce the environmental impacts of farm chemicals. In the same exercise, the farmers were asked to suggest solutions for the problems they identified, and many have been incorporated into crop husbandry recommendations.

An example of the impact of the ZT Platform is the multiplication of short courses on ZT, made available through leading farmers, researchers, extension personnel and crop consultants. APDC has held over forty 2-5 day short courses since 2000, with some 1,800 participants and participation of advanced farmers. Training in the ZT farming system, as opposed to crop by crop training, is now the rule for technical personnel of farm input suppliers.

The participatory involvement of farmers has been fundamental to the success of ZT/CA. These developments, including identification of problems for

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research, have resulted in the following practical advances in knowledge in land management in tropical and subtropical areas:

- improved understanding of the roles of entomology, plant pathology and weed science, as well as biological control mechanisms with ZT/CA;
- improved understanding of soil management, including crop rotations and cover crops and the dynamics of ZT/CA in these environments;
- development of equipment and methods for planting, fertilizing, tilling, and harvesting tailored to tropical and subtropical environments;
- the extension and application of ZT/CA beyond annual cropping, to include high value crop production in enterprises such as fruit culture, forestry, horticulture, coffee plantations, pastures, forests;
- stimulation of technologies for small holder farmers, including animal traction machines for planting and harvesting;
- better organization of farmers and technicians around the concepts of ZT/CA, with significant advances in institutional arrangements.

Some of the advances in science and research have been the following:

- significant improvement of soil porosity compared with soils under conventional tillage;
- identifying that humic acids from decaying residues reduce aluminium toxicity in the soil, reducing requirements for lime, and increases the mobility of calcium and magnesium, contributing to the expansion of the rooting zone;
- demonstration that improved resistance to pests and diseases can be achieved with ZT/CA.

The agronomic benefits of ZT/CA are:

- Zero-tillage increases soil porosity by preserving rooting channels, and thereby improves water infiltration and drainage, eliminates pulverization of soil aggregates from tillage and destructive rain storms, and reduces formation of plough pans, and draft power for planting, while also improving habitat for macrofauna;
  - Crop residues on the surface practically eliminate soil erosion, reduce water evaporation, and act as a reserve of organically-bound nutrients (as residues decompose to humus);
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- Increased soil organic matter greatly enhances available water and nutrient retention, higher biological activity (enhancing biological controls), higher levels of water-stable aggregates and a positive carbon sink.

The impacts for society are:

- positive soil carbon sink and (possible) reduced N<sub>2</sub>O emissions;
- reduced CO<sub>2</sub> emissions through reduced fossil fuel use and cultivation;
- cleaner air through effective elimination of dust as a product of cultivation;
- less water pollution and greater aquifer recharge from reduced rainfall run-off;
- reduced demand for (tropical) de-forestation, by permitting crop expansion on steeper lands;
- reduced flood and drought-induced risks;
- increased wildlife populations (skylarks, plovers, partridge and peccaries) ;
- improved conservation understanding in farmers.

## *Conclusion*

Farming in the tropics and subtropics requires more than simply producing food, fiber and biofuels for everincreasing and demanding populations. Increasingly, it is recognized that specialized modern technologies mustbe mobilized to counteract the potential for devastating environmental and economic devastation in these regionsthat are highly susceptible to erosion. Successful soil conservation in these areas is increasingly based onapplication and maintenance of the natural environmental processes of nutrient, water, and organic mattercycling, and soil biodiversity. This is highly knowledge intensive soil management.

The paradigm of ZT/CA integrates the concepts of soil erosion control with crop rotation, maintenance ofpermanent soil cover, integrated pest, disease and weed management, development of more productive andadapted species, varieties and cultivars, and more rational fertilization systems. This is done within the context ofdifferent farming systems suitable to different ecological conditions and within constantly changing market andeconomic conditions. This integration results from the work and innovation of pioneer farmers, extensionpersonnel,

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technical consultants, agricultural researchers, and university professors. This has made Brazilian agriculture one of the most sustainable in the world.

The adoption of ZT/CA implies benefits to the agricultural community as well as to society in general. It results in reduced inputs of fertilizers, seeds and chemicals, reduced CO<sub>2</sub> emissions through reduced farm fuel use, reduced on-farm labor, and reduced costs for road maintenance, water reservoir replenishment, waterway dredging, and domestic water treatment. It results in better overall air quality, flood and drought prevention, less deforestation, and the mitigation of greenhouse gases through reduced fuel use and carbon sequestration. Through ZT/CA, farmers are no longer a part of the environmental problem, but rather part of the solution. EMBRAPA, in partnership with universities and public and private institutions, has promoted and anchored the use of systems such as ZT/CA which are well adapted to Brazilian conditions.

The successful soil conservation initiative in Brazil is due in no small measure to the pioneer farmers and technicians who developed and contributed to the experimentation and innovations that ultimately resulted in the evolution of this new, innovative system of farming. This is the legacy of their contributions.

## *References*

Borges, G. O. de. (1993). Resumo Histórico do Plantio Direto no Brasil. In: Embrapa, Centro Nacional de Pesquisa de Trigo. Embrapa, CNPT, Plantio Direto no Brasil. Passo Fundo, Brazil: Aldeia Norte/FUNDACEP/FECOTRIGO/FUNDAÇÃO ABC. pp. 13-18.

Bragagnolo, N., Pan, W., and Thomas, J. C. (1997). Solo: uma experiência em manejo e conservação, Curitiba, Brazil. Author's Edition, 102 p.

Brasil. (1987). Programa Nacional de Microbacias Hidrográficas, Manual Operativo, Brasília, DF, Brazil, Ministério da Agricultura. 59 p.

Derpsch, R. (1984). Histórico, requisitos, importância e outras considerações sobre Plantio Direto no Brasil. In: Plantio Direto No Brasil, Fundação Cargill. pp. 1-12.

Derpsch, R., Sidiras, N., and Heinzmann, F. (1985). Manejo do solo com coberturas verdes de inverno. *Pesq. agropec. bras.* Brasília, 20 (7), 761-773.

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Derpsch, R., and Calegari, A. (1985). Guia de plantas para adubação verde de inverno. Londrina: IAPAR, 96 p. (Iapar, Documentos, 9). Derpsch, R., and Calegari, A. 1985, Guia de Plantas para Adubação Verde de Inverno, Londrina: IAPAR, 96 p. (Iapar, Documentos, 9).

Derpsch, R., Roth, C. H., Sidiras, N. and Kopke, U. (1991). Controle da Erosão no Paraná, Brasil: sistemas de cobertura de solo, plantio direto e preparo conservacionista do solo, Eschborn, GTZ, and Londrina, Brazil, Iapar, 272 p.

FEBRAPDP. (2013). Expansão da Área Cultivada em Plantio Direto. Available at: <http://www.febrapdp.org.br/arquivos/BREvolucaoPD72a06>.

Freitas, P. L. de. (2001). Organization of a technology platform for cooperative research and development in zero-till agriculture in Brazil. Available at [www.embrapa.br/plantiodireto/](http://www.embrapa.br/plantiodireto/).

Freitas, P. L. de, Martin-Neto, L., and Manzatto, C. V. (2007). Solos: além de tudo, sequestro de carbono. Revista Agroanalysis, Fundação Getúlio Vargas, Caderno Especial: Serviços ambientais no negócio agrícola, 27 (4), E15-E16.

Hernani, L. C., Freitas, P. L. de, Pruski, F. F., Maria, I. C. de, Castro-Filho, C., and Landers, J. N. (2002). A Erosão e seu Impacto. In Manzatto C. V., Freitas-Júnior E., and Peres J. R. R. (Eds.), Uso agrícola dos solos Brasileiros. Rio de Janeiro, Brazil, Embrapa, 174 p. Chap. 5. pp. 47-60.

Iapar (Org). (1981). Plantio Direto no Estado do Paraná, Londrina, Brazil, Iapar, Iapar, Circular Técnica, 23. 244 p.

Landers, J. N. (1996). O Plantio Direto na Agricultura: o caso do Cerrado. In Lopes I. V. et al. (Org.), Gestão ambiental no Brasil: experiência e sucesso. Rio de Janeiro, Brazil, Fundação Getúlio Vargas, pp. 3-33.

Landers, J. N. (Ed.). (1994). Fascículo de Experiências de Plantio Direto no Cerrado. Goiânia, Brazil, APDC. 261 p.

Landers, J. N. (1999). How and Why the Brazilian Zero Tillage Explosion Occurred. In Stott, D. E., Mohtar, R. H., Steinhardt, G. C. (Eds.), Proceedings of the 10th International Soil Conservation Organization Meeting. West Lafayette, Indiana, USA: ISCO. pp. 29-39.

Landers, J. N., Barros, G. S., Rocha, M. T. de, Manfrinato, W. A., and Weiss, J. (2001a). Environmental Impacts of Zero Tillage in Brazil: a first approximation. Proceedings of the World Congress on Conservation Agriculture. Conservation agriculture: a worldwide challenge. Madrid, FAO-ECAF, Volume I, Chapter 34, pp. 317-326.

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Landers, J. N., Freitas, P. L. de, Guimarães, V. and Trecenti, R. (2001b). The Social Dimensions of Sustainable Farming with Zero Tillage. Proceedings of the International Conference on Land Degradation and Meeting of the IUSS Subcommission C-Soil and Water Conservation. Rio de Janeiro, Brazil. Paper S6-03.12 p.

Landers, J. N., Saturnino, H. M., Freitas, P. L. de, and Trecenti, R. (2001c). Experiences with farmer Clubs in Dissemination of Zero Tillage in Tropical Brazil. In Garcia-Torres, L., Benites, J., and Martinez-Vilela, A. (Eds.), Conservation Agriculture: A Worldwide Challenge. Proceedings of the 1st World Congress on Conservation Agriculture. Madrid, Espanha: FAO and ECAF, Volume I: Keynote Contributions. 387 p. pp. 71-76.

Landers, J. N., Rass, G., Freitas, P. L. de, Basch, G., González-Sánchez, E. J., Tabaglio, V., Kassam, A., Derpsch, R., and Friedrich, T. (2013). Effects of Zero Tillage (No-Till) Conservation Agriculture on soil physical and biological properties and their contributions to sustainability. Proceeding of European Geosciences Union Meeting, Vienna, Geophysical Research Abstracts, Vol. 15, EGU2013-11756-1, 2013 EGU General Assembly.

Lara Cabezas, W. A. R., Freitas, P. L. de. (Eds.). 1999. Plantio direto na integração lavoura-pecuária. Uberlândia: Universidade Federal de Uberlândia, Goiânia: APDC, 282 p.

Machado, O. A., and Freitas, P. L. de. (2004). No Till Farming in Brazil and its Impact on Food Security and Environmental Quality. In Lal, R., Hobbs, P., Uphoff, N., and Hansen, D. (Eds.), Sustainable Agriculture and the Rice-Wheat System. Marcel Dekker, Inc., Chapter 18. pp. 291-310.

Manzatto, C. V., Ramalho-Filho, A., Costa, T. C., Santos, C. L. M. de, Coelho, M. R., Silva, E. F. da, and Oliveira R. P. de. (2002). Potencial de Uso e Uso Atual das Terras. In Manzatto, C. V., Freitas Junior, E., and Peres, J. R. R. (Eds.), Uso agrícola dos solos brasileiros. Rio de Janeiro, Brasil: Embrapa Solos, 174 p. Cap. 2. pp. 13-21.

Muzilli, O. (1988). A pesquisa em sistemas de produção: um enfoque voltado para o desenvolvimento da pequena propriedade. In Moniz, A. C., Furlani, A. M. de, Furlani, P. R., and Freitas, S. S. (Eds.), A responsabilidade social da ciência do solo. Campinas, SP, Sociedade Brasileira de Ciência do Solo. pp. 239-245.

Norman, D. W. (1980). The farming systems approach: relevancy for the small farmer. East Lansing, Michigan State University. (MSU Rural Development Papers, 5). 26 p.

Ramalho-Filho, A., and Beek, K. J. (1995). Sistema de avaliação da aptidão agrícola das terras. 3. ed. rev. Rio de Janeiro: EMBRAPA-CNPS. 65 p.

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Ramalho-Filho, A., Freitas P. L. de, and Claessen, M. E. C. (2009). Land degradation and the zero-tillage system in Brazil. *Advances in GeoEcology*, 40, 311-324.

Sade, M. (2000). Uma Breve Histórico do Sistema de Plantio Direto na Palha no Brasil. In: *Harmonia do Homem com a Natureza: Desafio do 3º Milênio*. Encontro Nacional de Plantio Direto na Palha, 7º, Foz do Iguaçu, PR. Resumos, Ponta Grossa, FEBRAPDP, 2000. pp. 15-17.

Saturnino, H. M., and Landers, J. N. (1997). *O Meio Ambiente e o Plantio Direto*. Goiânia: APDC. 116 p.

Saturnino, H. M. (1998). Sustentabilidade do Agronegócio: contribuição do sistema de Plantio Direto. In Caldas, R. A. de et al. (Eds.). *Agronegócio Brasileiro: Ciência, Tecnologia e competitividade*. Brasília, CNPq. pp. 215-224.

Saturnino, H. M. (2001). Evolução do Plantio Direto e as Perspectivas nos Cerrados. *Informe Agropecuário*, 22 (208), 5-12.

Saturnino, H. M., and Landers, J. N. (Eds.). (2002). *The Environment and Zero-Tillage*. Brasília, Brazil: APDC, Rome, Italy: FAO. 144 p.

Shaxson, T. F. (1988). Produção e proteção integradas em micróbios. In Moniz, A. C. et al. (Eds.), *A responsabilidade social da ciência do solo*. Campinas, SP, Sociedade Brasileira de Ciência do Solo. pp. 263-271.

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# Virtual Water in The Rural Sector of Argentina, Brazil, Paraguay and Uruguay and its Potential Impact on Global Water Security

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## Summary

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There are strong links between water, agriculture and the economy in the ABPU region (Argentina, Brazil, Paraguay and Uruguay). Even more, agriculture is a significant economic sector for this region with some being major world players in the agricultural commodities world markets, such is the case for Brazil and Argentina who contribute to 13% of the global green water export. Virtual water (VW) was used as an indicator to estimate the total volume of freshwater that is used to produce goods and services consumed and traded by a nation as result of activities within the different sectors of the economy, in this case agriculture. The consumptive water use of agricultural production was on average  $696.5 \text{ Gm}^3/\text{yr}$  (or billion  $\text{m}^3/\text{yr}$ ) for the period 1996-2005; of which, 94% corresponds to the green VW (water from soil moisture and rain), whereas 3% refers to the blue component (water for irrigation). Grazing represents 25% of the total green VW of agriculture production in these countries. The remaining 75% belongs to crop production, with a large share destined to soybean production. This indicates that ABPU relies heavily on green water for agricultural production, i.e. rain-fed agriculture. The incidence of irrigation is not important in the ABPU region.

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Concerning agricultural products, the ABPU region has been a net exporter of green ( $182.7 \text{ Gm}^3/\text{yr}$ ) with negligible amounts of blue ( $1.9 \text{ Gm}^3/\text{yr}$ ) VW. Besides, all ABPU countries show high national water self-sufficiency (91%), defined as the ratio of the internal to the total VW of national consumption. This means that these countries use their own available resources to supply most of the agricultural products consumed by their inhabitants. Under this view, ABPU agricultural production significantly contributes to the water security of destination countries of its exports (mainly Asian and European countries). Most of the VW is provided by Brazil through traded meat. Thus, mainly green, but also blue water plays a significant role for ABPU economies and for food security. Sustainable water management should not be seen as a barrier for the development of the region, but rather as the way to develop and grow as a region.

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# Introduction

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Human activities consume and pollute a lot of water. The sustainable use of water as a vital resource is one of the major global challenges of the 21st century. At a global scale, most of the water use occurs in agricultural production: approximately 70% of the freshwater used worldwide is used for irrigation. Also there are substantial water volumes consumed and polluted in the industrial and domestic sectors (WWAP, 2009). The ABPU region is relatively well endowed with water resources. However, the spatial and temporal variability of water, coupled with rapid urbanization and inadequate water governance is putting considerable pressure on the available water resources (Zárate, 2014). Until the recent past, there have been few thoughts in the science and practice of water management about consumption and pollution during the production process.

The VW of national production is defined as the total freshwater volume consumed or polluted within the territory of the nation as a result of activities within the different sectors of the economy (Hoekstra and Mekonnen, 2012). VW trade (also known as trade in embedded or embodied water) refers to the hidden flow of water if food or other commodities are traded from one place to another. Freshwater is increasingly becoming a global resource, driven by

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growing international trade in water-intensive commodities. Apart from regional markets, there are also global markets for water-intensive goods such as crop and livestock products, natural fibers and bio-energy. As a result, use of water resources has become spatially disconnected from the consumers. Hoekstra and Chapagain *et al.* (2008) have shown that visualizing the hidden water use behind products can help in understanding the global character of fresh water and in quantifying the effects of consumption and trade on water resources use. The improved understanding can form a basis for a better management of the globe's freshwater resources.

Within this framework, in a previous GPS report (Viglizzo and Ricard, 2015) the issue of greenhouse gases (GHG) emission, global warming, food and VW exports from the ABPU (Argentina, Brazil, Paraguay and Uruguay) region to China and European Union was undertaken. In this new report current figures and trends of VW management from the perspective of the agricultural sector are analyzed by: providing a broad review of several water-agricultural related issues, virtual water trade and water availability of ABPU and discussing the capacity of the region to ensure global water security.

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## On Methods

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In this report, VW was used as a multidimensional indicator to calculate the total volume of freshwater that is used to produce goods and services consumed and traded by a nation (Hoekstra *et al.*, 2011). The blue VW refers to consumption of blue water resources (surface and groundwater) of a product. The green VW refers to consumption of green water resources (rainwater insofar as it does not become run-off). The grey VW refers to pollution and is defined as the volume of freshwater that is required to assimilate the load of pollutants given natural background concentrations and existing ambient water quality standards. The grey VW data used refer to the nitrogen pollution alone and are based on Mekonnen and Hoekstra (2011), who estimated it based on nitrogen leaching-runoff from fertilizer use.

In this context, the accounting is applied from two perspectives: the VW of agricultural production and the VW of agricultural consumption. The first one, related to agricultural production, refers to the total freshwater volume consumed or polluted (blue, green and grey VW) of all the agricultural processes (crop and livestock production), taking place within the political borders of the country as a result of activities within the different sectors of

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the economy (Hoekstra *et al.*, 2011; Zárate *et al.*, 2014). The VW of agricultural consumption refers to the quantification of the water consumed and polluted to produce the agricultural products consumed by the population of a country. It national consumption consists of two components: the internal (water volume consumed by the population of the country) and external VW (water volume exported and used in other nations) (Zárate *et al.*, 2014).

This work was based on the analysis of secondary sources of data provided by FAOSTAT (FAO, 2016a), AQUASTAT (FAO, 2016b), World Bank (2016), and Water Footprint Network (WFN, 2016). Given that these global organizations have standardized and unified statistical estimates for all countries in the world, we considered that those data sources were more suitable to this assessment than those independently collected and published by each country in the region. Then, these databases were processed together with those available from Mekonnen and Hoekstra (2011) to address the specific objectives of this work.

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## Background

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In ABPU region, agricultural production has notably increased during the last years, with Brazil expanding production by more than 70 % (Zárate *et al.*, 2014). This region as a whole is increasingly becoming a major source of agricultural commodities for the world market and thus influencing food security. As such, improving resource management in the region promises to have important benefits for both the inhabitants of ABPU and the world. Agriculture is essential to food security. However, food production requires substantial amounts of water, both stored in the soil as soil moisture from rain (green water) and as water for irrigation (blue water). ABPU values are even higher than the global share. In this region, the VW related to agricultural production takes the largest share in the total VW within the country. About 97% of VW is related to agricultural production (696.5 Gm<sup>3</sup>/yr), whereas 2% and 1% correspond to the domestic and industrial sectors, respectively (Table 1). The highest amount of agricultural water use is recorded in Brazil (464 Gm<sup>3</sup>/yr) which reaches 67% of the total consumed in the region (Table 1). Uruguay has the lowest agricultural VW use with a share of 2% (12.6 Gm<sup>3</sup>/yr) (Table 1).

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**Table 1. Virtual water (VW) of production in ABPU countries (in cubic gigameters per year and % of total VW) (average 1996-2005)**

	VW Agricultural production ([Gm <sup>3</sup> /yr] [%])	VW Industrial production ([Gm <sup>3</sup> /yr] [%])	VW Domestic water supply ([Gm <sup>3</sup> /yr] [%])	Total VW (Gm <sup>3</sup> /yr)
Argentina	186.2 (97.4%)	1.6 (0.9%)	3.2 (1.7%)	191.1
Brazil	464.0 (96.3%)	8.0 (1.7%)	9.7 (2.0%)	481.7
Paraguay	33.7 (99.6%)	0.03 (0.1%)	0.09 (0.3%)	33.8
Uruguay	12.6 (99.1%)	0.04 (0.3%)	0.08 (0.6%)	12.7
ABPU	696.5 (96.8%)	9.7 (1.4%)	13.1 (1.8%)	719.4

**Source:** Data from Mekonnen and Hoekstra (2011)

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## Water Withdrawal in ABPU Agricultural Production

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Quantifying actual crop water consumption is crucial to understand real water needs for agriculture. The consumptive water use of agricultural production (crops and livestock) for the ABPU region (green and blue VW), was on average 674.87 Gm<sup>3</sup>/yr for the period 1996-2005, corresponding to 9% of the global VW of agricultural production (Table 2). Of these 674.87 Gm<sup>3</sup>, 94% corresponds to the green component of the VW (656,51 Gm<sup>3</sup>/yr), whereas only 3% corresponds to the blue component (18.36 Gm<sup>3</sup>/yr) (Table 2). The major proportion of green and blue VW of this region belongs to crop production with 75 and 77%, respectively (estimated from Mekonnen and Hoekstra, 2011). The remaining ratio of green (25%) and blue (23%) VW is used for grazing and animal water supply, respectively (estimated from Mekonnen and Hoekstra, 2011). Brazil accounts for 66% of the total (green and blue) VW of the region, followed by Argentina (27%), Paraguay (5%) and Uruguay (2%) (Table 2). This data points towards two fundamental issues: (i) ABPU relies heavily on green water (94%) for agricultural production, i.e. rain-fed agriculture; (ii) Brazil and Argentina alone account for 93% (629.33 Gm<sup>3</sup>/yr) of agricultural water consumption in ABPU.

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This provides an indication of the global significance of these two countries in terms of agricultural water consumption and VW trade.

**Table 2. Green, blue and grey agricultural VW of ABPU region for the period 1995-2006.**

	Green VW (Gm <sup>3</sup> /yr)	Blue VW (Gm <sup>3</sup> /yr)	Grey VW (Gm <sup>3</sup> /yr)
Argentina	176.19	5.08	4.96
Brazil	435.97	12.09	15.92
Paraguay	32.85	0.31	0.54
Uruguay	11.50	0.88	0.23
ABPU	656.51	18.36	21.65
World	6684.06	945.05	733.18

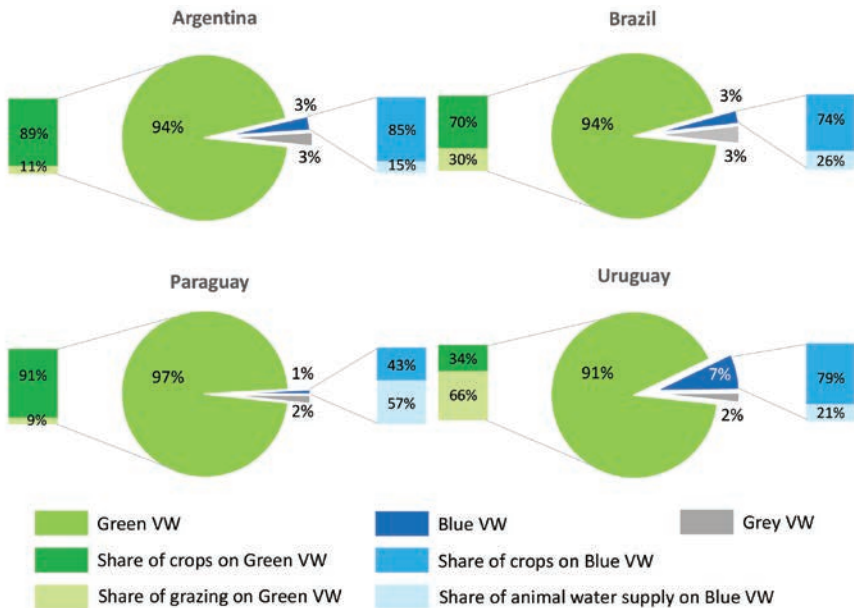
**Source:** Data from Mekonnen and Hoekstra (2011)

Irrigated areas in ABPU region increased steadily during the 20th century and particularly from the 1950s onwards (FAO, 2016). These increases are, however, modest in comparison to Asia and sub-Saharan Africa. Indeed, the proportion of area under irrigation in these countries is negligible, with values of 0.8, 0.6, 0.3 and 1.5% for Argentina, Brazil, Paraguay and Uruguay, respectively. The total blue VW of agricultural production in the region is 18.36 Gm<sup>3</sup>/yr (Table 2). Brazil has by far the largest irrigated area with over 3.2 million hectares (FAO, 2016) and the biggest contribution (12.09 Gm<sup>3</sup>/yr or 66%) to ABPU blue agricultural VW (Table 2). Is followed by Argentina (27%), Uruguay (5%) and Paraguay (2%) (Table 2). Brazil and Argentina occupy together 95% of the ABPU area and therefore contribute with a significant blue VW. These data show that most food is produced by rain-fed agriculture in ABPU. The irrigation potential for the region is estimated at 4.7 million hectares (FAO, 2016). Most of the regional irrigation potential (96%) is located in Argentina and Brazil (estimated from FAO, 2016).

Figure 1 shows the differences in agricultural VW partitions of each ABPU country. Green water ranges from 91 to 97% of total VW. The percentages of

blue oscillate only between 3 and 7% (Figure 1). ABPU primarily produce for world markets under rain-fed conditions, indicating an increased use of green water instead of blue water. In general, the largest proportion of green water is allocated to crops with higher values in Argentina and Paraguay (89 and 91%, respectively). On the contrary, two thirds of green agricultural VW is destined to grazing cattle in Uruguay. The proportion of blue water used for crop, although insignificant in absolute terms, is also higher in most countries in relation to the total blue water used (between 74 and 85%), except in Paraguay, where the main uses are for animal water supply. In all countries the proportion of grey water was very low.

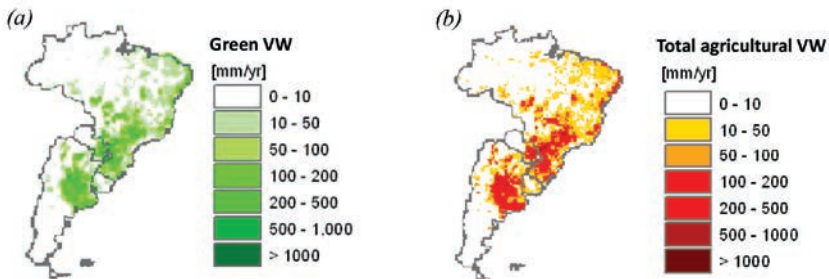
**Figure 1. Partition of VW provided by agricultural products in the ABPU countries. Average period 1996-2005.**



**Source:** Data from Mekonnen and Hoekstra (2011).

The spatial distribution of the green and total VW of agricultural production (crop and livestock) within ABPU nations is shown in Figure 2. VW density overlaps with core areas of dense cultivation. This Figure confirms the idea that the total VW used for agriculture also spatially corresponds with the increased use of green water throughout the region.

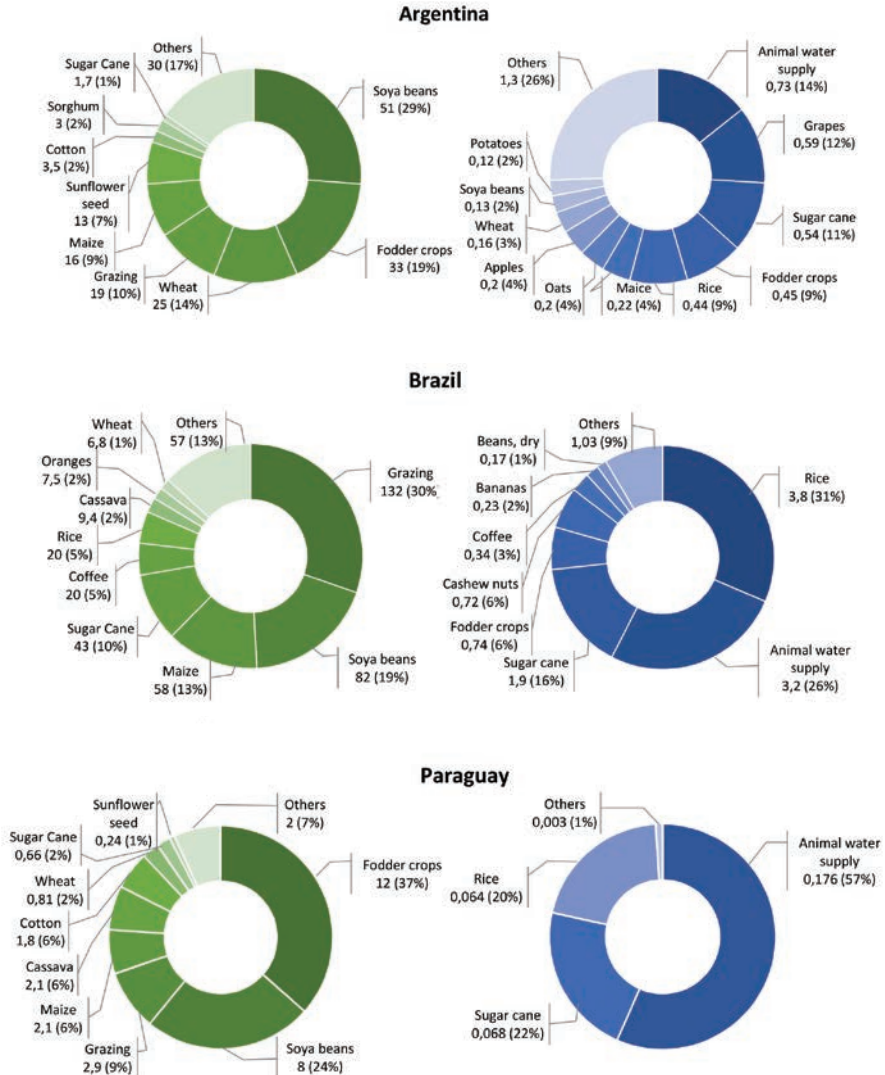
**Figure 2. The green (a) and total VW provided by agricultural products (b) in the ABPU region at a 5x5 arc minute resolution. Average period 1996-2005.**



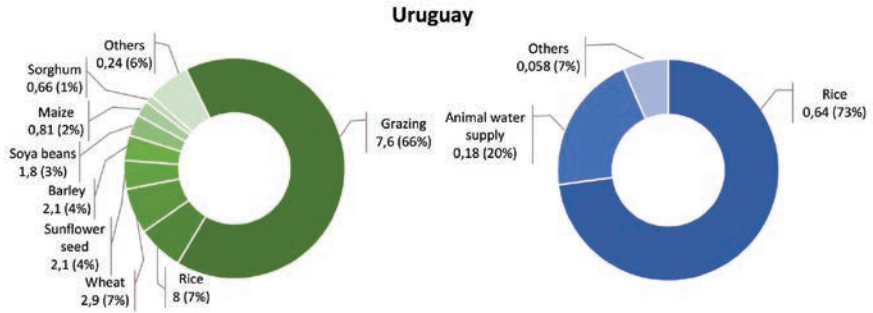
**Source:** modified from Hoekstra and Mekonnen (2012).

Figure 3 shows the distribution of agricultural green and blue VW for Argentina, Brazil, Paraguay and Uruguay, according to their main agricultural uses. Soybean is a fundamental crop in ABPU countries. It represents 21% of the total agricultural (green and blue in a lesser extent). The estimated VW used by this crop in the four countries amounts 141.5 Gm<sup>3</sup>/yr. Soybean is especially important in Argentina, Brazil and Paraguay. Maize is another important crop, with a share of 11% (76.6 Gm<sup>3</sup>/yr) of the total agricultural VW, followed by wheat and rice with 5 and 4%, respectively. Sunflower, sorghum, cotton and sugar cane are also important crops for these countries with different participations in each one. Grazing contributes significantly with 24% of the total green VW of the regional rural sector (161.1 Gm<sup>3</sup>/yr). Rice, in particular, makes up a significant contribution to the blue VW, which represents 27% of total blue VW used in the region. The consumption of blue water by livestock - an essential activity to support food security in the ABPU region - amounts 23%, or 4.2 Gm<sup>3</sup>/yr.

Figure 3. Contribution of different crops to the total volume of water used for agricultural production (in cubic gigameters per year) in ABPU region. Average for the years 1996–2005.



(Figure 3 continues in the next page)



**Source:** Data from Mekonnen and Hoekstra (2011) and the Water Footprint Assessment Tool (WFN, 2013).

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## Water Quality

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Water quality deserves as much attention as water quantity. Water scarcity problems are exacerbated by water quality. The most well-known effect of agriculture on water quality is chemical contamination by fertilizers and pesticides. In addition, the problem of salinity caused by irrigation is a serious constraint in Argentina and to a lesser extent, in the arid regions of northeastern Brazil (Biswas *et al.*, 2006). This section focuses on demonstrating the insignificance has the agricultural grey VW caused by nitrogen pollution in ABPU due to the use of fertilizers.

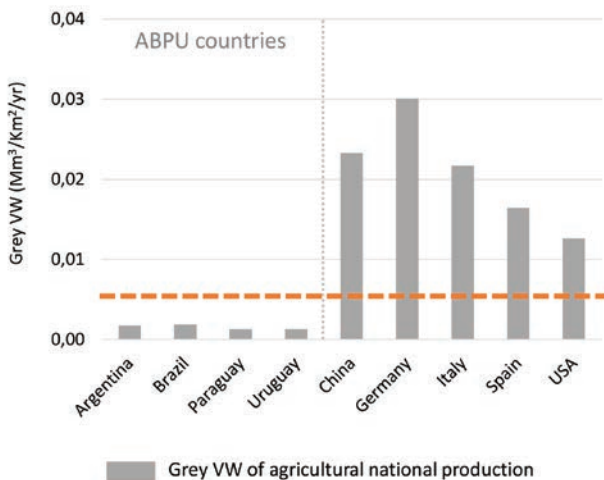
The agricultural grey VW amounted to 21.65 Gm<sup>3</sup>/yr for the period 1996 to 2005. This value corresponds to just 3% of the total agricultural VW used in the region. Although this component of VW used in the rural sector is negligible, Brazil and Argentina are the largest contributors to the agricultural grey VW of the region. These two countries amounts 20.88 Gm<sup>3</sup>/yr, corresponding to 96% of the agricultural grey VW in ABPU. Brazil alone already constitutes 74% of the agricultural grey VW in the region. These values are disproportionate due to the area occupied by each country.

Figure 4 shows the grey agricultural VW of different countries according to the surface of each one. When analyzing the grey VW of each ABPU country

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regarding the major importer of raw materials from this region, is possible to detect several aspects. On the one hand, the production systems in the four ABPU countries are much more environmentally friendly than those implemented in Asia, Europe and the USA. Even more, the volume of freshwater that is required in ABPU countries to assimilate the load of pollutants given natural background concentrations and existing ambient water quality standards is much lower than the world average. Grey agricultural WF in ABPU countries is between 62 (Brazil) and 73% (Paraguay and Uruguay) lower than the world average. Conversely, grey agricultural WF in developed countries analyzed ranges between 256% (USA) and 611% (Germany) above the world average. This means that the growing challenges of ensuring food security, environmental sustainability and limit the negative impacts of the production, position ABPU countries very favorably. The low level of grey water used by the rural sector in the ABPU region is indicative of low contamination of water sources, and this represents a comparative environmental advantage regarding other agricultural countries in el world.

**Figure 4. Grey VW of agricultural production of ABPU countries and some developed countries compared to the world average (average 1996–2005).**



**Source:** Data from Mekonnen and Hoekstra (2011).

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## Water Footprint of Agricultural Products' Consumption

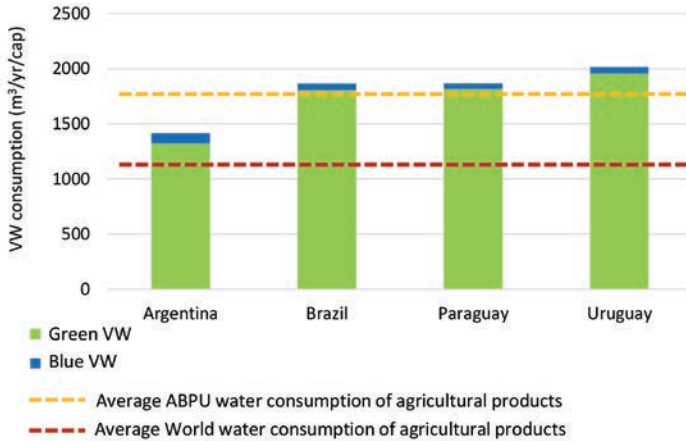
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As Figure 5 shows, the consumption of water through agricultural products - mainly green water - in the ABPU countries exceeds that of the global average consumption (1268 m<sup>3</sup>/capita/yr). The contribution of blue and grey water is negligible. The equivalent value for the ABPU region was 1843 m<sup>3</sup>/capita/yr (96% green, 4% blue), with 1,790 m<sup>3</sup>/capita/yr corresponding to the blue and green VW and 53 m<sup>3</sup>/capita/yr to the grey VW, equivalent to 97 and 3%, respectively. Figure 5 shows that VW of agricultural products consumption range between 1454 m<sup>3</sup>/capita/yr (91% green, 6% blue, 3% grey) for Argentina and 2065 m<sup>3</sup>/capita/yr (95% green, 3% blue, 2% grey) for Uruguay. Argentina besides has the highest percentage of blue water in their VW of consumption (6%). Despite this, the share of blue water in the consumption of agricultural products from these countries is low (remaining ABPU countries have values of 3%).

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**Figure 5. Average ABPU and world consumption of VW provided by agricultural products during the period 1996-2005.**



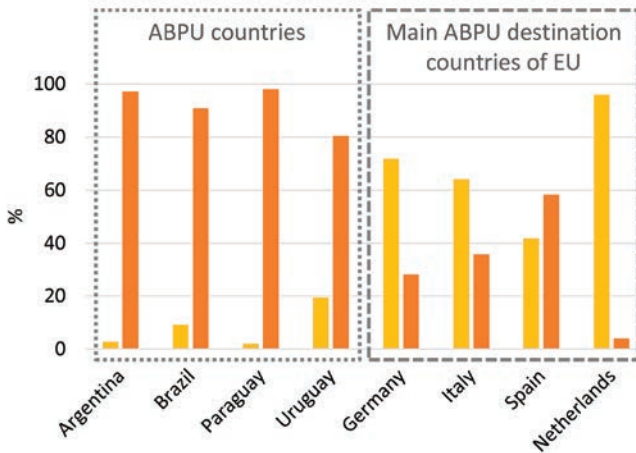
**Source:** Data from Mekonnen and Hoekstra (2011).

At this point, it is interesting to delve into the components of the VW consumption of agricultural products: (i) the internal (VW resources consumed by the population of the country) and (ii) the external (volume of water used in other nations to produce commodities consumed by the population in the nation under consideration) (Zárate *et al.*, 2014). The VW import dependency of a nation is defined as the ratio of the external to the total VW for national consumption, whereas the national water self-sufficiency is defined as the ratio of the internal to the total VW for national consumption (Zárate *et al.*, 2014).

Figure 6 shows the VW import dependency versus national water self-sufficiency of ABPU countries and some of the major importers from the region belonging to the European Union (EU). While ABPU are self-sufficient in terms of VW provision, countries like Netherlands, Germany, Italy and Spain strongly depend on ABPU countries to get VW through agricultural product import (Figure 6). VW demands the four European countries from the ABPU region range between 42% and 96% of total VW consumption. This means that these countries import most of the VW required to cover the agricultural needs of

its population, showing a notable dependency on external water resources. Conversely, Argentina, Brazil, Paraguay and Uruguay have very low VW import dependency values (3, 9, 2 and 20% respectively) indicating high self-sufficiency. This means that these countries use their own available resources to supply most of the agricultural products consumed by their inhabitants. Overall, ABPU region has a high self-sufficiency averaging 91%.

**Figure 6. Domestic and external dependency on VW in ABPU and some European countries (average 1996–2005).**



*Source:* Data from Mekonnen and Hoekstra (2011).



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# Virtual Water Flows Related to Trade of Agricultural Products

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Countries can both import and export VW through their international trade relations. This enables us to map out the dependency of some economies from other economies. This has implications on food security, economy and diplomacy. In the case of water-scarce countries it may be attractive to import VW in order to deliver their own water sources to be used in activities other than those of agricultural production. In Europe as a whole, 40% of the VW lies outside of its borders (Mekonnen and Hoekstra, 2011).

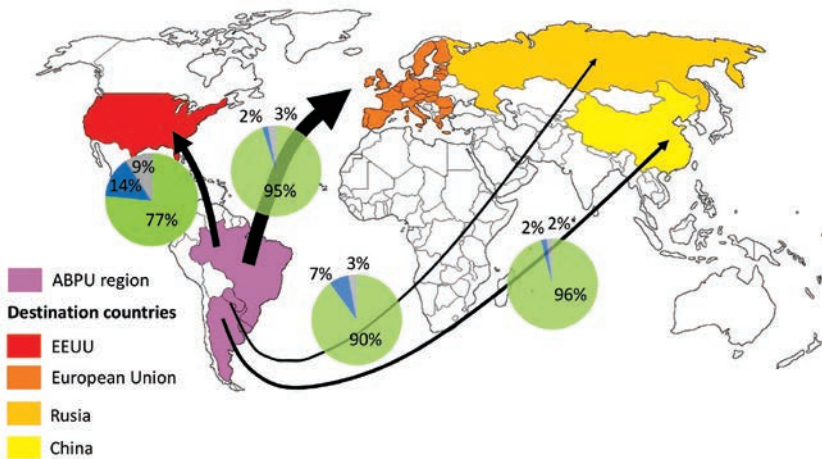
Figure 7 shows the principal exports destination countries from ABPU region related to agricultural products over the period 1996-2005. The width of arrows indicates the amount of VW exported to those countries/group of countries. The greater amount of VW exported, related to crop and animal products, is made to the European Union (close to 65% or 147 Gm<sup>3</sup>/yr). Followed in importance USA, China and Russian Federation with 19, 11 and 5% of the total VW export from the region, respectively.

While ABPU's gross VW export to the rest of the world related to agricultural products was 228.2 Gm<sup>3</sup>/yr (95% green, 2% blue and 3% grey) in the period 1996-2005, gross VW import was 39.8 Gm<sup>3</sup>/yr (Table 3). These values confirm the

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role of ABPU as a net VW exporter of agricultural products, with an average net VW export of 188.3 Gm<sup>3</sup>/yr during the period 1996-2005, mostly (97%) in the form of green water (Table 3). A high proportion of the net exports, around 87% (163.7 Gm<sup>3</sup>/yr), corresponds to crops (Table 3).

**Figure 7.** Global map showing export-destination countries from ABPU region related to agricultural products over the period 1996-2005.



Only the biggest gross virtual water flows (over 10 cubic gigameters per year) are shown. Arrows and circles represent the proportion of VW (green, blue and grey) exported.

**Source:** Data from Mekonnen and Hoekstra (2011).

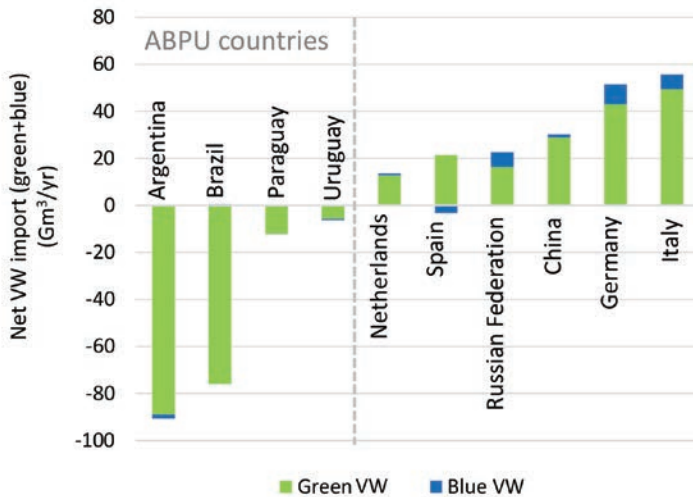
**Table 3.** ABPU's virtual water trade balance (Gm<sup>3</sup>/yr) related to agricultural products. Period 1996-2005.

	Gross virtual water import			Gross virtual water export			Net virtual water import		
	Green	Blue	Grey	Green	Blue	Grey	Green	Blue	Grey
Related to crop products	32.8	2.3	2.2	192.5	2.8	5.6	-159.7	-0.5	-3.5
Related to animal products	2.4	0.2	0.1	25.4	1.6	0.3	-23.1	-1.5	-0.2
Total agricultural products	35.2	2.5	2.2	217.9	4.4	5.9	-182.7	-1.9	-3.7

**Source:** Data from Mekonnen and Hoekstra (2011)

Figure 8 shows VW flows related to trade of agricultural products in the ABPU region and the principal importers of ABPU's products. Negative net import of VW recorded in Argentina, Brazil, Paraguay and Uruguay implies a net outflow of VW, which means that these countries are net exporters of VW. On the contrary, Netherlands, Spain, Russian Federation, China, Germany and Italy are net importers (positive values) of virtual water, which implies a net inflow of virtual water to these countries. Italy, in particular, is the largest virtual water importer.

**Figure 8. Total net imports of green and blue VW provided by agricultural products (average 1996–2005).**



**Source:** Data from Mekonnen and Hoekstra (2011).

Table 4 shows the contribution of ABPU region to the global water security. Through the trade of agricultural products (crops and animal products), Argentina, Brazil, Paraguay and Uruguay provide 24% of the VW that European Union, USA, China and Russian Federation purchased in the world. Most of the VW is provided by Brazil, which amounts 48% (110.3 Gm³/yr) of the total ABPU contribution. The most significant portion of the VW traded from ABPU region (88% or 200.9 Gm³/yr) is related to crop products. However, each country contributes differentially to

the total export of VW (see Figure 9). For example, more than half of VW exported by Uruguay (although in smaller quantities) comes from beef production.

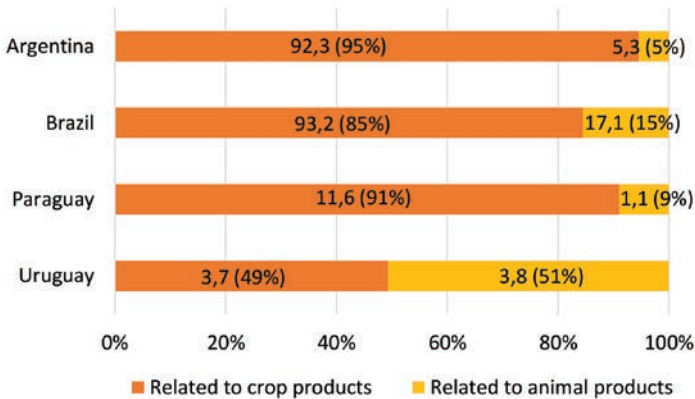
What does this mean in terms of global food and water security? The ABPU region provides EU, USA, China and Russian Federation more or less 228 Gm<sup>3</sup>/yr of VW. This hydrological transference covers the 24% of annual water needs of the population of thirty-one countries (almost 564 million people). Even more, according to data from Mekonnen and Hoekstra (2011), only Argentina and Brazil contribute with almost 13% (198.7 Gm<sup>3</sup>/yr) of the total (relate to crop and animal products) green water exported to the world. ABPU countries in total contribute with almost 14% (Table 5).

**Table 4. Absolute and relative participation of ABPU in the amount of total (green, blue and grey) VW demand by the principal importers from the region (average 1996–2005).**

		Trade of agricultural VW (Gm <sup>3</sup> /yr)		Trade of agricultural VW (%)
		Country/Region	Total	
Demand	European Union	615.6	957.4	100
	USA	183.8		
	China	107.6		
	Russian Federation	50.3		
Supply	Argentina	97.6	228.2	24
	Brazil	110.3		
	Paraguay	12.7		
	Uruguay	7.6		

**Source:** Data from Mekonnen and Hoekstra (2011).

**Figure 9. The partition of total VW provided by crop and animal products in the ABPU region (average period 1996-2005).**



**Source:** Data from Mekonnen and Hoekstra (2011).

The amount of VW that an exporter sells and transfers to the importer is highly influenced by the composition of the bulk product. Different foods have different water footprint, that is, the content of VW may vary greatly from one product to another (Viglizzo and Ricard, 2015). Besides, ABPU countries primarily produce different agricultural products for the world market under rain-fed conditions, suggesting a predominant use of green water in relation to the blue one. This is reflected in the scale differences used to represent green (Figure 10) and blue (Figure 11) virtual water exports of the main products traded by each ABPU country.

In general, four major products have dominated the virtual water export from ABPU. Soybean accounts for the largest share of green virtual water export in the four countries (Figure 10). With the exception of Argentina, the other three countries export a significant amount of green water through livestock products (Figure 10). Moreover, these countries export a lot of blue water through these products, while Argentina does mainly through maize and to a lesser extent, wheat and cattle (Figure 11).

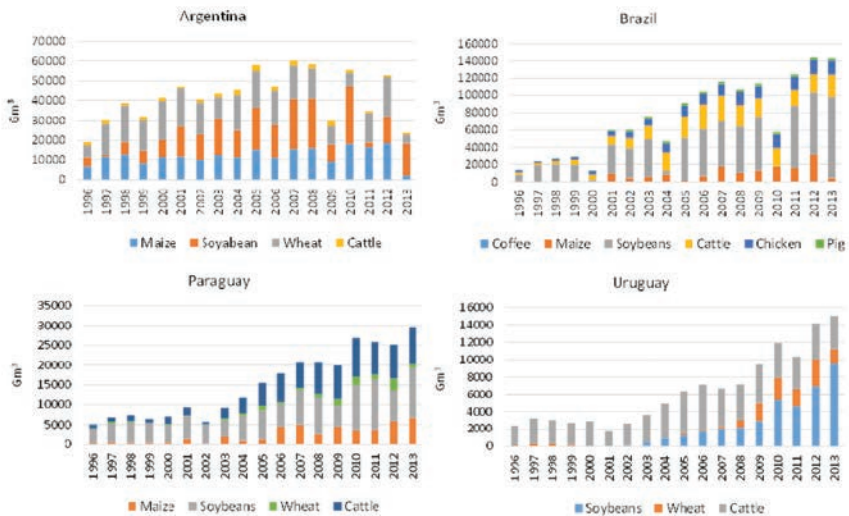


**Table 5. Green, blue and grey VW export from ABPU region and the world (average 1996-2005).**

	Green VW (Gm <sup>3</sup> /yr)	Blue VW (Gm <sup>3</sup> /yr)	Grey VW (Gm <sup>3</sup> /yr)	Participation in green VW world exports (%)
Argentina	93.31	1.83	2.49	5.9
Brazil	105.43	1.79	3.10	6.6
Paraguay	12.52	0.06	0.14	0.8
Uruguay	6.65	0.73	0.18	0.4
ABPU	217.91	4.41	5.91	13.7
World	1585.55	279.01	173.43	100.0

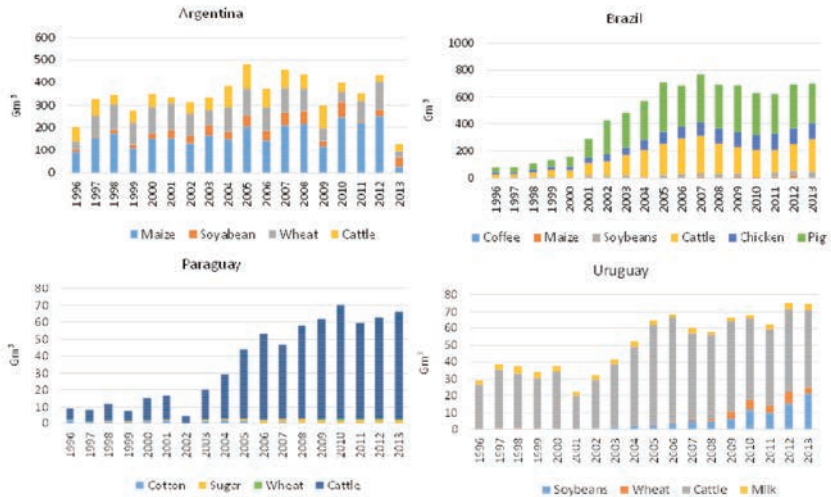
*Source: Data from Mekonnen and Hoekstra (2011).*

**Figure 10. Temporal trends in the partition of green water among principal agricultural exports in the ABPU region. Values expressed in cubic gigameters.**



*Source: Data from Mekonnen and Hoekstra (2011) and FAO (2016).*

**Figure 11. Temporal trends in the partition of blue water among principal agricultural exports in the ABPU region. Values expressed in cubic gigameters.**



**Source:** Data from Mekonnen and Hoekstra (2011) and FAO (2016).



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## Water Availability in the ABPU Region

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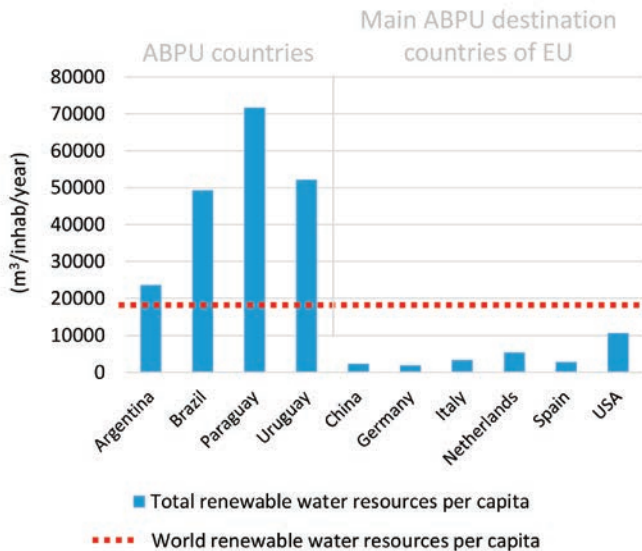
Availability of renewable water resources per capita is shown in Figure 12. In ABPU countries, the existence of freshwater is high, ranging between 23600 and 71700 m<sup>3</sup>/inhab/yr for Argentina and Paraguay, respectively. Moreover, average water availability for the region is 250% higher than the global average availability (19400 m<sup>3</sup>/inhab/yr). Conversely, all major importers of agricultural products from the region exhibit a low water availability, even lower than the world average, with values ranging from 1800 and 10600 m<sup>3</sup>/inhab/yr for Germany and USA, respectively.

Figure 13 shows the pressure on freshwater resources as a relation between the availability of renewable water resources per capita and the total water withdrawal per capita. This figure shows that water withdrawals account for little of the total renewable water resources in ABPU (0.6 and 4%). Even more, for most of these countries the use of this resource represents less than the world average (2.7%). By contrast, the main importers of agricultural products from the region have higher values than the world average, with a maximum of 33% for Spain (Figure 13).

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Probably, the smaller pressure on water resources in the ABPU region may be related, in an underlying way, with the considerable effort of private and public sectors to boost the incorporation of conservation agriculture practices such as minimum/zero-tilling. These practices are very effective in improving soil moisture conservation and achieve a more efficient use of water. Despite disparities among the proportion of arable area under conservation practices in these countries, the widespread adoption of reduced tillage was an outstanding achievement of agriculture in ABPU, still much higher than in the major importers countries from the region (Figure 13).

**Figure 12. Per capita water availability of ABPU countries and their principal demanders.**

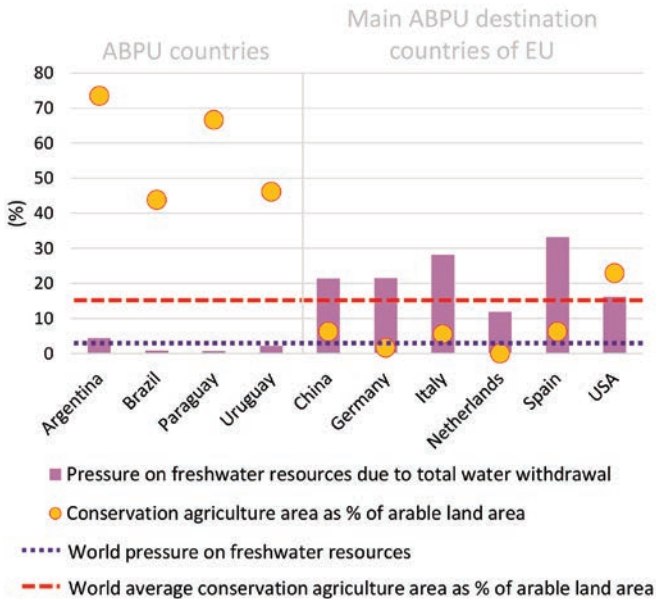


**Source:** Data from FAO (2016b).

Although irrigated area in the ABPU region has expanded at an average annual rate of 63300 hectares over the past two decades (FAO, 2016), the proportion of blue water used for agricultural purposes has been very low. Areas of high

irrigation density are located along the border between Brazil and Uruguay. In addition, numerous other, smaller irrigation areas are spread across the ABPU region (Mekonnen *et al.*, 2015). The results of Figure 12 and 13 reveal abundant water resources relative to use for human purposes in this region and, certainly, a significant connection exists between a country's capability to produce food and its renewable water resources availability. With this, is possible to argue that ABPU has a high potential to provide blue water and developing large-scale irrigation systems. Irrigation delivers a powerful management tool against the vagaries of rainfall and makes it economically attractive to grow high-yield seed varieties and to apply adequate plant nutrition as well as pest control and other inputs, thus giving room for a boost in yields. There is an effective synergy between irrigation, crop variety and inputs.

**Figure 13. Pressure on water resources and application of tillage conservation practices in ABPU countries and their principal demanders.**



**Source:** Data from FAO (2016b).

There are strong links between water, agriculture and economy in ABPU. Both green and blue water are a vital fuel for ABPU's economies and for its food security. This region is producing and supplying more and more food to other parts of the world using rainwater. Many parts of the region have abundant green water resources, which suggest that there is room for expansion of rain-fed agriculture. However, this "abundance of green water" is misleading, because a great part of the green water resources in the region is attached to forested lands. Claiming new land and associated green water resources for agriculture will be at the expense of natural forests. At this point, the good availability of blue water in ABPU represents a good opportunity to produce and supply more food for itself and for other parts of the world. Irrigation is a key component of the technical package needed to achieve productivity gains. In the future, as high levels of costly inputs are added to cropland to sustain yield increases, the security and efficiency of irrigated production will become even more important to world farming, and the ABPU region is in position to do so.

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## Epilogue

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World's agriculture still accounts for the majority of human water use. ABPU region is not the exception to this trend. The challenges facing agriculture and the water resources upon which it depends are clear and multiple: to produce more food in the future is necessary reconcile the use of land and water resources and improve food security; all this in the context of a changing climate and associated risks.

This work has set out the evidence that some countries are under stress or vulnerable, respect to water availability. There is a risk, as demand rises, that current trends will deteriorate further, with consequent threats to local food security and the resource base on which production and livelihoods depend. The possible repercussions for global food security are not negligible. ABPU's exports of virtual water could help to alleviate the future increase of water demand for food due to climate change impacts and population growth. Through importation of food and certain commodities that would otherwise consume great quantities of water, such as agricultural and livestock products, countries affected by water scarcity could alleviate this issue. Agricultural imports from ABPU region has already played a key role in compensating local water shortages in those countries with water scarce. In other words, ABPU region has been key to generate global water safety.

Appropriate water management can expand production efficiently while limiting impacts upon productive regions, such ABPU, on which many countries depends. The use of technology for water conservation and efficiency in agriculture offers the best hope to increase productivity security and facilitate economic growth. Irrigated agriculture is expected to produce much more in the future while using less water than it uses today. This positions the ABPU region in a favorable condition to feed its citizens and export large quantities of agricultural products in the short and long term, through a more efficient agriculture. Future of food and water security are inextricably connected.

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## References

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BISWAS, A.K., TORTAJADA, C., BRAGA, B., & RODRIGUEZ, D.J. (eds) (2006). Water Quality Management in the Americas. Water Resources Development and Management. The Netherlands, Springer.

CHAPAGAIN, A.K.; HOEKSTRA, A.Y. 2008. The global component of freshwater demand and supply: An assessment of virtual water flows between nations as a result of trade in agricultural and industrial products. *Water International*, 33 (1):19-32.

COMPREHENSIVE ASSESSMENT OF WATER MANAGEMENT IN AGRICULTURE. 2007. Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture. London: Earthscan, and Colombo: International Water Management Institute.

FAO (Food and Agriculture Organization). 2016a. FAOSTAT. Production and Trade Statistics. [Online] Available from: < <http://faostat3.fao.org/home/E>>. Website accessed on [15/09/2016]

FAO (Food and Agriculture Organization). 2016b. AQUASTAT Main Database. [Online] Available from: <<http://www.fao.org/nr/water/aquastat/data/query/?lang=es>>. Website accessed on [15/09/2016]

HOEKSTRA, A.Y.; CHAPAGAIN, A.K. 2007. Water footprints of nations: water use by people as a function of their consumption pattern. *Water Resources Management*, 21 (1): 35-48. doi:10.1007/s11269-006-9039-x

HOEKSTRA, A.Y.; CHAPAGAIN, A.K.; ALDAYA, M.M.; MEKONNEN, M.M. 2011. The Water Footprint Assessment Manual: Setting the global standard. London, Earthscan.

HOEKSTRA, A.Y.; MEKONNEN, M.M. 2012. The water footprint of humanity. *Proceedings of the National Academy of Sciences*, 109 (9): 3232-3237.

MEKONNEN, M.M.; HOEKSTRA, A.Y. 2011. National Water Footprint Accounts: The Green, Blue and Grey Water Footprint of Production and Consumption. Volume 2: Appendices. Delft, The Netherlands, UNESCO-IHE. Value of water, Research Report Series No. 50.

MEKONNEN, M.M.; PAHLOW, M.; ALDAYA, M.M.; ZARATE, E.; HOEKSTRA, A.Y. 2015. Sustainability, efficiency and equitability of water consumption and pollution in Latin America and the Caribbean. *Sustainability*, 7(2): 2086-2112.

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MEKONNEN, M.M.; HOEKSTRA, A.Y. 2016. Four billion people facing severe water scarcity. *Science Advances*, 2(2): e1500323.

NIEMEYER, I.; GARRIDO, A. 2011. International farm trade in Latin America: does it favour sustainable water use globally? In: Hoekstra, A.Y., Aldaya, M.M. & Avril, B. (eds). *Proceedings of the ESF Strategic Workshop on Accounting for Water Scarcity and Pollution in the Rules of International Trade*. Delft, The Netherlands, UNESCO-IHE. *Value of Water Research Report Series No. 54*. pp. 63–84.

SCAVAGE. 2016. Foreign trade. [Online] Available from: <[www.scavage.com/trade](http://www.scavage.com/trade)>. Website accessed on [17/09/2016]

VIGLIZZO, E.F.; RICARD, M.F. 2015. Greenhouse gases (GHG) mitigation in the rural sector of Argentina, Brazil, Paraguay and Uruguay and its potential impact on global food and water security. GPS Repot, July 2015.

WORLD BANK. 2016. World Bank Development Indicators. [Online] Available from: <[data.worldbank.org/indicator](http://data.worldbank.org/indicator)>. Website accessed on [15/09/2016]

WFN (Water Footprint Network). 2016. Water Footprint Assessment Tool. [Online] Available from: <[www.waterfootprint.org/?page=files/waterfootprintassessmenttool](http://www.waterfootprint.org/?page=files/waterfootprintassessmenttool)>. Website accessed on [15/09/2016]

WWAP (World Water Assessment Programme). 2009. *The United Nations World Water Development Report 3: Water in a Changing World*, WWAP, UNESCO Publishing, Paris, and Earthscan, London.

ZARATE, E.; ALDAYA, M.; CHICO, D.; PAHLOW, M.; FLACHSBARTH, I.; FRANCO, G.; ZHANG, G.; GARRIDO, A.; KUROIWA, J.; PASCALE-PALHARES, J.C.; ARÉVALO, D. 2014. Water and agriculture. In: Willaarts, B.A., Garrido, A., Llamas, M.R. (Eds.), *Water for Food and Wellbeing in Latin America and the Caribbean. Social and Environmental Implications for a Globalized Economy*. Routledge, Oxon and New York, pp. 177-212.

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