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BEYOND THE FOOTPRINT TWO TALES ON WATER, CARBON AND FOOD

APRIL, 2017

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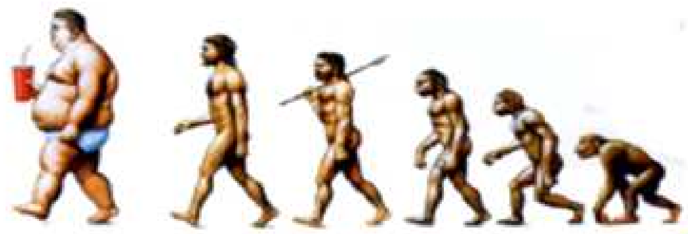

Beyond the Footprint

Two Tales on Water, Carbon and Food

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GPS (Group of Producing Countries from the Southern Cone)

BEYOND THE FOOTPRINT
TWO TALES ON WATER, CARBON AND FOOD

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This article reflects the principal concepts that the authors released in a panel organized by GPS (and moderated by Horcio Sánchez Caballero) at the Grünen Woche (Green Week) in Berlín (Germany) on January 20, 2017.

Introduction

There is no doubt that humans have left their footprints on the planet throughout its evolution. Global warming, climate change and water scarcityhave emerged as three big environmental challenges that nowadaysarealso affecting the sustainability offood production and socio-economic development. The Earth's climate is changing because of anthropogenic activities that startedwith the industrial revolution, and is affecting the potential for food production in different regions of the world, especially in areas where water availability is subjected to increasing demand and sectoral competition. (OECD, 2014).

While the global carbon (C) budget and the climate change receive increasing attention at international forums among politicians and business leaders, freshwater scarcity has recently become an important subject in the environmental agendas of governments and companies. Human activities increasingly release carbon (C) to the atmosphere affecting the global climate, and consume, waste and pollute large amounts of freshwater. 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). This has an impact on all sectors of society, but primarily affects food security at a global scale.

Therefore, there is a growing demand for new approaches and indicators on carbon and waterthat can help find the main drivers of unsustainability in modern societies and identify sustainable solutions. The critical role of food security in a context of water withdrawal and greenhouse gases (GHG) emissions deserves special attention. Thus, the issue ofcarbon and water footprints has been cause of increasing concern of food-exporting countries in the ABPU (Argentina, Brazil, Paraguay and Uruguay) region in

South America. The fear that agricultural footprints in ABPU can be used as argument to raise commercial barriers or trigger protectionist policies in traditional markets is cause of growing concern in the region.Therefore, the aim of this lecture is to put in context the question of water use, carbon emission and food production in the ABPU region and propose strategic ways to undertake the issue.

The context and the tales

As mentioned above, the question of water and carbon footprint of nations has been subjected to the increasing scrutiny of scientists, policy makers and even the business community.The analysis of this issue is particularly important in the ABPU region because of the relevant role that this region has (and will have) in global food and water securitysince it provides about 43% of grain (cereal + oilseed) and 30 % of beef demand.Two contextual tales can be considered to illustrate the story.

The small tale: the case of water and the carbon footprint

Water and Carbon Footprints have become widely used concepts in the public debate on the threat ofclimate change and water scarcity.The notion of Water Footprint (WF) lies on the exploration of the amounts of water used along the supply chains in order to understand the global withdrawal offreshwater as a critical natural resource. On the other hand, the Carbon Footprint (CF) is a notion related to the emissions of carbon along the supply chains in order to assess their contribution to global warming and climate change.

In quantitative terms,the WF is a measure of the total volume of freshwater used throughout the food chain to produce 1 kg of a given product, and is normally expressed as liters of water used per kilogram of a given product.(Hoekstra andChapagain, 2006).Among other things, this expressionis primarily used to describe the hidden links between global trade and the transference of water resources among countries (Hoekstra, 2003), helping to set strategies for water governance (Hoekstra, 2011). On the other hand, CF is a measure of the total emission of greenhouse gases (GHG) throughout the life cycle of a given product, starting with inputs used for manufacturing and finishing with the final disposal of the product after domestic consumption. It is expressed in terms of quantity of CO_2 equivalents emitted per kg of o given product (Wiedmannand Minx, 2008).

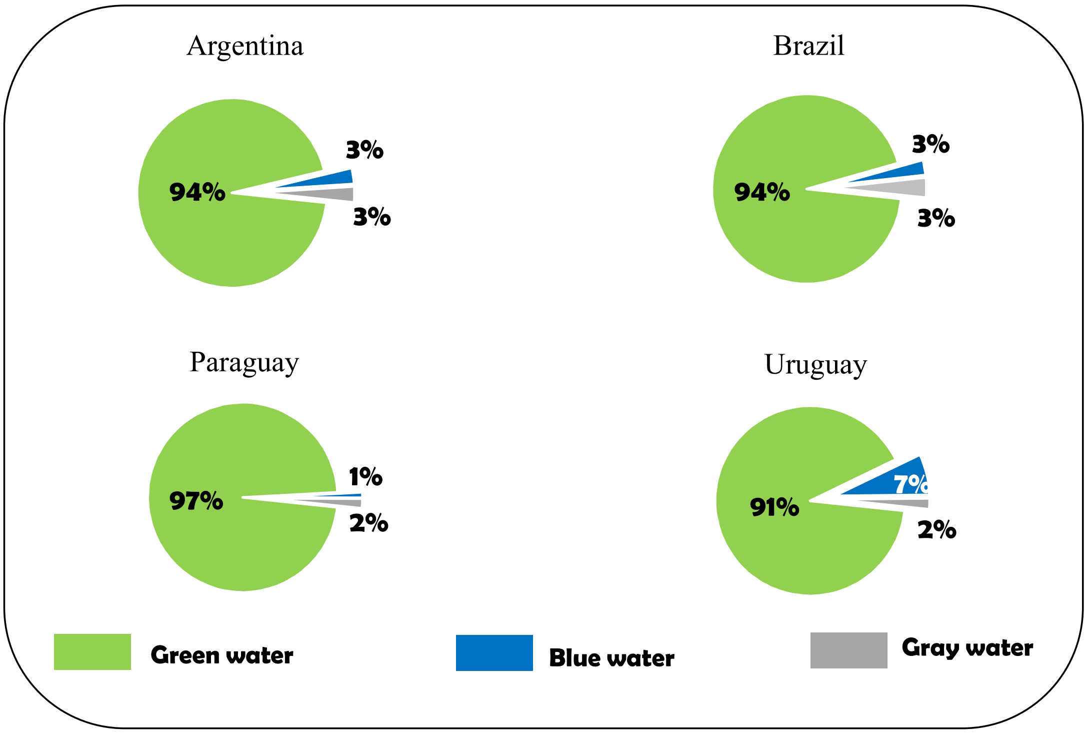

Figure 1. Partition of virtual water provided by agricultural products in the ABPU countries. Average figures for period 1996-2005. Sources: Mekonnen and Hoekstra (2011); Ricard andViglizzo (2017).

Considering that water is increasingly becoming a scarce commodity, the great challenge in the coming future is to produce more food with less water. What makes up our water footprint?Three water fractions are considered in water footprint calculations: green, blue and grey water. Green water is used to measure the water supplied by precipitation, whereas blue water is that fraction abstracted from rivers, lakes and groundwater to irrigate the crops, and grey water is the amount of water used to dilute pollution and polluted flows.

In terms of water-use efficiency: The more the green water (rainfall water) is used, the more efficient the process of water use will be. As **Figure 1** shows, the ABPU region almost entirely relies (between 91-97%) on rainfall water to produce food. This means that agriculture does not compete for water with other sectors of society, nor leaves as waste a worrying amount of polluted water.

World trade in food represents a huge transfer of water between exporting and importing countries. Countries with abundant water exports"embodied" or virtual water (water consumed to produce food)while importing countries "acquire" water embodied in food to compensate their physical scarcity (Hoekstra and Hung, 2002).Given that there are countries with water surplus and countries with water deficit, there is a spontaneous flux of water embodied in food from water-rich to water-scarce countries (**Figure 2**). As a result, the use of water resources is spatially disconnected from local consumers. Estimations indicate that water embedded in food that is exported from ABPU region saves water enough to match the water demand of about 700 million people in water-scarce countries (Ricard and Viglizzo, 2017).

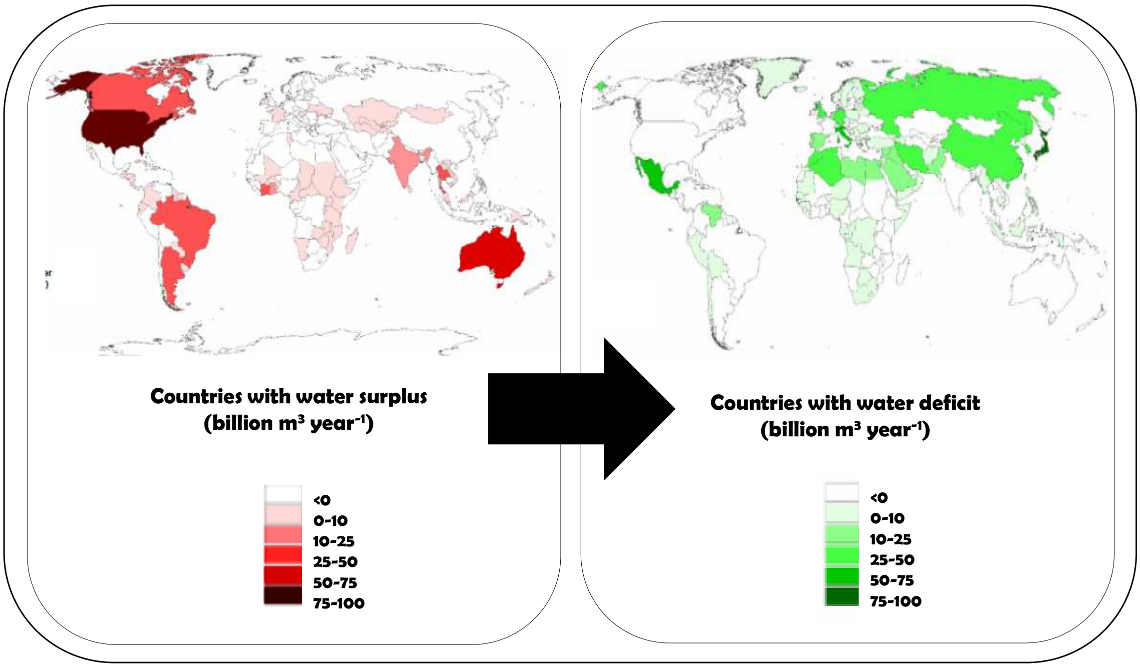

Figure 2. Countries with surplus and deficit of water resources. Source: Chapagain*et al*. (2006).

On the other hand, the carbon footprint is the result of summing out the carbon emissions throughout the whole process of food production on both sides, on the field and across the rest of the chain in a so-called "life cycle assessment" (Wiedmann and Minx, 2008). It is now recognized that food production, processing, marketing, consumption and disposal have importantenvironmental implication because of the overall GHG emissions of the food industry.Some conventional figures on water and carbon footprint are deployed in**Figure 3** for plant and animal products. Values are greater in animal than in plant products. Besides, the carbon footprint increases with food processing (**Figure 4**). Setting aside the specific footprints of different products,, there is strong positive correlation between the WF and the CF (**Figure 5**).

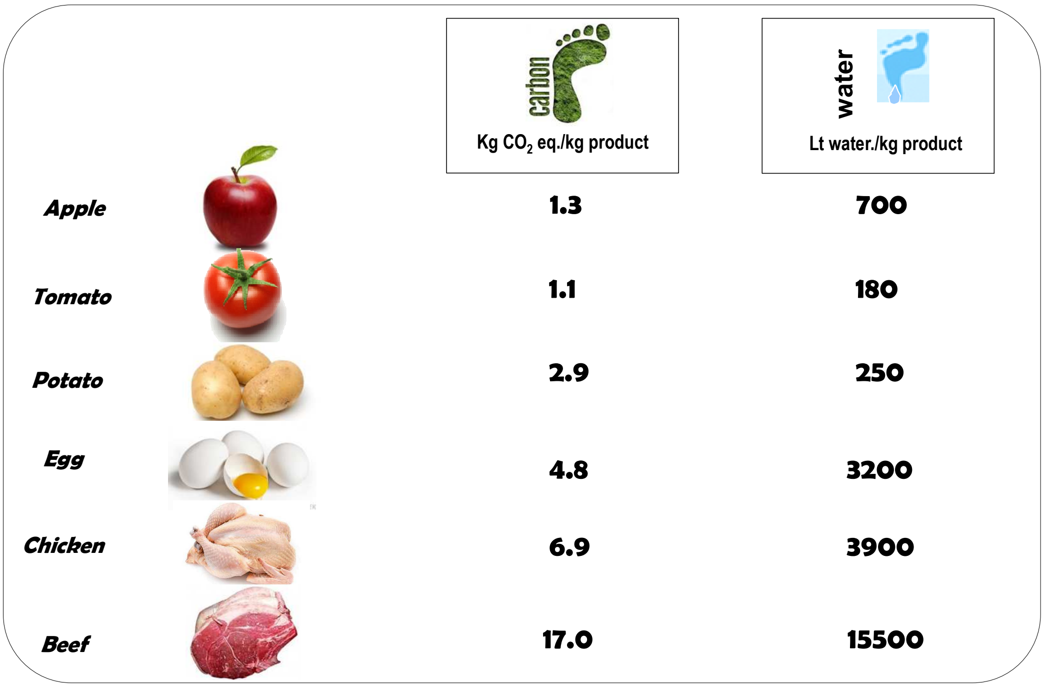

Figure 3. Standard figures on carbon and water footprint of plant and animal products. Sources: WFN(2016); Mekonnen and Hoekstra(2012); Heller and Keoleian (2014).

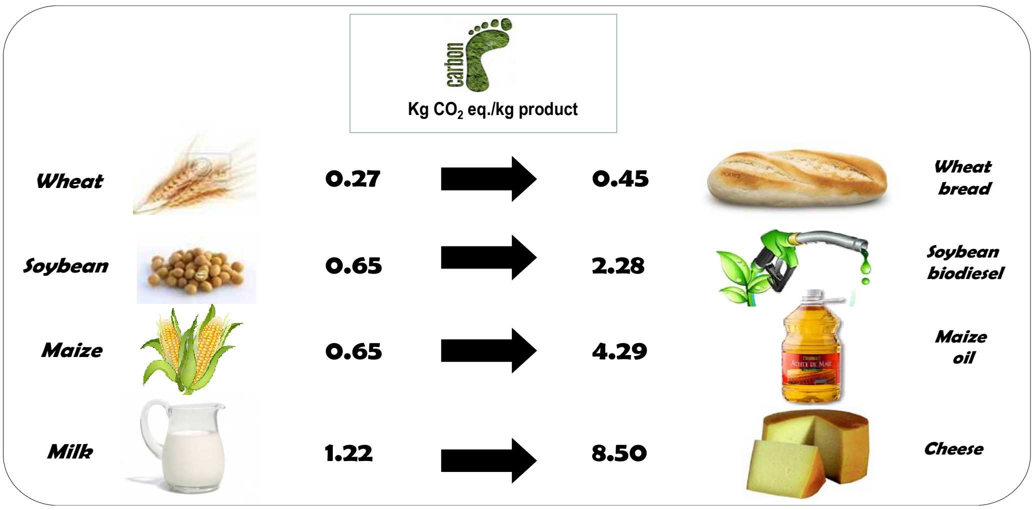

Figure 4. Carbon footprint of processed and non-processed foods. Source: Fritsche andEberle (2009); Heller and Keoleian (2014).

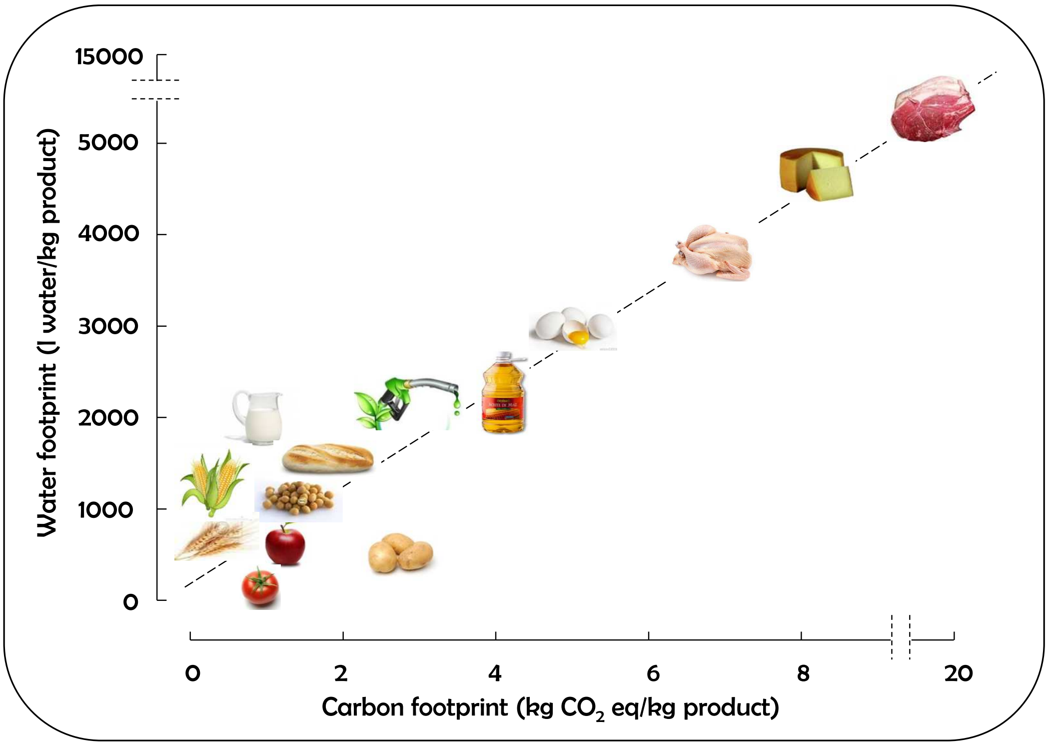

Figure 5. Relationship between the water and the carbon footprint of plant, animal and processed products. Sources: own elaboration from Fritsche and Eberle (2009); Mekonnen and Hoekstra(2012); Heller and Keoleian (2014).

The Big Tale: water and carbon in ABPU region and the world

A key question is needed before proceeding: What is the practical implications of ABPU footprints on the global balance of water and carbon?

Regarding water

It can easily be appreciated in **Figure 6** that a large proportion of the total renewable freshwater endowment of the world is located on the ABPU region. In average, the ABPU region amounts more than 15% of renewable freshwater resources of the world, and more than 50% of freshwater resources of South America. Water availability (m^3/inhab/year) in the region is, in average, 250% higher than that of the global average availability (FAO, 2016b). With the exception of arid and semiarid lands of Argentina, water is not a scarce resource in this part of the planet.In terms of pressure on freshwater resources per capita, FAO figures (FAO, 2016b) indicate a small water withdrawal in ABPU region, which ranges between 0.6 and 4% of the total global water withdrawal.

The ABPU region amounts more than 15 % of renewable freshwater resources of the world, and more than 50 % of freshwater resources of South America.

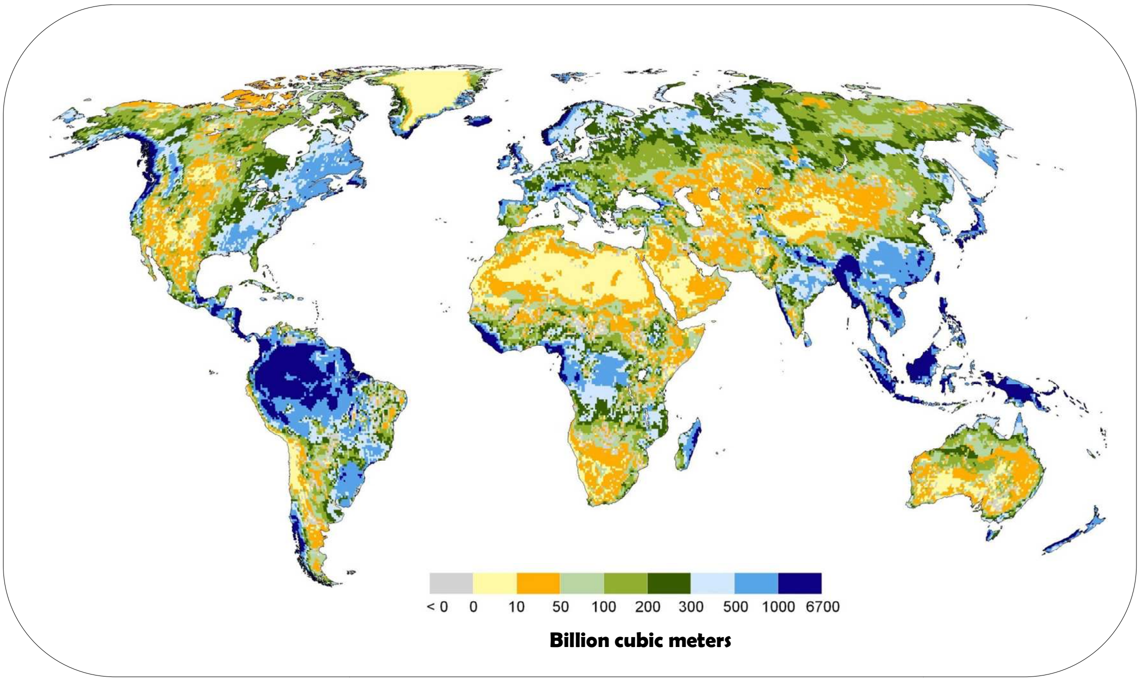

Figure 6. Global representation of total renewable freshwater resources. Source: Brooks (2016).

The ABPU region evaporates and transpires more than 15 % of the total world evapotranspiration, feeding the global hydrological cycle.

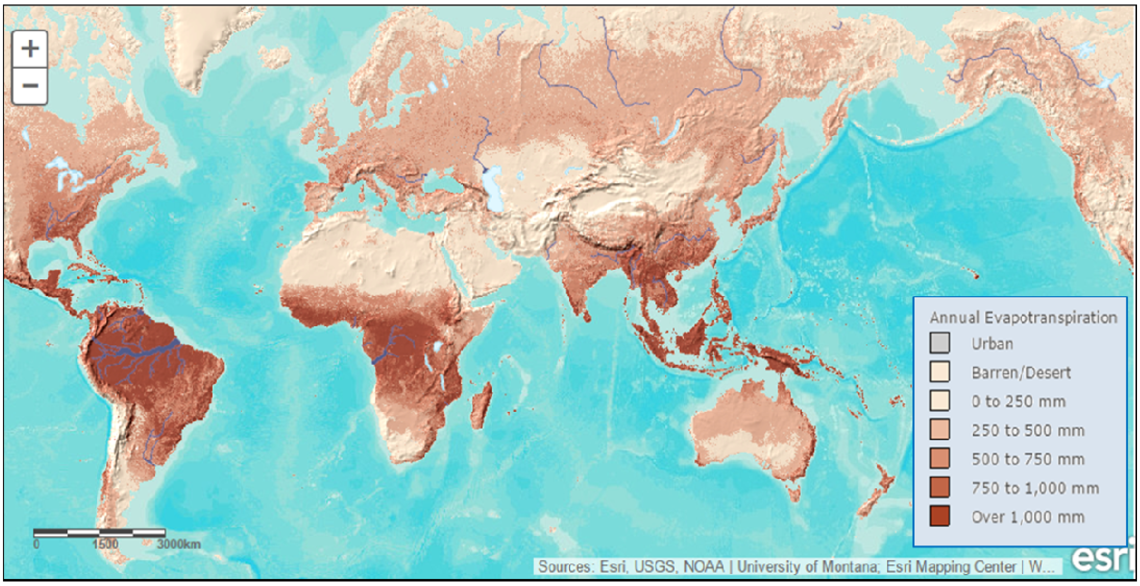

Figure 7.Representation of mean evapotranspiration rate (mm/year) in different regions of the world.Source: Montana University (2016).

Similarly, the region is rich in terms of underground aquifers, thus opening a significant potential for irrigation in areas where surface streams are not available (BGR/UNESCO, 2008). The irrigation potential for the region is estimated around 47 million hectares (FAO, 2016b).According to this source, the region is able to expand its irrigated lands to nearly 7 times its current size, and most of the regional irrigation potential (96%) is located in Brazil and Argentina. In hydrological terms, it is estimated that lands and vegetation in ABPU region evaporates and transpires more than 15% of the annual evapotranspiration of the world, thus contributing to support the global hydrological cycle (Jung *et al.*, 2010). See **Figure 7**.

Regarding carbon

Humans have affected the global balance of carbon through deforestation/devegetation of natural lands by human action in different stages of history.

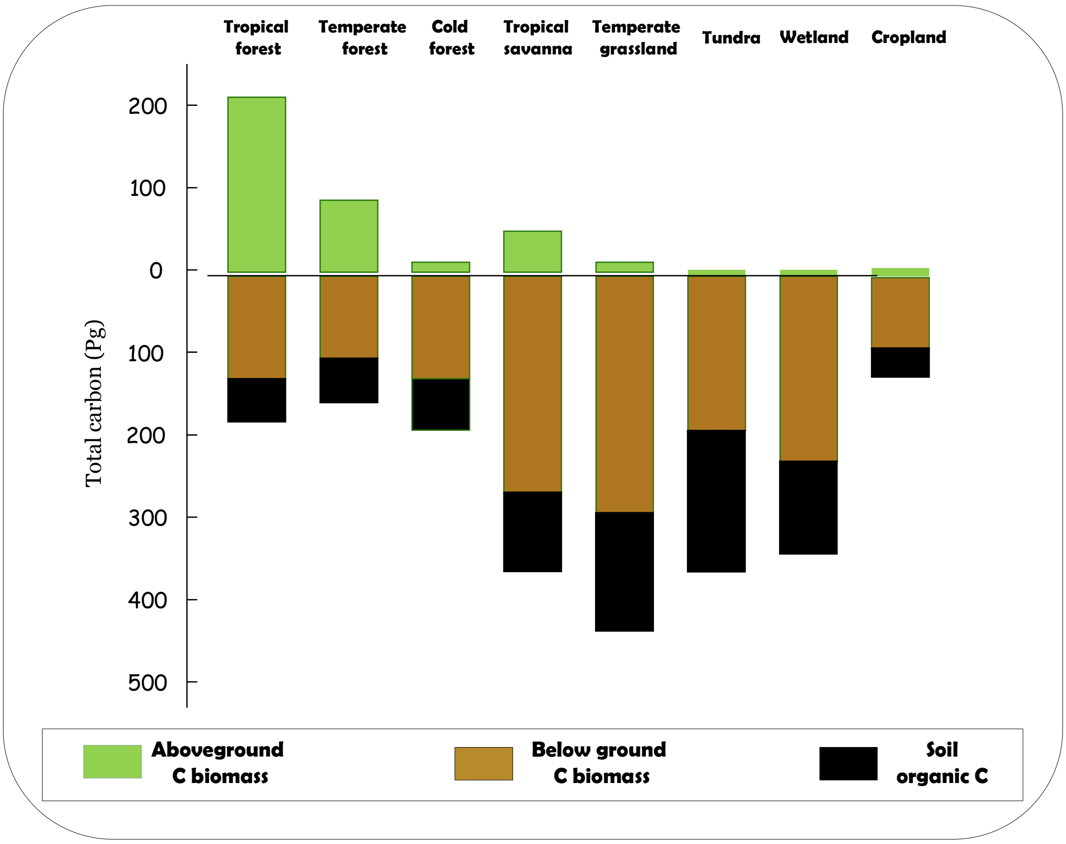

Figure 8. Organic carbon storage in above-, below-ground biomass and soil. Reference: 1 Pg = 1 billion ton. Sources: FAO (2001); Ravindranath and Ostwald (2008).

Rapid increases in atmospheric CO_2 due to humanactivities since the Industrial Revolution have caused dramatic modifications in the stocks and flows of carbon on Earth. Because ofthe large areas involved at regional/global scale, forestsoils have played an important role in the global carbon cycle (Jobággy andJackson, 2000). There is consensus that emissions from land use andland cover change (LULCC) are, besides fossil fuel burning, the second largest anthropogenicsource of carbon into the atmosphere (IPCC, 2007), and the most uncertain component of the global carboncycle (Houghton*et al.*, 2012). From a global standpoint, carbon emissions from LULCC rely on three mainfractions of organic C: C in aboveground biomass, C in belowground biomass and soil organic C (Scharlemann*et al.*, 2014). But, as can be appreciated in **Figure 8**, the terrestrial biomes significantly differ in the relative proportion of these three C fractions.

The proportion of C in aboveground biomass is greater in tropical and subtropical climates than in the temperate and cold ones. On the other hand, the proportion of C in belowground biomass and soil is greater in temperate and cold climates than in the tropical and subtropical ones. Therefore, because of its geographical extension, C fractions in above- and below-ground biomass and in soil vary in different ecological areas of the ABPU region (**Figure 9**).

As a simplistic general rule, it can be stated that biomes tend to protect and preserve carbon stocks below the ground in the more aggressive and marginal environments. The result of studies on 82 forests (Vogt et al., 1996) shows that the proportion of C in aboveground biomass is larger in tropical and subtropical climates than in the temperate and cold ones. Therefore, the implications of deforestation are drastically different. Deforestation removes most of the C endowment in tropical forests where about 80% of the carbon is locatedabove the surface, but this does not occur in cold forests where more than 40 % of C endowment is located below the ground. A rather similar principle can be applied in the case of grasslands and savannas (IPPC, 2006).Estimations indicate that the relationship between aboveground and belowground biomass is about 1-1 in grasslands and savannas of tropical regions, and ranges between1 and 3 in temperate grasslands and 1 and 4 in the cold ones.This is an important issue to be considered when land-use policies should be designed and implemented.

The combination of different climatic regions and different biomes explains the total carbon endowment of the ABPU region as a whole

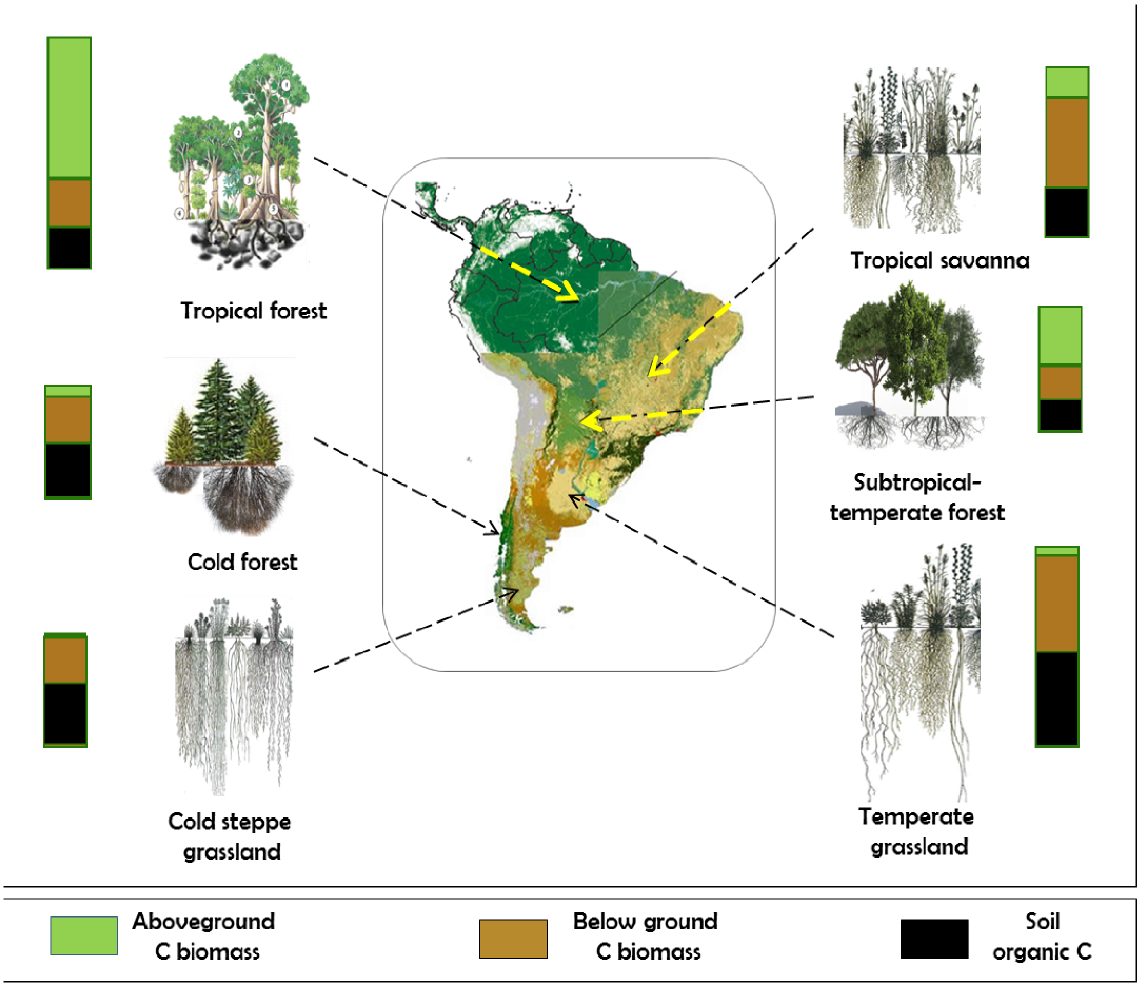

Figure 9. Organic carbon storage in above- and below-ground biomass, andsoil in different ecological areas of the ABPU region.

As **Figure 9**shows, different climatic regions and biomes can be found across the entire ABPU regions, from tropical, subtropical-temperate and cold forest to tropical savanna, temperate grassland and cold-steppe vegetation. Certainly, the combination of different climatic regions and different biomes poses a methodological difficulty to be overcome when scientists, technicians and policy makers have to estimate the total carbon endowment of the ABPU region as a whole.

The global geographical distribution and the proportion of aboveground C, belowground C and soil organic C differs substantially from one region to another.

The ABPU region contains 6 % of the global carbon stock in total biomass (above- and below-ground) and soil.

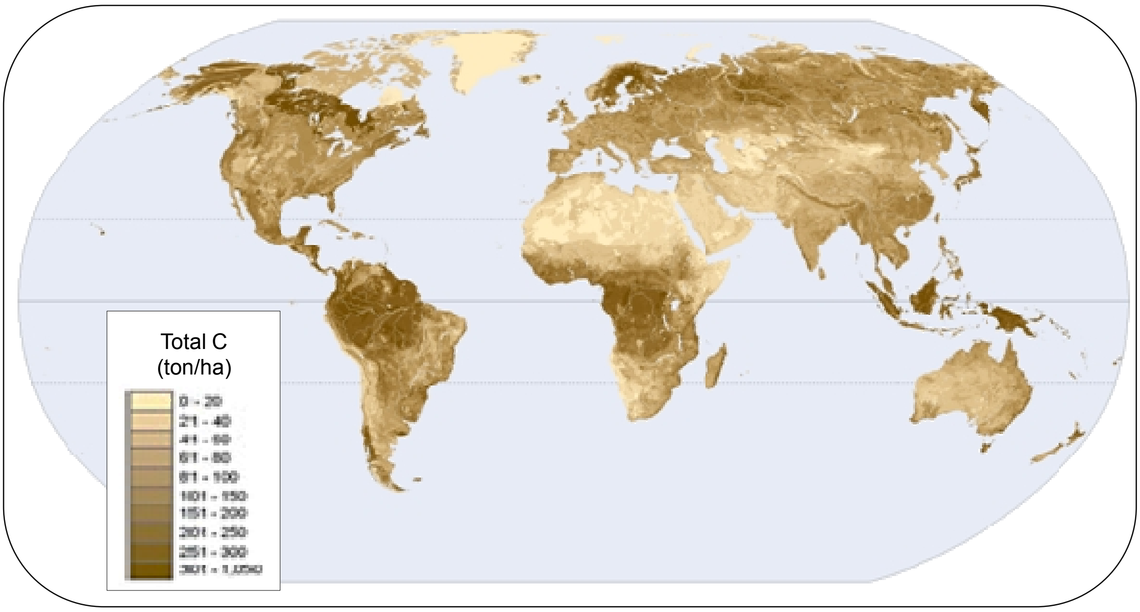

Figure 10. Global carbon density in above-, below-ground biomass and soil organic carbon. Sources: Rueschand Gibbs(2008); FAO, IIASA, ISRIC-CAS, JRC(2009).

As **Figure 10**shows the largest amounts of carbon are stored in the tropics, mostly as biomass, but in high-latitude ecosystems the C stocks are largely located in soil layers. This accumulation is particularly important in peat and permafrost soils of cold regions.Although global assessments estimate that the ABPU region contains about 12 % of the world aboveground biomass, the region stores about 6 % of world total carbon, which is shared by biomass(above- and below-ground) and soil (Batjes, 1996).

Regarding GHG emissions

Land-use change (deforestation/de-vegetation), livestock production and crop activities explain GHG emissions in the rural sector (IPCC, 2007).Major hotspots of gross GHG emissions in the world due to land-use change are located in the tropical and subtropical areas (**Figure 11**). Together with central Africa and South Asia, the ABPU region is considered one of the largest GHG emitters, amounting about 17 % of global GHG emissions attributed to deforestation and de-vegetation (FAO, 2016a). Likewise, FAO (FAO, 2016a) estimates that ABPU amounts 23 % of global GHG emissions attributed to cattle production (**Figure 12**). On the other hand, Carlson et al (2017) have estimated that crop production in the ABPU region only contributes to about 12 % of the worldemissions of rural areas, which is a small figure considering the high contribution of ABPU tothe global grain production (**Figure 13**).

Together with central Africa and South Asia, the ABPU region is one of largest GHG emissions. ABPU amounts 35-40% of global GHG emissions attributed to deforestation and land-use change.

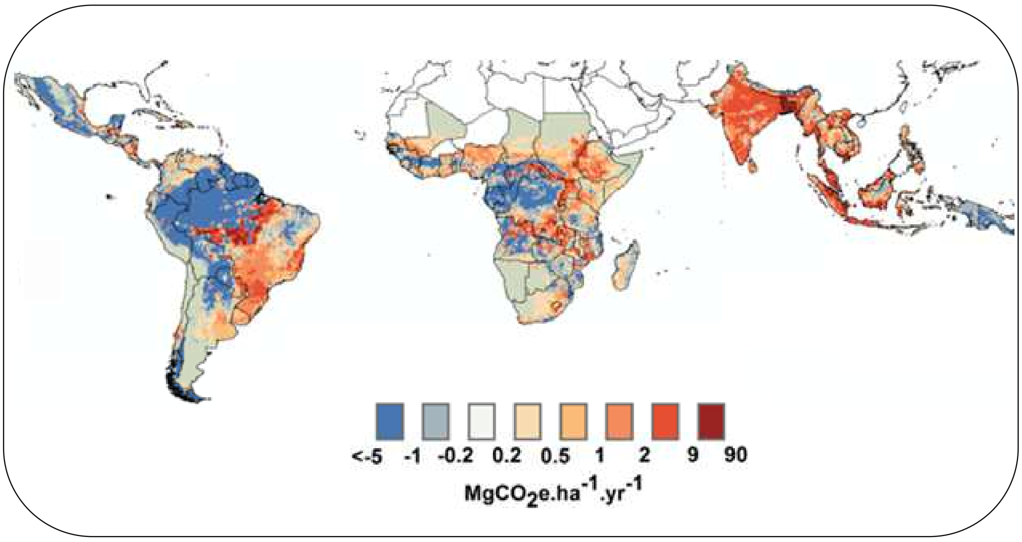

Figure 11. Major hotspots of gross GHG emissions from land-use change during the period 2000-2005. Source: Roman-Cuesta *et al*. (2016).

ABPU amounts approximately 18 % of global GHG emissions attributed to livestock production.

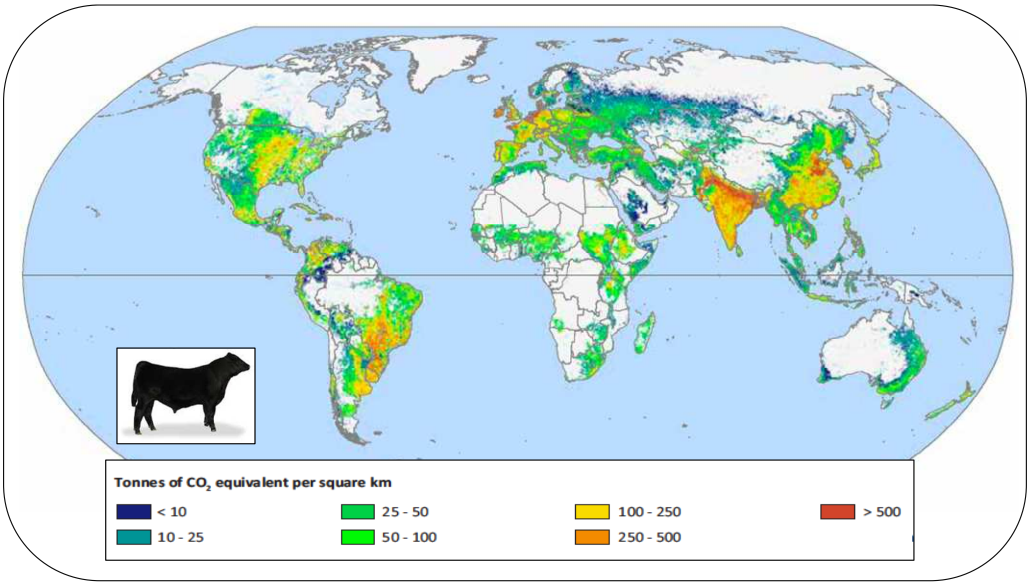

Figure 12. Hotspots of global emissions from cattle production. Source:Gerber *et al.* (2013).

ABPU amounts 12% of global GHG emissions attributed to cropping activities.

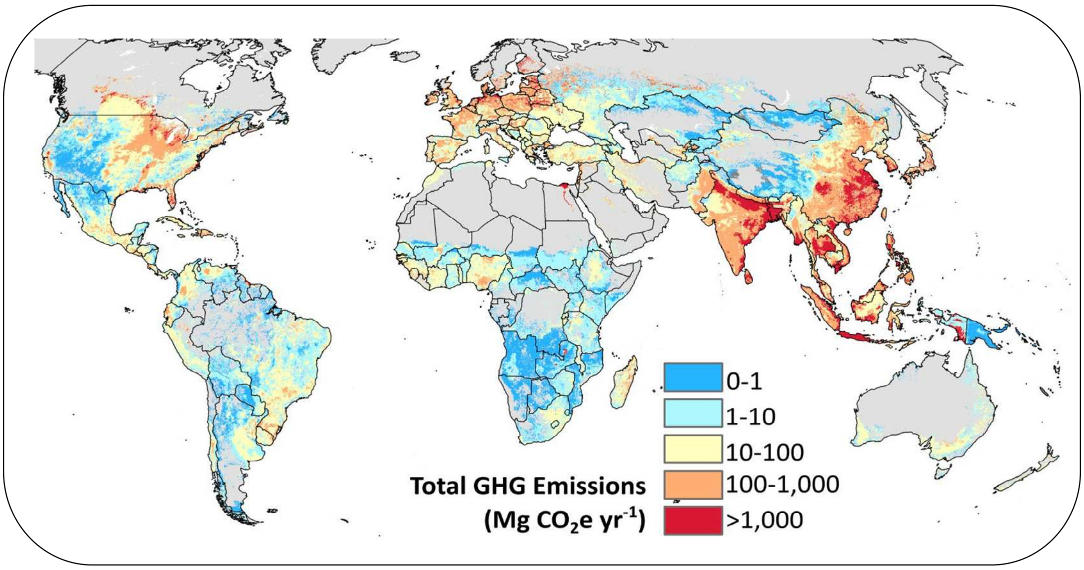

Figure 13. Distribution and intensity of greenhouse gas released from cropping activity. Estimated global emissions from crop production for 172 crops. Source: Carlson *et al.* (2017).

Looking ahead

Are the carbon and water footprints of food production in the ABPU region a threat to the global environment? Are ABPU food exports destabilizing the global carbon and water balance? Would the imposition of trade sanctions on the region because of this issue be justified? Or are regional footprints a false dilemma and potential sanctions a demonstration of commercial myopia? If the answer to the last question is "yes", this would mean that overemphasizing on footprints would mislead objectives and priorities in food commercial trade.

If the incidence of ABPU food exports on the balance of water and carbon is assessed in terms of its global implications, one can rapidly realize that the water and carbon footprints are negligible in global terms (**Figure 14**). In percentage, the water consumption and carbon emissions of ABPU rural sector respectively represents only 8 and 13 % of the same figures for the global rural sector. And even more, footprints are negligible when figures specifically referred to ABPU exports in comparison to those global figures. While ABPUcontribution to the global food trade is about 43% of grain and 30 % of beef, the water and carbon footprint of its exported food respectively represents only 2.7% and 0.3% of the total water consumption and carbon emissions of global agriculture. Certainly, ABPU food exports have a negligible impact on the global balance of water and carbon.

The footprint of food exports from ABPU region does not have a meaningful impact on the global balance of water and carbon

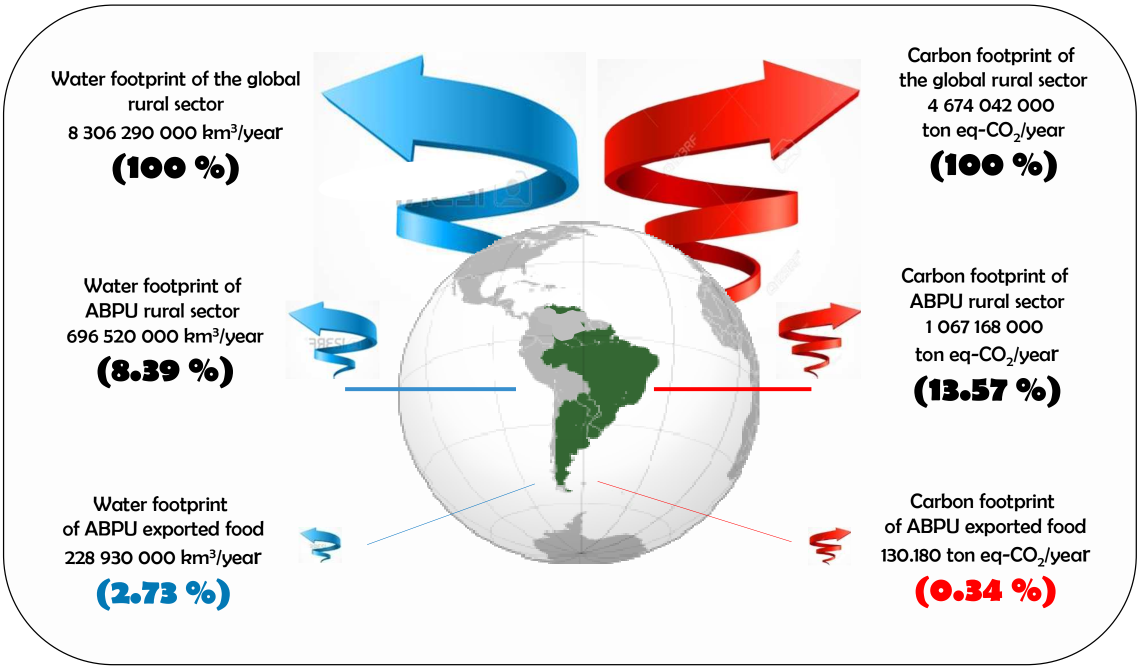

Figure 14. Incidence of ABPU rural sector on the balance of water and carbon in the total rural figures of the world. Sources: own elaboration from Mekonnen and Hoekstra (2012) and FAO (2016a).

Then, putting too much attention on the footprints of food exports in ABPU region may be fully irrelevant in practical terms. Why? Simply because footprints will not have any meaningful impact on the global balance of water and carbon.

No doubt, solutions will be elusive if people in ABPU insist in tackling the problem by the wrong side. The pressing challenge is neither water nor carbon footprint generated by food exports. The main problem is how to tackle GHG emissions at the broad regional scale (e.g, the Mercosur region) through sensible and coordinated land-use policies.To address the problem, the mitigation efforts should be focused on three main sources of emission for the rural sector: deforestation, cattle production and crop operations. They respectively represent 16%, 23% and 12% of rural emissions on global basis(FAO, 2016a).

The ABPU counties strongly differ in their forest area and absolute deforestation figures

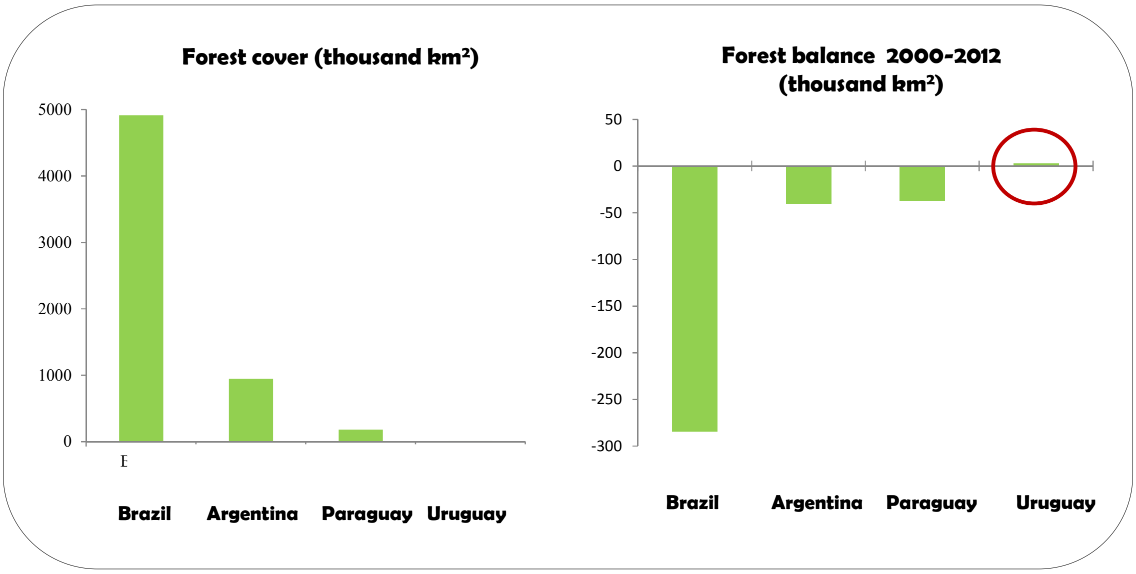

Figure 15. Relative weight of forests and forest loss and gain in the ABPU region. Source: Jones *et al.* (2017).

Regarding deforestation, the attention should be put on the contribution of Brazil because of its huge area covered by tropical forest (**Figure 15**). It should be noted that the Brazilian deforestation rate is several times higher than those of Argentina and Paraguay. On the other hand, because of its long-term afforestation program, only Uruguay shows a positive forest balance nowadays, which in practice has little impact on regional figures because of the small land country area of Uruguay.

Beyond the marked differences among countries, the ABPU region as a whole shows a highly encouraging trend in terms of its decreasing deforestation rate (**Figure 16**)**.** Due to its high gravitational strength, Brazil drags the whole region in its long-term programfor decreasing deforestation.

The ABPU region as a whole shows a marked trend to decrease C emissions due to deforestation rate in response to the dragging effect of Brazil

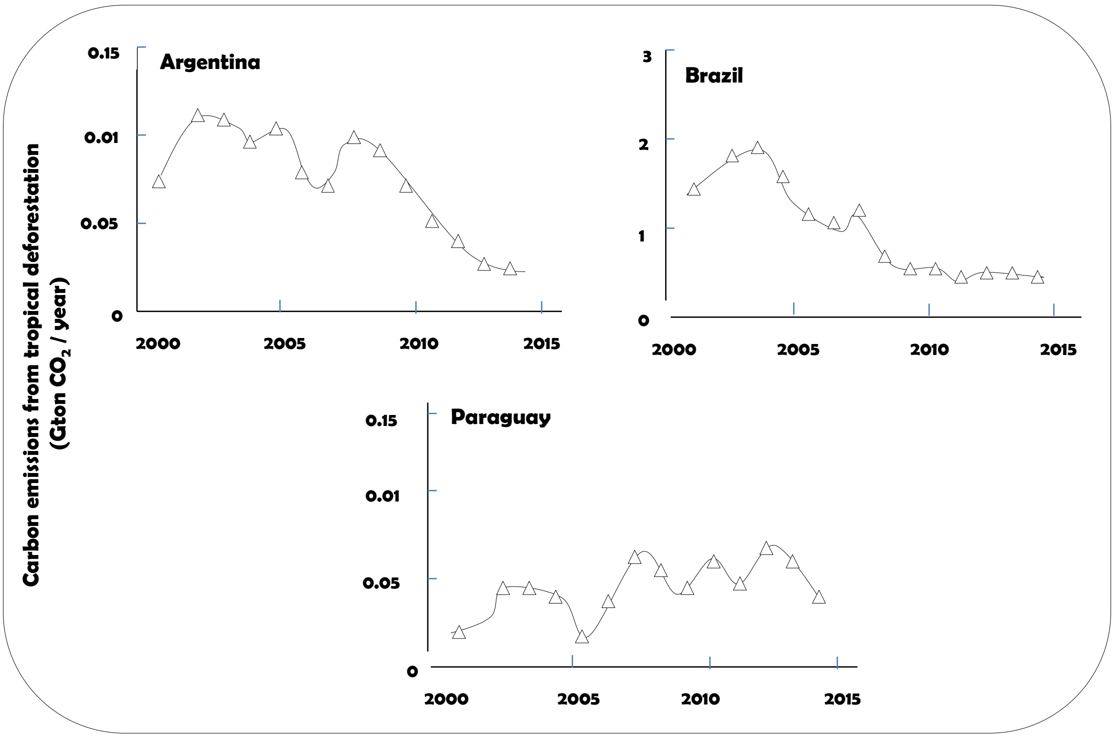

Figure 16. Carbon emissions from deforestation. Source: WB (2016); Zarin*et al.*(2016).

In terms of extensive cattle production, mitigation programs are constrained because emissions under grazing conditions are an unavoidable metabolic constant in ruminants. A quantitative reduction of cattle head appears to be the only practical way to mitigate livestock emissions, but this alternative is difficult to implement because of the high economic dependence of Brazil on its beef industry exports. On the other hand, cattle cannot be easily removed from fields in South America because of social and economic reasons. Beef cattle provide food security in arid and semiarid areas where other production alternatives are not viable.As **Figure 17** shows, a recent analysis(Herrero *et al.*, 2013) on global livestock systems demonstrates that beef production systems in ABPU have medium-low CF in the comparison to other regions (e.g., sub-Saharan, South Afican and Indian system) when C emissions are measured in relation to protein production (kg CO2 equivalent/kg of protein). There is still much room to reduce the CF of grazing livestock by increasing the carbon sequestration in the root system of grasslands and savannas, improvinganimal genetics and reproductive performance, and reducing the time required by animals to reach the slaughter weight.

Beef production systems in ABPU show medium-low CF in comparison to other regions when C emissions are measured in relation to protein production.

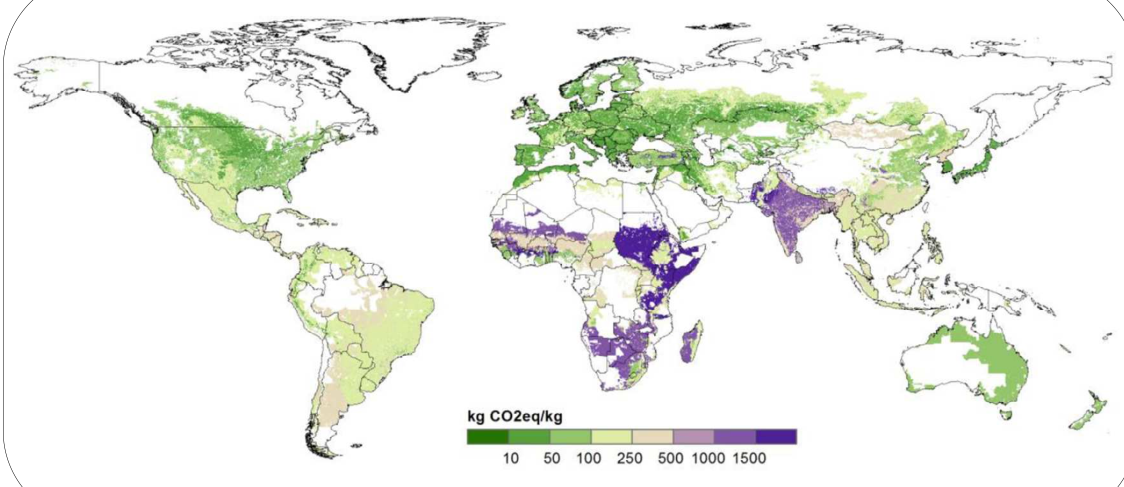

Figure 17.GHG efficiency of bovine production systems (expressed in Kg CO_2eq/g protein) on global basis at the beginning of the 21st century. Source: Herrero *et al.* (2013).

On the other hand, "high-tech, precision farming" is a promising way to save inputs and reduce carbon emissions in crop production and spare land for carbon sequestration and ecosystem service provision. Modern satellite and information technology allows a much more precise use of inputs that depend on fossil fuel for manufacturing, thus reducing C emissions to the environment. It entailsi) release crop- and grazing-land to conservation by increasing productivity on smaller land surface; ii) adopt minimum- and no till systems; iii) increase the efficient use of agricultural inputs (oil, fertilizers, pesticides) that demand fossil fuel for manufacturing; and iv) minimize water and energy use by increasing irrigation efficiency.

In relation to this, as a former GPS investigation shows (Viglizzo, 2014),the private sector and the domestic policies in ABPU countries have boosted a definite trend toward the so-called "sustainable intensification", which reflects in a lower carbon footprint of agricultural activities as a result of high technology adoption. High-tech has demonstrated to be an efficient tool and a way toreduce carbon emission per kg o ton of grain and meat produced. As yield in crop and beef production systems increases, the carbon footprint remarkably decrease.

Concluding remarks

Because of its large availability of land and renewable water, the ABPU region plays today, and will play in future, an increasing strategic role in global food and water security by exporting food and virtual water to food- and water-scarce countries.Even more, ABPU's exports of virtual water could help to alleviate the future increase of water demand for food due to climate change and population growth.

Fair trade and open markets are the ways to guarantee food and water security to an increasingly interconnected world.The scientific evidence does not support that markets can use the notion of water and carbon footprint to raise potentialtrade barrier.The water embedded in food and the carbon released throughout the food chain in various food export countries is fully irrelevant in practical terms and have no measurable impact on the global water and carbon balance. Problems related to carbon emission and water use in agriculture should be resolved on broad-scale basis beyond the inconsequential small-scale footprint view.

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