The Sustainable Development Goals in a NEXUS perspective among the food trade market – focus on the EU agri-food import dependency

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Abstract

The demand for water, energy and food tends to increase globally, as well as the efforts to access and secure those resources which are threatened by the increasing scale and complexity of the interactions between the human needs and the environment. The Sustainable Development Goals are a valuable opportunity to address this enormous challenge. As the world's largest food and energy importer, Europe's food and energy systems depend on increasingly unsustainable imports, namely from the least developing countries and from regions which are particularly vulnerable to the impacts of climate change. With this study we intend to understand if EU28 is performing a sustainable approach among the food trade market. The analysis is focused on the supplier countries for which EU28 has an import dependency on agri-food products above 20% per supplier, i.e., Brazil, Colombia, Costa Rica, Côte d'Ivoire, Ecuador, Ghana, United States of America and Vietnam. For each country and EU28, an analysis on the efficiency of the agriculture sector was performed by considering the (a) energy use per hectare, (b) water use per hectare and (c) CO_{2eq} emissions per hectare. Data was obtained from 2000 to 2014 and was acquired through FAOSTAT. Results show that EU28 food trade market is contributing, at a certain extent, to continue the unsustainability observed in a group of supplier countries for which the production of agri-food products is less inefficient than in EU28 in terms of CO_{2eq} emissions, energy and water use per hectare. In the last instance, EU28 is promoting unsustainable agriculture practices among importers, in opposition to actions towards (a) an affordable and clean energy and (b) climate mitigation, that should be implemented. Nevertheless, results also show that for a group of supplier's countries, and by considering GHG emissions, EU28 is not transferring its unsustainability on agriculture production. Our analysis recommend future EU28 policies need to consider the impacts on GHG emissions, energy consumption and water use in the food supplier countries, taking a holistic perspective of sustainable development at global level.

1. Introduction

A range of pressures from global and regional change, such as population growth, economic development and changing lifestyles and diets, and the urgent need to improve water, energy and food security for all, place a growing pressure on the Earth limited resources (Hoff, 2011). By 2050 the world population is expected to increase by 2.4 billion people (34% higher than today levels) (FAO, 2009; UN, 2013) and it is also expected that 70% of the world's population will be urban (FAO, 2009).

Urban living promotes more resource intensive lifestyles and concentrates consumption and waste production (Hoff, 2011). The already observed rapidly expanding of the middle class in emerging and developing countries (Hoff, 2011) accompanied by an intensification on the consumption patterns, will result in an increased demand for more water, food, and energy. In fact, the Foresight report foresees a food demand increase by 50% by 2030 and 60-70% or more by 2050, meaning an increase in agricultural production 60% higher than in 2005-2007 (Alexandratos & Bruinsma, 2012).

These growing trends will greatly intensify the global extraction and use of resources, which based on current trends is expected to reach 140 billion tons annually by 2050 (three times higher than what it was recorded for the year 2000) (UNEP, 2011). In addition, evidence suggests that climate change will further intensify this pressure, which greatly reduces Earth's ability to deliver goods and services essential to human well-being.

The intensification of the interaction between the humankind and the environment reached a tipping point. The trespassing of the planetary boundaries due to the overuse of resources and sinks is compromising the maintenance of the life patterns now and in the future for the humans (Rockström, Johan, Will Steffen, Kevin Noone, Åsa Persson, F. Stuart Chapin, Eric F. Lambin, Timothy M. Lenton, 2009). This is contributing to the increased awareness on this challenging balance. The transformation required implies a new mind set (O'Brien, Karen, Jonathan Reams, Anne Caspari, Andrew Dugmore, Maryam Faghihimani, Ioan Fazey, Heide Hackmann, 2013) so that a jointly action among resource use efficiency on water, energy and land can be performed towards a win-win-win strategy" (Ringler, Claudia, Anik Bhaduri, 2013).This kind of holistic approach reached the most political level commitment when the Sustainable Development Goals was launched in 2015 (UN General Assembly, 2015). Now the challenge is to translate this perception to the practice. The SDGs commit subscribing countries to new action targets aimed at achieving sustainable agriculture production and water and energy use, as well as promoting more inclusive economic development (United Nations, 2014).

Avoiding the risk of trade-offs and achieving the Sustainable Development Goals (SDGs) synergistically, will require concerted policy action at global, regional, national and local levels. These policies will have to generate new strategies based on resource management that address the entire set of SDGs leading to net positive results across the SDGs as a whole (UNEP, 2015).

According to (Obersteiner, 2015), examining the SDGs from a resource perspective means that greenhouse gases (GHGs) mitigation policies in the agricultural sector can achieve significant improvements in nutrient efficiency, water savings and biodiversity conservation. Contrariwise, in the absence of a leading SDG policy setting, the production of adequate and nutritious food could increase competition for already stretched resources such as water, land and energy. Consequently, if policies are combined and efficiently affecting both demand and supply and by considering the externalities of international trade, and if integrated in an environmental and social protective system, the efforts to achieve these combined goals are radically reduced compared to the implementation of individual policies.

Integrated strategies that incorporate transformations in production systems and in the consumption of services derived from natural resources will be necessary across all nations (UNEP, 2015). The water–energy–food nexus has been pointed as a new conceptual but holistic tool to discussions regarding the implementation and subsequent monitoring of the SDGs (Biggs et al., 2015; Hoff, 2011).This is considerably important to provide insights for policy coherence, across the nexus policy areas and across different scales and regions.

European Union (EU) policies have embraced key sustainability and climate stabilization issues applied to the member states. These include the concern on green economy, resource efficiency, renewables, climate mitigation and adaptation and integrated water management. However, at the same time, it is also observed an increasing trend externalizing the production of goods and services through international trade (Logan, 2015). This trend contributes to increasing the pressure on resources and ecosystems in other regions of the Planet, namely on developing countries.

The impacts and dependencies on resources use to ensure food security, low-carbon energy, sustainable water management and climate change mitigation, both in the EU territory and overseas, must be further understood in order to improve EU policies and measures in a way that will enable a sustainable development for all. Consequently, there is a need to track the environmental impacts of EU's goods and services demand along the supply chain, all the way back to the location of the original export production in different geographical regions. This will allow identifying how Europe depends from other regions' resources and how it affects other regions, in order to include this in new policy goals aiming to secure climate stabilization and sustainable development for all.

The goal of this study is to understand whether the EU28 food trade market is following a (un)sustainable approach, by considering the supplier countries for which EU28 has an agri-food import dependency above 20%. The performance of the SDG 2[1], 6[2] and 7[3] were analysed for the agriculture sector on each supplier country and EU28 by considering the intensity use of resources, namely the (a) water use per hectare, (b) CO_{2eq} emissions per hectare, and (c) energy use per hectare.

2. Methods

The EU is the biggest importer of agri-food products from the least developed countries and highly dependent on regions which are particularly vulnerable to the impacts of climate change (Hanks & Craeynest, 2014). Europe is also considered one of the most advanced regions in terms of sustainability and climate stabilization policies (Logan,

[1] SDG 2 - End hunger, achieve food security and improved nutrition and promote sustainable agriculture. Target 2.4 - By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality

[2] SDG 6 - Ensure availability and sustainable management of water and sanitation for all. Target **6.4** By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity

[3] SDG7 - Ensure access to affordable, reliable, sustainable and modern energy for all Target **7.3** By 2030, double the global rate of improvement in energy efficiency

2015). Therefore, this study uses a Nexus approach by analysing the water and energy use, as well as, the GHG emission in the agriculture sector among the European agri-food supplier's countries. The goal is to recognize if Europe is contributing or not for sustainable agriculture practises on those countries.

The analysis is focused on the supplier countries for which EU28 has an import dependency on agri-food products above 20%, i.e., Brazil, Colombia, Costa Rica, Côte d'Ivoire, Ecuador, Ghana, United States of America and Viet Nam. For each country and EU, an analysis on the efficiency of the agriculture sector was performed by considering the (a) water use per hectare, (b) CO_{2eq} emissions per hectare and (c) energy use per hectare. Data was obtained from 2000 to 2014 and was acquired through FAOSTAT.

The first step was the identification of the main agri-food products imported by EU28 between 2005 and 2014. For those products, the supplier countries were identified. Secondly, we selected the supplier countries for which EU28 dependency per product was above 20%. The selected products were Cocoa beans, Coffee beans, Banana, Soya beans and Tropical fruits[4], and these products were used to select the set of supplier countries, which are identified on Table 1.

Table 1 – Agri-food products and supplier's countries for which EU28 had an import dependency above 20%, between 2005 and 2014

	Cacao	Coffee	Banana	Soy	Tropical fruits
Cote D´Ivoir	x				
Ghana	x				
Brazil		x		x	
Vietnam		x			
Ecuador			x		
Colombia			x		
USA				x	
Costa Rica					x

The third step was the identification of the total energy and water consumption, as well as, of the GHG emissions, recorded between 2000 and 2014, on the agriculture sector and for each of the eight supplier countries. For the estimation of GHG emissions it was excluded livestock emissions; it was considered the following GHG emission sources: Synthetic Fertilizers, Rice Cultivation, Manure applied to Soils, Crop Residues, Burning - Crop residues, Burning – Savanna and Cultivation of Organic Soils and emissions from energy use. Due to the lack of data, it was not possible to draw the tendency of water use on agriculture for the same period of time. Instead, it was used the most recent year with records on water consumption on agriculture for each supplier country and EU28.

On the fourth step, we estimated the intensity of resource use (water and energy) and GHG emissions on agriculture production, for each supplier country and for EU28. We used the total harvested area on each supplier country and EU28, from 2000 to 2012, in order to have the resources use and GHG emissions for unit of land. Finally, for an easier

[4] FAOSTAT – Meta data – classification: category 603 - Tropical fruits fresh: Including inter alia: breadfruit (Artocarpus incisa); carambola (Averrhoa carambola); cherimoya, custard apple (Annona spp.); durian (Durio zibethinus); feijoa (Feijoa sellowiana); guava (Psidium guajava); hog plum, mombin (Spondias spp.); jackfruit (Artocarpus integrifolia); longan (nephelium longan); mammee (Mammea americana); mangosteen (Garcinia mangostana); naranjillo (Solanum quitoense); passion fruit (Passiflora edulis); rambutan (nephelium lappaceum); sapote, mamey colorado (Calocarpum mammosum); sapodilla (Achras sapota); star apple, cainito (Chrysophyllum spp.). Other tropical fresh fruit that are not identified separately because of their minor relevance at the international level. In some countries mangoes, avocados, pineapples, dates and papayas are reported under this general category.

analysis, we subtracted EU28 data on resource use per hectare and GHG emissions per hectare from the ones obtained for each supplier country.

The equation 1, 2 and 3 show the method to identify the difference on the intensity of resource use (water and energy) and on the intensity of GHG emissions on agriculture production on EU28 and on the supplier's countries. In the equation 2, the emission sources are divided in two groups: one with the emissions from the agricultural process and another from the energy use, once policies to improve the efficiency in these two different groups are quite different. In the equation 2 the period of analysis considered was from 2000 to 2014 and for equation 3 it was considered the time period between 2000 and 2012. In equation 1, the data was available only for one year, therefore for each supplier country and EU28 it was used the most recent data. It was therefore easier to identify in which periods and in which supplier's countries, is the EU28 was promoting a less efficient use of resources through the agri-food trade market. Data was acquired through FAOSTAT.

There are climatic conditions and social and historical constrains that certainly affected agriculture production among the eight countries and EU28, which were not taken into account in this study.

Equation 1 – Water use intensity

$$WS_{is} = \frac{W_{i,EU}}{H_{i,EU}} - \frac{W_{i,s}}{H_{i,s}}$$

Where **WS =** water sustainability (or resource use efficiency) in relation to EU28, ***i*** = year and **s =** supplier country. **W =** total amount of water withdrawal for agricultural proposes and **H** = total harvest area.

Equation 2 – Emissions of GHG intensity

$$GS_{i,s,n} = \left(\frac{\sum G_{i,EU,(n-e)}}{H_{i,EU}} - \frac{\sum G_{i,s,(n-e)}}{H_{i,s}}\right) + \left(\frac{\sum G_{i,EU,e}}{H_{i,EU}} - \frac{\sum G_{i,s,e)}}{H_{i,s}}\right)$$

Where ***GS*** means the emissions sustainability, ***i*** means the year and **s** means the supplier country. ***G*** is the total amount of emissions of GHG (or CO_{2eq}) for agricultural proposes, ***n*** is the different sources of emissions[5], ***e*** is the emissions from the energy use, part of the set n, and **H** means the total harvest area.

Equation 3 – Energy consumption intensity

$$ES_{i,s} = \frac{E_{i,EU}}{H_{i,EU}} - \frac{E_{i,s}}{H_{i,s}}$$

Where **ES** means the energy intensity (or resource use efficiency) in relation to EU28, ***i*** mean the year and **s** means the supplier country. **E** is the total energy consumption for agricultural proposes and **H** means the total harvest area.

The main limitation of this work is that the data used is related to the agriculture sector as a whole and does not consider only the agri-food products produced among the eight supplier countries, which are then imported by EU28. Even if a specific agri-food product

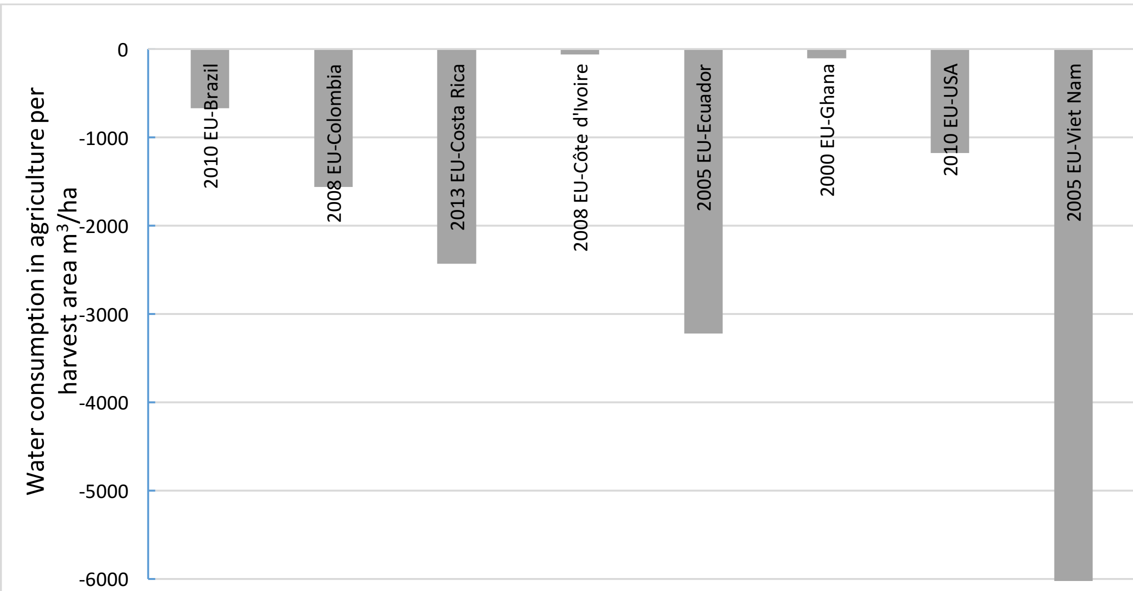
[5] ***n*** is the set of different emissions sources: Synthetic Fertilizers, Rice Cultivation, Manure applied to Soils, Crop Residues, Burning - Crop residues, Burning – Savanna and energy use.

is highly imported by EU28, it does not mean that that product is highly relevant in the total harvested area in the supplier country, for example, the Colombian Banana is highly imported by EU28 but in Colombia the total area dedicated to this crop was no more than 5% in 2012.

3. Results

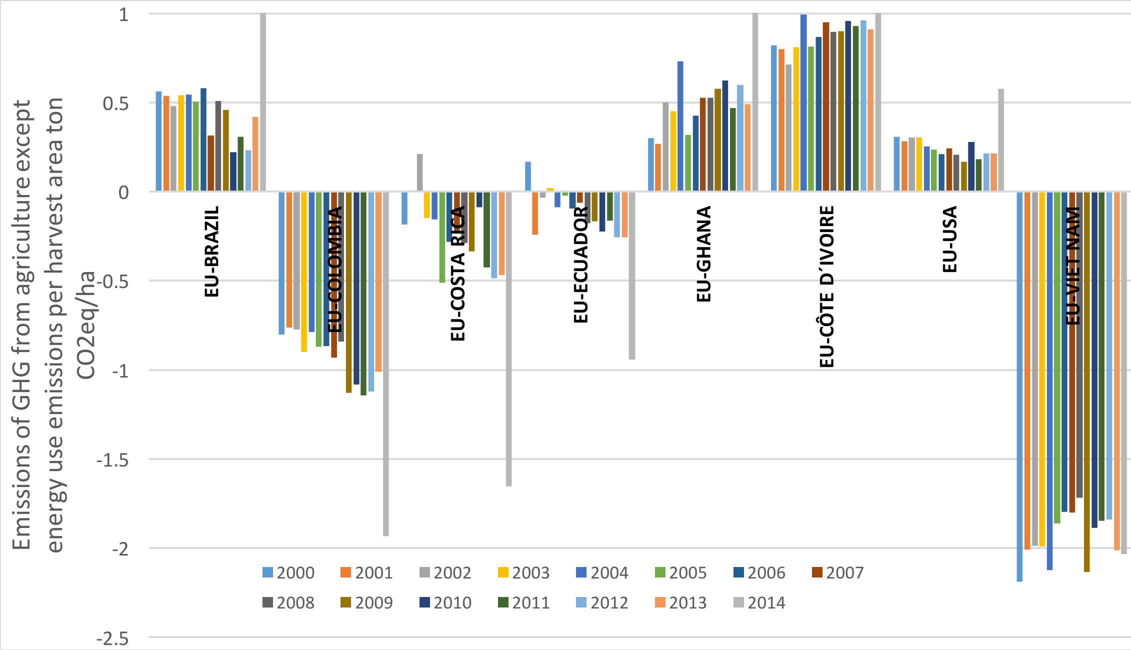
The water use efficiency (figure 1) seems to be the clearest case of transference of efficiency promoted by EU28 while importing agri-food products from the considered supplier's countries. Among all supplier countries the agriculture system seems to be more water use intensive than in EU28 per harvested area. In some countries this difference is very little such as in Côte D'Ivoire and Ghana. However this difference is very expressive when considering Viet Nam, which appears to be much more water use intensity due to the large rice cultivation, which in 2005 corresponded to 57% of the total harvest area of the country.

Figure 1 - Water intensity use in agriculture.



In what refers to the GHG emissions (figure 2), results show that the transference of efficiency depends on the region, with few cases of tendency inversion during the timeframe. For Brazil, USA, Côte D'Ivoire and Ghana, when the EU28 imports food, it is being apparently more efficient in terms of emissions because the emissions of the agriculture in these countries are lower than on EU28. The opposite behaviour happens in Ecuador, Colombia, Costa Rica and Viet Nam which emit more on agriculture production, per unit of harvest area, when comparing with EU28. Between 2000 and 2014, for Brazil and Viet Nam, it does not seem to be a clear tendency in terms of efficiency or inefficiency respectively. For Colombia, Costa Rica and Ecuador it is possible to identify a tendency of increase of inefficiency in terms of emissions in relation with the EU28 emissions. In Ghana and Cotê D'Ivoire there is a tendency of increase of the efficiency. The USA presents the closer results with EU28, probably due to the similar agricultural production method.

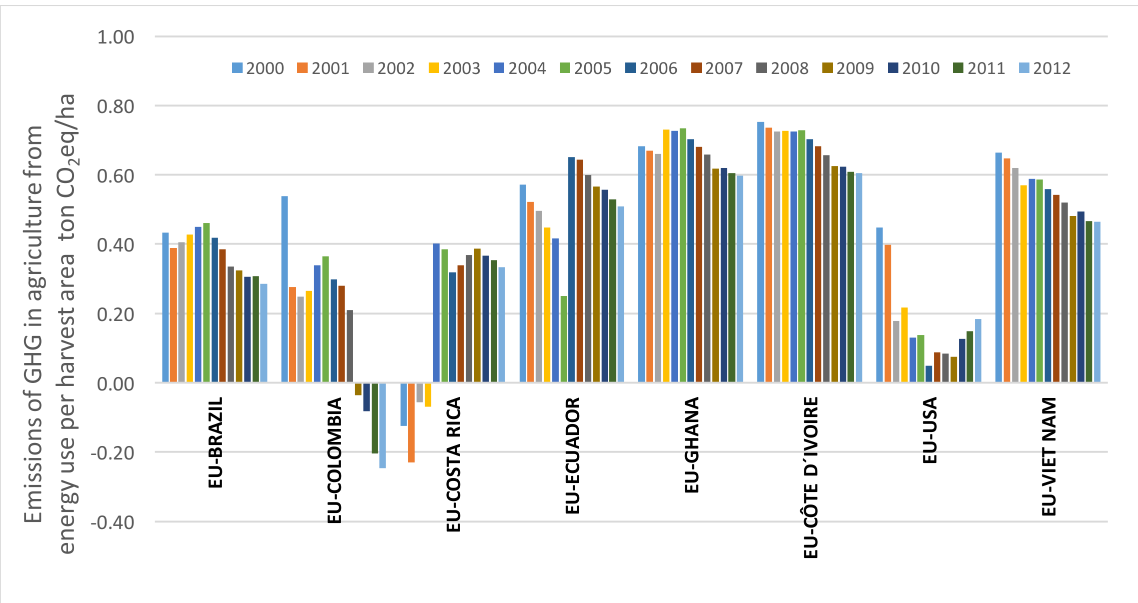
Figure 2- Greenhouse gas emissions except from energy use



The GHG emissions considered on the agriculture sector, follow the IPCC Guidelines for the National GHG Inventories (Alexandratos & Bruinsma, 2012), however it was excluded the livestock emission (i.e Enteric Fermentation, Manure Management and Manure left on Pasture) and by including the energy use emissions on agriculture. On figure 3 it is shown the GHG emission on the energy use on agriculture.

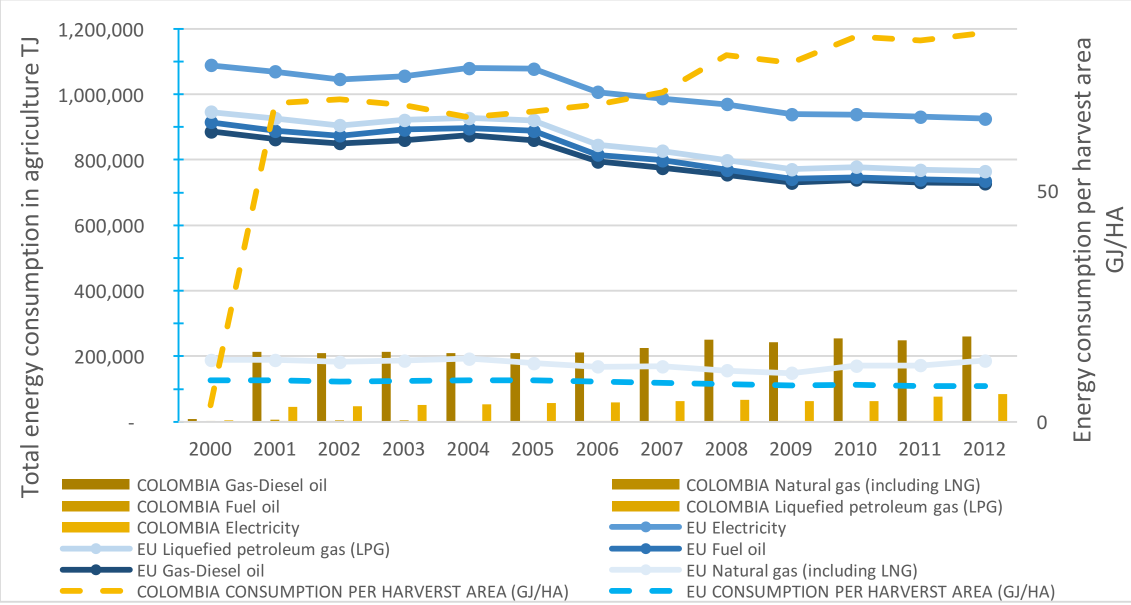
Another emission source in agriculture considered on this analysis is the energy consumption (figure 3), which was considered separately once there are different tendencies founded, as well as, different policies to address resource efficiency on the agriculture emissions and on the energy use on agriculture. In this case the emissions from energy use are bigger in EU28 than among the supplier countries, with the exception of Colombia, between 2010 and 2014, and in Costa Rica from 2000 to 2003.

Figure 3 – Greenhouse gas emissions from energy use



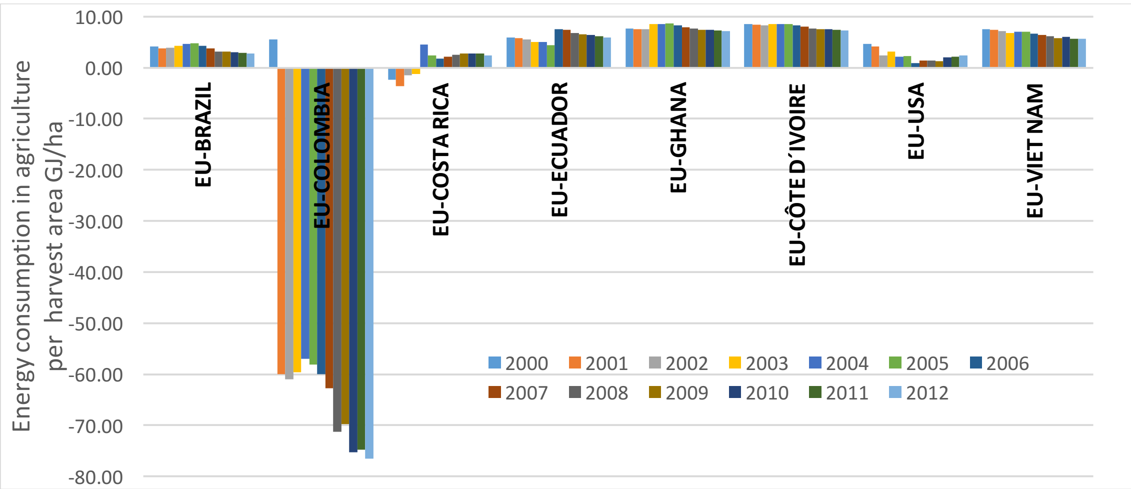
On figure 4, one can see that, due to the distinct emissions factors of the different fuels, the use of the energy do not follow the same tendency. This different in Colombia could be explained by the large use of diesel in this country with a soft tendency to increase. The opposite occurs with the use of this fuel in the agriculture sector of EU28, where diesel use has been decreasing specially after 2005. The use of natural gas, a less emitter fuel in the EU28 but not in Colombia, also explains the large difference.

Figure 4 Energy consumption in agriculture by fuel Colombia and EU28 (absolute terms) and energy consumption per harvest area Colombia and EU28



Results on figure 5 show that only in Colombia, the energy consumption in agriculture is less efficient than in EU28 and this tendency seems to be increasing in the last years. This fact could be explained also by the decrease on the use of energy in agriculture in EU28, especially with a decrease of diesel use, a less energy-efficient fuel. In the other seven supplier countries, the use of energy per unit of harvest area is less than in EU28 but the tendency shows a decreasing difference. USA presents again a less difference in relation to EU28.

Figure 5 - Energy use in agriculture



4. Conclusion

With this study we intend to understand whether the EU28 food trade market is following a (un)sustainable approach, by considering the supplier countries for which EU28 has an agri-food import dependency above 20%. The performance of the SDG 2, 6 and 7 were analysed for the agriculture sector on each supplier country and on EU28 by considering the intensity use of resources, namely the (a) water use per hectare, (b) CO_{2eq} emissions per hectare, and (c) energy use per hectare.

Results show that the efficiency levels on resource use on the agriculture sector is different among supplier's countries and EU28, as expected. In terms of water use efficiency, agriculture practices seem to be more sustainable in EU28 than among the supplier countries, as more water is consumed in agriculture per harvest area, among the supplier countries than in the EU28. This means that when EU28 is importing agri-food products from the analysed supplier's countries, it is apparently promoting an inefficient water use elsewhere. Therefore, SDG 6 must be strongly taken into account on the EU28 food trade policies.

Regarding GHG emissions it seems to be two distinct groups, one emitting less than EU28 per harvested area and other where the opposite appears. Regarding energy consumption, the resource use outside EU28 seems to be more efficient in the majority of the supplier countries, than in EU28 agriculture systems. Thus, regarding energy use, the food trade market (i.e, EU28 imports) appears to contribute to the overall sustainability of the system.

With this work we show that there is a potential for EU28 to promote the efficiency resource use, namely on water and energy, as well as on GHG emissions in some regions of the planet, specifically among the countries with which EU28 has a trade relation. This may be done by promoting its vertical coherence of sustainable agricultural policies, such as by transferring technology.

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