Latin American Agricultural Trade: The Role of the WTO in Sustainable Virtual Water Flows

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Abstract

International agricultural trade has been growing significantly during the last decade. Many countries rely on imports to ensure adequate food supplies to the people. A few are becoming food baskets of the world. This process raises issues about the food security in depending countries and potentially unsustainable land and water use in exporting countries. In this paper, we analyse the impacts of amplified farm trade on natural resources, especially water. Farm exports and imports of five Latin America countries (Brazil, Argentina, Mexico, Peru and Chile) are examined carefully. A preliminary analysis indicates that virtual water imports can save valuable water resources in water-short countries, such as Mexico and Chile. Major exporting countries, including Brazil and Argentina, have become big exporters due to abundant natural resource endowments. The opportunity costs of agricultural production in those countries are identified as being low, because of the predominant green water use. It is concluded that virtual water trade can be a powerful tool to alleviate water stress in semi-arid countries. However, for exporting nations a sustainable water use can only be guaranteed if environmental production costs are fully reflected in the commodity prices. There is no basis for erecting environmental trade tariffs on exporters though. Setting up legal foundations for them in full compliance with WTOs processes would be a daunting task.

Keywords: farm trade, water, blue water, green water, global sustainability, food production, global food demand, water pricing,, WTO

1 Introduction

During the last decade globalization has led to increased agricultural trade in many countries. Because of large differences in per capita resources among countries, there will always be a mismatch between the areas with the largest potential and the populations living in countries without the capacity to produce more. Particular attention has been paid to water resources availability as a limiting factor in agricultural production (Affuso, 2010; Yang and Zehnder, 2002). This water crisis will likely be aggravated by climate change as well as the increasing food demand due to a rapid demographic growth and dietary changes (Liu et al. 2008; Liu and Savenije, 2008). In a scenario of a globalized world, a possible solution to mitigate scarcity tensions in water-short countries is the concept of virtual water trade (Allan, 1998; Falkenmark and Lannerstea, 2010).

Virtual water is defined as the water used to produce a commodity, good or service, that is traded internationally (Allan, 1998; Wichelns, 2004). The concept of virtual water trade defines one possible demand-side adaptation opportunity for water-short nations by purchasing a portion of its food requirements in international markets, rather than using scarce water resources to produce all food crops themselves (Wichelns, 2004).

Nevertheless, increasing trade between countries and continents also raises the question of sustainable water use in the world’s leading agricultural exporting countries. The social and environmental costs that are often associated with an excessive water use remain in the exporting countries.

This trend of an increasing reliance on farm trade raises a number of crucial issues. First, the recent experience during the food crisis of 2007 and 2008 was a painful lesson for some of the poorest importing countries. Second, hotspots can be created in the exporting countries that do not have the capacity or the political willingness to curtail powerful exporting sectors on the basis of environmental constraints. Third, eating habits can change in favour of more standardised diets, against local culture and locally produced goods. And fourth, it goes against common sense that the world will ever feed itself sustainably and equitably without world champions of food production supplying the rest of the world commodities at the lowest cost.

Underlying some of these issues is the role of the World Trade Organization. WTO’s trade rules could include provisions and regulations meant to ensure that the negative environmental consequences of farm trade can be brought to the minimum. In other words, one can ask whether there is rationale for erecting trade barriers based on unsustainable resources conservation and management against exporting countries.

The aim of this paper is to illustrate the concept of virtual water trade and its potential, but also identify some risk factors for selected Latin American countries. The study considers Latin American agricultural trade and its development over the last decade. Major importing and exporting nations are viewed to illustrate the role of agricultural trade in achieving global food security in a sustainable manner. In light of this, we reflect on the WTO’s role in, not only in securing transparent and rules-based world trade, but also in helping sustainable water and land use.

2 Issues

Globalization associated with increased agricultural trade may be part of the transformation to a promising prospect for feeding the world. Especially for countries with very low water availabilities, food imports are an inevitable alternative to domestic agricultural production. Yang et al. (2003, 2007) highlighted that countries with lower water availabilities than a certain threshold are dependent on staple food imports in order to ensure sufficient feeding of their people. There is wide acceptance that a healthy, non-purely vegetarian diet (3000 kcal/day) requires 1,300 cubic meters per year. Falkenmark and Lannersted (2010) conclude that “... global food security with present dietary tendencies develops into a 1/3–2/3 world of massive food trade from water surplus countries to almost 5,000 million people in countries with agricultural water deficit” (p.19).

The following subchapters will reveal that the concept of virtual water trade from both perspectives, the importer's as well as the exporter's view, together with the influence of environmentally-based tariffs possibly implemented by the WTO are subject to some controversy.

2.1 Lack of consistent conceptual basis for virtual water trade

Wilchelns (2010) claims that, although the notion of virtual water trade has been effective in encouraging analysts and politicians to look at water issues, it lacks a conceptual underlying framework. He reviews the literature debate on whether virtual water trade is a good indicator to guide policy decisions. Using graphical analyses of nations, Wilchelns (ibid.) concludes that arable land in per capita terms is a better predictor of trading flows than water endowment, even though he concedes that even land scarcity is not sufficient to explain trade flows.

Asink (2010) claims that the concept of virtual water has been used incorrectly to make claims that are not in line with empirical facts and standard economic theory. In the same vein, the fact that observed trade flows cannot be explained by the virtual water perspective has been posed by Kumar and Singh (2005) to conclude that trading strategies based on its postulates will not mitigate water scarcity.

2.2 Increasing farm trade and its environmental effects on exporting countries

In environmental terms, it is crucial to establish whether the observed water uses originate from rainwater evaporated during the production process (green water) or from surface and/or groundwater sources evaporated as a result of the production of the product (blue water). Traditionally, emphasis has been given to the concept of blue water through the "miracle" of irrigation (Aldaya et al. 2010). However, for the analysis of sustainability aspects of international agricultural commodity trade, the green water component plays a crucial role. Green water differs from blue water in its scope of application and is generally associated with lower opportunity costs than blue water (Albersen et al. 2003). Green water cannot be automatically reallocated to uses other than natural vegetation or alternative rainfed crops, whereas blue water can be used for irrigating crops as well as for urban, agricultural and industrial water uses (Garrido et al. 2010). Furthermore, excessive irrigation can cause severe salinization, water logging and soil degradation, which are evident in many areas of the world (Postel, 1999).

From the viewpoint of opportunity cost of the use of water resources, trading green virtual water is overall more efficient than trading blue virtual water, holding other factors constant (Yang et al. 2006). Thus, the use of green water in crop production is considered more sustainable than blue water use, although this is not necessarily the case if blue water resources are not over-exploited (Garrido et al. 2010). In some cases increasing production under rainfed conditions could be achieved by excessive farm land expansion which in turn might have negative effects due to land use changes.

2.3 The coherence between trade liberalization and sustainable food supplies

As previously stated, international farm trade may reduce the demand for scarce world water resources. The trade liberalization process that has been targeted by the Doha-Round since 2001 will likely lead to further growth of agricultural trade flows (Reimer, 2010). This involves the chance to increase global food security accompanied by regional and global water savings and welfare gains. However, trade liberalization is unambiguously welfare-improving and environmentally friendly only if property rights are well defined. This can be achieved through the introduction of water markets or efficient resource pricing. The four main types of responses to higher water prices are the use of less water on a given crop, the adoption of water conserving irrigation technologies, shifting water usage to more water-efficient crops, and the change in a crop mix to higher valued crops (Rosegrant, 2009; Ringler, 2000). Thus, whether trade is economically optimal will depend on whether the water opportunity cost and production's externalities are properly internalized. Especially in developing countries, cost internalization does not take place though (Berrittella et al. 2008). The current level and structure of water charges mostly do not encourage farmers to a more efficient water use. Very often irrigation water is offered at subsidised rates (Garrido and Calatrava, 2009; Berrittella et al. 2008) leading to unsustainable irrigation water use.

2.4 Environmentally-based tariffs by the WTO

Due to market distortions as well as many other trade influencing factors, water scarcity will likely be a poor explanatory factor of virtual water trade in many countries (De Fraiture et al. 2004, Wichelns, 2004; Garrido et. al, 2009; Affuso, 2010). This is for example reflected by existing counter-intuitive virtual water trade flows, meaning exporting from water scarce regions to water abundant regions. Thus, the prices of the agricultural commodities understate the true environmental costs which may lead to unsustainable trade flows.

This raises the question whether environmentally-based tariffs possibly implemented by the WTO could contribute to solving regional water problems by shifting trade flows in an optimal way. According to Hoekstra (2010), binding multilateral rules should be established to remedy the market failure of not-internalized external effects of production of traded goods. Different economic studies dealing with the implementation of water pricing show that it is an adequate mechanism to shift production away from water intensive products to water extensive products if water is a scarce input factor in that region (Berrittella, 2008; Bartolini 2007; Merrett, 2004). These studies however show only the effects of unilateral water pricing. Without an international treaty on proper water pricing, reflecting the water scarcity rents of the different regions, it is unlikely that a globally efficient pattern of water use can be achieved.

3 Methods

We have compiled data of farm imports and exports of Argentina, Brazil, Chile, Mexico and Peru for which FAOSTAT provided production data as well as trade data. We looked at the area harvested in hectares, production in tons, imports and exports in tons. Yield is given as additional information. Crops that are most relevant in each category (adding up to at least 70%) are used for the analysis.

3.1.1 Agricultural market structure

The paper reflects on changes of the agricultural market by depicting variants of intraregional and international import and export volumes of the most traded goods in all 5 countries. To explain the evolving trade flows, potential alterations in production data as well as expanding areas harvested are assessed.

3.1.2 Specialization

According to international trade theory, the globalization process leads to increasing trade flows, which in turn entails a specialization process of trading partners (Vousden, 1990). We examine empirically if the trend of amplified trade really leads to such a specialization process in the focal countries of this paper. Data on production and area harvested in each country are analysed dynamically.

3.1.3 Origin of water and land use change for crop production

From a sustainability point of view the water origin in crop production is highly important. The virtual water content of a product consists of three components: green, blue and grey water. At the present time we only distinguish between green and blue water for our analysis. This differentiation is policy relevant because the various water components have different characteristics.

We shall give an overview of which crops are grown under rainfed and which others under irrigated conditions. To determine the area harvested under irrigated and rainfed conditions, we subtract the irrigated area harvested per crop from the total area harvested of the respective crop and thus obtain the rainfed area harvested per crop. In order to identify the share of green and blue water components per crop we put rainfed area harvested in proportion to irrigated area harvested per crop.

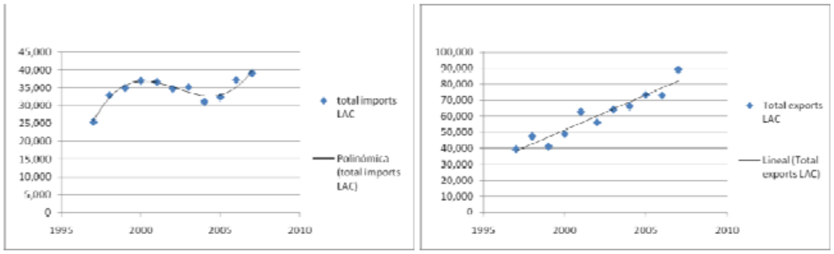
To connect altered trade flows to the use of natural resources, the green and blue water components of exported and imported crops, are reviewed. Beyond, we dissect environmental impacts by reflecting on the source of the amplified export production. If production gains for the export market mainly come from farm land expansion in contrast to yield increases, the environmental effects are likely to be more severe.

4 Results

4.1.1 Trade flows

The results of the above described issues are presented for the countries Argentina, Brazil, Chile, Mexico and Peru. The overall trend of the magnitude of agricultural trade flows within the last decade has been upward in all five countries. In all nations, except Brazil, imports from global markets have risen. The same holds for total exports in all countries. (See Figure 1)

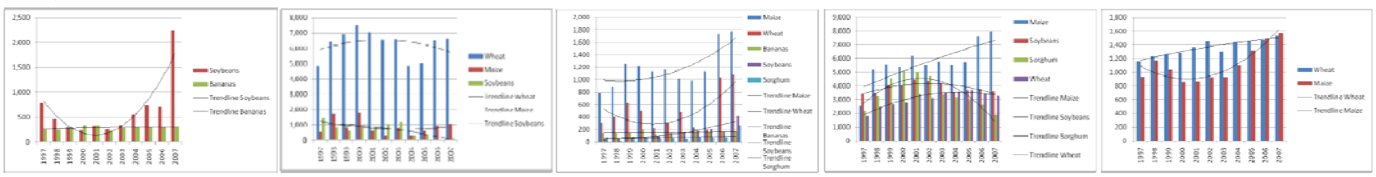
Figure 1: Total Latin American imports (left) and exports (right) of crops (in thousand tons)



Source: own elaboration, data from FAO (2010)

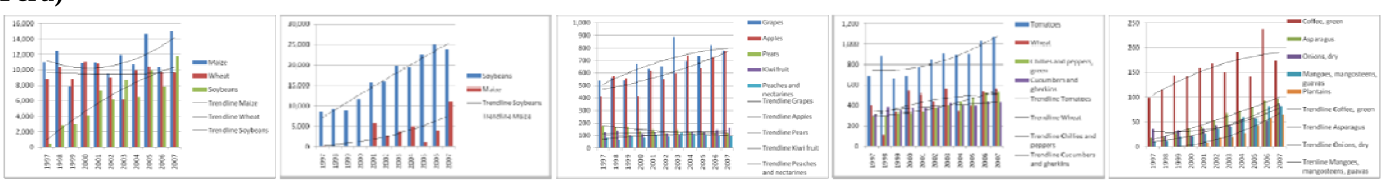
If we look separately at the most traded crops of the Latin American countries, the picture is more diverse than the general trade trends.

Figure 2: Total imports of most traded crops (in thousand tons) (read from left to right: Argentina, Brazil, Chile, Mexico, Peru)



Source: own elaboration, data from FAO (2010)

Figure 3: Total exports of most traded crops (in thousand tons) (read from left to right: Argentina, Brazil, Chile, Mexico, Peru)



Source: own elaboration, data from FAO (2010)

Argentina is a net exporter of agricultural products showing a steady upward trend during the last decade and will likely remain as such in the future. Total agricultural imports have also increased from 1997 to 2007. After a sharp drop in imports in the years 1998 and 2002, imports have been vigorously increasing until 2007. Crops with the highest export amounts are maize, wheat and soybeans making up almost 90% of total crop exports. Export volumes of soybeans and maize have recorded very high growth rates since 1997. Soybean exports have gained the most during the last decade, whereas wheat exports have stagnated on a high level (see Figure 3). In the years between 1997 and 2007 around 70% of total maize production has been produced for the export market, the soybean production for export purposes grew from 4% of total production in 1997 to almost 25% in 2007. The share of wheat production for exports varied in the range of 41.94% and 82.30%.

The Argentinean import market is dominated by bananas and soybeans, adding up in average to almost 85% of all crop imports. This tendency reveals again the growing importance of soybeans as a global product. Especially the sharp increase in total agricultural imports can be explained by the soybean market. Banana imports, with bananas being high volume but rather low value fruits, seem to be stable (See Figure 2). Green coffee and vegetables also belong to the group of most imported products in Argentina, although on a much lower level and with a rather declining tendency.

Brazil is a very large international trade participant. Crop exports amount to 22 million tons on average between 1997 and 2007, against average imports of 9 million tons during that time period. Figure 3 illustrates the increasing importance of the export market in Brazil. Within 11 years crop exports have more than tripled. With slightly declining imports, Brazil has turned into a significant net exporter over the years. Especially, soybeans and maize have been increasingly produced for the export market. Nevertheless green coffee, tobacco and wheat exports are also expanding.

Brazil's imports the major crops have been wheat, maize and soybeans on average making up 87% of imported food crops between 1997 and 2007. Total food imports have been relatively stable at a level of approximately 9 million tons per year. In line with this trend are also the slightly decreasing import amounts of wheat, maize and soybeans. Although other products, such as onions, barley and pears show slightly increasing import amounts, their import magnitude is relatively low (See Figure 2)

The third images of Figure 2 and Figure 3 plot Chilean's commodities imports and exports from 1997-2007 with a clear trend upwards. Total crop exports and imports have approximately the same magnitude. The growth in both cereal imports and fruits exports is clear. Import volumes of maize have more than doubled in the last decade, wheat imports even increased from 308,111 tons to 1,086,320 tons and soybean imports have multiplied more than tenfold. The growth rates of fruit exports (to mention a few: grapes, apples, pears and kiwi fruit) are more moderate than imports, nevertheless show a steady upward trend.

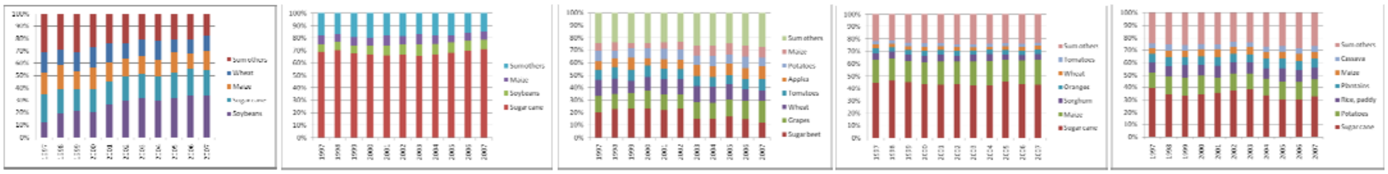
Mexico is a net importer of agricultural products, with high volumes of virtual water embedded in the imports. The overall trend of Mexico's trade flows show however that not only imports but also exports have grown significantly. In absolute terms, Mexico still imports much more than it exports though. Imports being at a level of almost 20 million tons in 2007 (almost 12 million tons in 1997) and exports being at a level of 6.7 million tons in 2007 (almost 4.4 million tons in 1997), most likely Mexico will maintain its net importing position in the future. The import market is dominated by maize, soybeans, sorghum and wheat, amounting to 85% of all crop imports during 1997 and 2007. Maize imports have grown with a linear trend during this time. Wheat grew slightly each year, though it levelled off in the last years of the series. Soybean and sorghum imports increased until 2001, but are declining since then and almost back to the level of 1997 (See Figure 2). Crops with the highest export amounts, shown in Figure 3, are tomatoes, wheat, green chillies and peppers as well as cucumbers and gherkins. Those products make up almost 40% of total crop exports. Adding fruits and vegetables as well as green coffee, amounts to more than 75% of all exported crops. The export activities for fruits and especially vegetables have increased significantly during the last decade.

Finally, Figure 2 and Figure 3 also plot Peruvian's most important commodities imports and exports from 1997-2007 with a clear trend upwards. Total imports have grown approximately by one third during this time, whereas exports have almost tripled. Therefore Peru has developed from a net agricultural importer to a net exporter in crops. The growth in both cereal imports and fruits exports is clear. Especially wheat, maize and barley imports have grown significantly, whereas green coffee, asparagus, dry onions and mangoes have been increasingly produced for the export market.

4.1.2 Specialization trends

According to international trade theory, open markets with enhanced trade flows lead to product specialization among trading countries. As we have stated above, there is a clear upward trend in trade activities in the five focal countries. However, empirical results show that the expected intra-industrial specialization process has not taken place (see Figure 4). Even if total production amount of many products has risen the share of the different crops on production seems to be relatively stable. An exception is the clear specialization trend towards soybean production in Argentina. As shown in Figure 4 the share of soybean production on total production has almost tripled, whereas the production of other crops has diminished from 30.54% to 18.13%. Brazil however has shown very little specialization tendencies over the last decade, even though soybean production has more than doubled with production being at very high production levels.

Figure 4: Share of main crops on total production (in %) (read from left to right: Argentina, Brazil, Chile, Mexico, Peru)

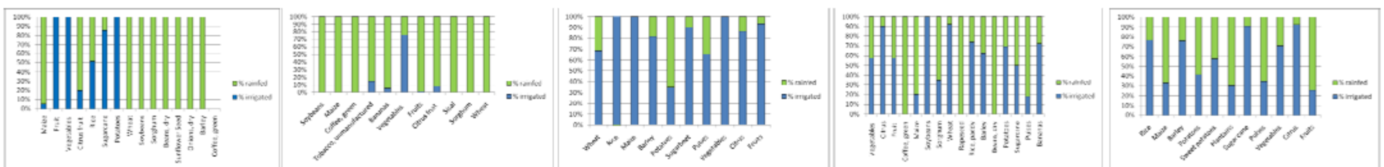


Source: own elaboration, data FAO (2010)

4.1.3 Trade water nexus

To connect the altered trade flows in the region, to the issues of sustainable water use, we consider the green and blue water use of the traded products in our analysis. Additionally, we analyse if the amplified trading activities affiliate to farm land expansions or yield expansion.

Figure 5: Share of irrigated and rainfed area harvested of different crops (in %) (read from left to right: Argentina, Brazil, Chile, Mexico, Peru)



Source: own elaboration, data from AQUASTAT (2010), data from year 2000

Figure 5 demonstrates that the green and blue water distribution among major exported products in Argentina and Brazil favours almost entirely rainfed conditions. In Argentina only fruits that make up only small few percentange of total production and exports are entirely irrigated. In Brazil about 15% of the tobacco's area harvested, in total only amounting to less than 1% of total area harvested, is grown under irrigated conditions. Also vegetables that are to a large part grown under irrigated conditions are negligible in terms of exports and area harvested. The third graph of Figure 5 plots Chile's harvested areas under rainfed and irrigated conditions. It is clear that Chile's agriculture, especially fruits produced for the export market is irrigated. In addition, wheat and maize with high production volumes are primarily grown under irrigated conditions. Also Mexico's agricultural areas depend on irrigation. Therefore the use of blue water in agricultural production for the domestic and export market is very high. Vegetables are grown under irrigated conditions to almost 58%. Wheat as the second largest export product is almost entirely irrigated. Also the most relevant imported goods, such as maize, sorghum, soybeans and wheat would have been grown with irrigation if Mexico had produced them itself. It is also clear that Peruvian's agriculture is mainly irrigation-driven. Sugar cane, potatoes, rice, plantains and maize making up 70% of total crop production are all grown under irrigated conditions to a certain extend. Fruits and vegetables production for the export market are also produced under irrigation. Therefore, Argentina and Brazil depict primarily use green water for their production whereas Chile, Mexico and Peru highly depend on blue water resources.

The escalation of the soybeans production as Argentina's and Brazil's main export crop has resulted from an expansion of farm land. In both countries the area harvested has more than doubled in the period of 1997-2007, whereas yields in soybean production have not been significantly growing. Area harvested of the other crops in the Argentina and Brazil has been relatively stable. Total crop production in Chile varies between 13 million and 15 million tons per year with a shift away from cereals towards fruit production. This result is in line with the development of Chile's trade activities. Harvested area has stabilised in the range of 1.2 to 1.3 million hectares in Chile. By contrast to Argentina and Brazil, Mexico´s area harvested has generally decreased. Production however is very stable or even slightly increasing, which leads to the assumption that productivity has been improved in Mexico. Peruvian´s total crop production is growing from 19 million tons in 1997 to 25 million tons in 2007. In line with this trend, harvested area in Peru has grown from 2.3 million hectares to 2.9 million hectares in the same period.

5 Discussion

This section attempts to bring the results to the policy context. For all analysed Latin American countries, trade activity has increased vigorously. This tendency of increasing global and regional agricultural market integration is a result of a proceeding trade liberalization process and will likely continue in this direction (Ramirez-Vallejo and Rogers, 2004; Martin and Mattoo, 2010).

The results from Argentina and Brazil show that these countries are progressively becoming part of the food basket of the world. Being major exporters of agricultural commodities, it is clear that they contribute to feeding the world. Besides maize, the most important exported product is soybeans in both Argentina and Brazil (proteins and hydrocarbons for animal feed are effectively the goods these two products represent). This tendency reflects the global evolution towards a more meat oriented diet, since soybeans serve as animal feed all over the world, especially monograstrics (chicken and pigs). Therefore soybean production is necessary to achieve the goal of a global food security with a balanced diet. To answer the question of whether this contribution to global food security also meets the standard of sustainable water use, we distinguished between green and blue water resources in the production process.

In Argentina as well as Brazil the main exported products are grown under rainfed conditions which enable production at a lower opportunity cost. This implies that virtual water exports are in line with an environmental friendly production and thus can continue in a sustainable way. However, increasing soybean production has led to a massive farm land expansion in both countries. The lack of specialization tendencies in Brazil, despite increasing soybeans exports, can also be explained by this phenomenon. If the magnitude of exports continues to increase with the same speed than in former times, they may hit environmental limits. In the case of Brazil, for the time being land as well was water availabilities are not crucial constraints though. There is a potential of 300 to 400 million hectares of arable land, so far using only 50 million hectares. This potential arable land with its water resources is not mainly located in the ecosystem sensitive area of Amazonia but rather in the “cerrado” (*The economist*, 2010). In conclusion Brazil has an immense potential to feed the world sustainably. Thus, virtual water trade can contribute to that goal. Producing within environmental limits and exporting the products to more constrained areas of the world helps promoting global food security and alleviating regional water stress. Although, there is more research needed in the field of land use change to make a final conclusion about whether the amplified production is sustainable.

As stated above, not all countries have such abundance of natural resources and rely on the world food markets. We showed that increased food trade can contribute to more food security in importing semi-arid countries. Looking at Mexico as a major food importer, reduced farm trade by closing up the markets would have severe consequences for the country’s food security as well as for the relatively scarce water resources. If Mexico had to produce all its imported crops itself, it would have to use valuable blue water resources. Since Mexico’s agricultural crops are in many parts grown under irrigated conditions, it can be stated that virtual water trade alleviates Mexico’s water stress. Nevertheless Mexico’s progressing agricultural market liberalization, especially through the North American free trade agreement (NAFTA), also has its downsides from an environmental perspective. Cereals, being produced to a larger part under rainfed conditions, are increasingly imported whereas irrigated vegetables are becoming the main export products. Whether or not the cost of the potential overexploitation is well reflected in the market price of the products is questionable. This would lead to unsustainable virtual water trade flows. This might be a reason why exports are growing much faster than imports. Yet the declining harvested area with slightly increasing production amounts lead to the assumption that productivity is still rising. Therefore Mexico still has potential to distend its agricultural markets.

Chile and Peru are much smaller market participants, though with increasing import and especially export amounts. Most of the exports are produced with blue water, and some of their most semi-arid river basins are perhaps suffering the pressure of irrigation water abstractions. It is questionable if Peru and Chile with their climatic conditions can establish their high export growth rates in the future without risking overexploitation. However, in Chile area harvested is even decreasing and production has stabilised. Therefore simply more products have been exported to global markets instead of domestic markets not effecting water resources. Peruvian’s harvested area has only increased slightly. Therefore production expansion of fruits for the export markets didn’t need new agricultural land. Neither in Mexico nor in Chile or Peru specialization of production took place during the last decade. Due to regional integration initiatives through FTA in the 1990’s, it is likely that the specialization of agricultural production had been finalized before our period of investigation, though. Through this trade induced shift of crop production towards irrigation intensive fruits and vegetables in all three countries blue water resources are continuously affected. It should be mentioned that cereals now being imported from rainfed areas in Brazil or Argentina, would have been produced under irrigation in Peru and Chile. Therefore virtual water trade opens opportunities to produce high value crops without putting too much pressure on land and water resources in those countries.

The results from Brazil and Argentina show that enhanced virtual water trade in Latin American countries has the potential to accomplish a more sustainable future combined with global food security. Therefore, the trade liberalization process should be pushed further to facilitate trade actions. However, the results also indicate environmental problems resulting from amplified trade. Thus, to really achieve sustainability, the liberalization process should proceed in conformity with environmental standards. As described in section 2.3 water pricing strategies play a crucial role. However, there is a standing tradition in Latin American countries of heavily subsidizing irrigation water. Water users therefore have little incentive to economize on its use. In Mexico and Peru, for example, unrealistically low water tariffs may have encouraged farmers to grow cereals, roots and livestock on irrigated lands in direct competition with small rainfed producers, crowding them out of the most dynamic markets or limiting their access to them (Ramirez-Vallejo and Rogers, 2010; Ringler, 2000). Recent changes in water tariffs in Mexico attest for the Government's clear determination to increase the cost recovery rates (Garrido and Calatrava, 2009). A successful example of the implementation of water pricing is Chile. This country adopted a comprehensive, market oriented water policy nearly twenty years ago. Tradable water rights in Chile have fostered efficient agricultural water use, which has in turn increased agricultural productivity, generating more production per unit of water.

The virtual water concept is globally relevant and connected to international farm trade. It has been argued that the concept of virtual water is connected to the notion of comparative advantages from international trade theory. However, empirical studies have shown that the Heckscher-Ohlin-Theorem (HO) does not hold true. Water is neither the main nor unique scarce input factor to explain the direction of trade flows. Also the strong assumption of factor price equalization does not reflect the reality of varying water prices. The HO-Theorem also does not take into account agricultural market distortions which affect production and trade flows (Ramirez-Vallejo and Rogers, 2010). Thus, virtual water flows are not driven by different water endowments. This raises the question of whether the WTO include among its disciplines environmentally-based tariffs to penalise unsustainably produced food exports. One of the main pillars of the WTO regulatory system is the principle of non-discrimination, which is twofold: first, the principle of most-favoured-nation (MFN) treatment requires that all advantages such as tariff reductions granted to a product from one WTO member must be granted to "like" products of all WTO members. Secondly, the principle of national treatment requires that "like" products, no matter if they are produced domestically or if they are imported, are treated equally in terms of taxes and regulations (Khalilian, 2009). Many concerns have arisen that these two principles ignore environmental aspects, because they implicate that products from unsustainable production and process methods (PPM) cannot be abandoned. Supporters of a tariffs based on unsustainable water use have argued that open trade will lead to a "race to the bottom", in which nations reduce environmental standards in order to gain competitive advantage. Hence, the argument goes, in order to allow producers in high environmental standard countries to offset "unfair" competition, it would be necessary to introduce new WTO disciplines against imports produced at lower cost causing water stress due to mispriced water resources in exporting countries.

However, empirical evidence does not support arguments that genuine problems of international competitiveness are created by differing environmental standards (Eglin, 2001). Yet even if such argument were found to be of real concern, the important question is whether trade restrictions are an effective way of trying to compensate for international differences in environmental standards. Le Vernoy and Messerlin (2011) argue that current international trade flows rather reflect domestic distortions and that limiting trade would be very costly in terms of water. Trade is defined as the difference between domestic consumption and production. Thus, taking measures for restricting virtual water trade is not the adequate solution to address production and consumption externalities since it does not address the initial problems raised by imperfect domestic water markets. It is even argued that trade is environmentally beneficial. Freer trade may facilitate the spread of environmentally friendly technology, and foster a more efficient use of natural resources in order to allow for the full beneficial effects of trade (Le Vernoy and Messerlin, 2011; Eglin, 2001). The results show that trade offers semi-arid countries such as Mexico, Chile or Peru a way of saving precious water resources. This is despite the fact that the current trade regime is not fully developed in order to address water issues and that it operates under distortive domestic water policies. Thus, trade restricting tariffs may be rather harmful than helpful with respect to environmental aspects. A crucial question is how international water pricing can be enforced under the guidance of the WTO in order to remove these market distortions at the problem source.

6 Conclusions

International farm trade is already substantial and is likely to increase further with continued global trade liberalization and regional free trade agreements (Ramirez-Vallejo and Rogers, 2004). As a consequence also water in its virtual form is transported around the world. The paper has shown that intensified trade offers both opportunities and risks. One major opportunity of virtual water trade lies in its capability to release pressure on domestic water resources in water scarce areas. Mexico, Chile and Peru are illustrative of those countries where virtual water imports are a cheap alternative source of water. This case proved that virtual water trade has the potential to help achieving the goal of global food security, resulting in the necessity to proceed with the trade liberalization process.

Furthermore the effects of increased farm trade on environmental aspects in exporting countries were analysed. The examples of Argentina and Brazil have shown that agricultural production practices for export commodities are usually in line with environmental requirements. The predominant use of green water instead of blue water in those water abundant regions has enabled sustainable virtual water exports. However, more research is needed on the effects of land use change. To guarantee sustainable trade flows in the future on a global level, negative external environmental effects should be internalized though. This gap of multilateral commitment is debated within the scope WTO’s environmental regulations.

It is essential to do further research on the concept of virtual water trade as a tool for feeding the world sustainably in the future. Latin America, containing very large exporters and importers of the world should be investigated more precisely. Especially the questions regarding the effects of environmentally based tariffs implemented by the WTO should be treated in more detail. An analysis of how water pricing would shift agricultural production and trade flows would follow. The effects of trade tariffs to enforce full cost water pricing are still not clear and need further investigation. This allows us to answer the important question of how to feed the world in a sustainable way, perhaps enforced with the support of WTO rules.

References

Aquastat (2010) FAO's Information System on Water and Agriculture, Retrieved 1.10.2010, 2010, from http://www.fao.org/nr/water/aquastat/main/index.stm

Faostat (2010) Food and Agriculture Organization of the United Nations, Retrieved 16.09.2010, from http://faostat.fao.org/site/567/default.aspx#ancor.

Affuso, E. (2010) International virtual water trade: A theoretical and empirical market analysis, SSRN eLibrary.

Albersen, P. J., Houba, H. E. D. and Keyzer, M. A. (2003) Pricing a raindrop in a process-based model: General methodology and a case study of the upper-zambezi, Physics and Chemistry of the Earth, 28: 183-192.

Aldaya, M. M., Allan, J. A. and Hoekstra, A. Y. (2010) Strategic importance of green water in international crop trade, Ecological Economics, 69: 887-894.

Allan, J. A. (1998) Virtual water: A strategic resource global solutions to regional deficits. Ground Water, 36: 545-546.

Ansink,E.(2010) Refuting two claims about virtual water trade, Ecological Economics, Volume 69, Issue 10, 15 August 2010, Pages 2027-203.

Bartolini, F, Bazzani, G.M., Gallerani, G.V., Raggi, M., Viaggi, D. (2007) The impact of water and agriculture policy scenarios on irrigated farming systems in Italy: An analysis based on farm level multi-attribute linear programming models, Agricultural Systems, 93: 90-114.

Berrittella, M., Rehdanz, K., Roson, R. and Tol, R.S.J. (2008) The economic impact of water pricing: A computable general equilibrium analysis, Water Policy, 10: 259-271.

Eglin, R. (2001). "Keeping the "T" in the WTO: Where to next on environmental and labor standards?" North American Journal of Economics and Finance 12: 173-191.

Falkenmark, M., Lannerstad, M. (2010) Food security in water-short countries – Coping with carrying capacity overshoot, In Martinez Cortina, L., Alberto Garrido, and Elena Lopez-Gunn. (Eds.), Re-thinking Water and Food Security: Fourth Marcelino Botin Foundation Water Workshop, Taylor & Francis, Leiden. 2010, 3-22.

Fraiture, C., Cai, X., Amarasinghe, U.; Rosegrant, M. and Molden, D. (2004) Does international cereal trade save water? The impact of virtual water trade on global water use, Comprehensive Assessment Research Report 4, IWMI, Colombo, Sri Lanka.

Garrido, A., Novo, P., Rodríguez-Casado, R. and Varela-Ortega, C. and Aldaya, M. M. (2010) Economic aspects of virtual water trade: Lessons from the Spanish case, In Martinez Cortina, L., Garrido, A. and Lopez-Gunn, E. (Eds.) Re-thinking Water and Food Security: Fourth Marcelino Botin Foundation Water Workshop. Taylor & Francis, Leiden. 145-159.

Garrido, A., M.R. Llamas, C. Varela-Ortega, P. Novo, R. Rodríguez-Casado, M.M. Aldaya. (2010) Water Footprint and Virtual Water Trade in Spain, Springer, New York.

Garrido, A. and Calatrava, J. (2009) Agricultural Water Pricing: EU and Mexico, OECD. Paris. http://www.oecd.org/dataoecd/25/38/45015101.pdf.

Hoekstra, A. Y. (2010) The relation between international trade and freshwater scarcity. In: Hoekstra, A. Y. (Ed.), WTO Staff Working Paper ERSD-2010-05, Geneva.

Khalilian, S. (2009) The WTO and Environmental Provisions: Three Categories of Trade and Environment Linkages, Kiel Institute for the World Economy in its series Kiel Working Papers with number 1485.

Kumar, R and Singh, K.D. (2005) Water Resources of India, Current science 89: 794 - 811.

Liu, J. and Savenije, H.H.G. (2008) Food consumption patterns and their effect on water requirement in China, .Hydrology and Earth System Sciences, 12: 887-898.

Liu, J., Yang, H. and Savenije, H.H.G. (2008) China's move to higher-diet hits water security, Nature 454 (7203): 397.

Martin, W. and Mattoo, A. (2010) The Doha development agenda: What's on the table?, Journal of International Trade & Economic Development, 19: 81-107.

Merrett, S. (2004) The potential role for economic instruments in drought managementt, Irrigation and Drainage, 53: 375-383.

Messerlin, A. and Le Vernoy, P (2011) Water and the WTO: Don't kill the messenger, Groupe d' Economie Mondial at Sciences Po, Paris.

Molle F. and J. Berkoff (Eds.) (2007) Irrigation Water Pricing Policy in Context: Exploring the Gap between Theory and Practice, Wallingford,UK,. CABI and IWMI, 295-327.

Nordström, H. and Vaughan, S. (1999) Trade and environment, In: Special studies 4, Geneva: World Trade Organisation (WTO).

Postel, S. (1999) Pillar of sand: Can the irrigation miracle last?, Issues in Science and Technology 16(2): 84-87.

Ramirez-Vallejo, J. and Rogers, P. (2004) Virtual water flows and trade liberalization, Water Science and Technology, 49: 25-32.

Reimer, J. J. and Li, M. (2010) Trade costs and the gains from trade in crop agriculture, American Journal of Agricultural Economics, 92: 1024-1039.

Ringler, C., Rosegrant, M. W. and Paisner, M. S. (2000) Irrigation and water resources in Latin America and the Caribbean: Challenges and strategies, EPTD Discussion Papers, Inter-American Development Bank (Ed.), Washington, D.C.

Rosegrant, M. W., Ringler, C., Zhu, T. J. (2009) Water for agriculture: Maintaining food security under growing scarcity, Annual Review of Environment and Resources, 34: 205-222.

The Economist (2010, August 26) The miracle of the cerrado brazil has revolutionised its own farms. Can it do the same for others?, In: The Economist, Retrieved September 21, 2010, from http://www.economist.com/node/16886442.

Vousden, N. (Ed.) (1990) The economics of trade protection, New York, Camebridge University Press.

Wichelns, D. (2004) The policy relevance of virtual water can be enhanced by considering comparative advantages. Agricultural Water Management, 66: 49-63.

Wichelns, D. (2010) Virtual Water: A Helpful Perspective, but not a Sufficient Policy Criterion, Water Resource Management, 24:2203-2219.

Yang, H., Wang, L. and Zehnder, A. J. B. (2007) Water scarcity and food trade in the southern and eastern Mediterranean countries, Food Policy, 32: 585-605.

Yang, H. , Zehnder, A. J. B. (2002) Water scarcity and food import: A case study for southern mediterranean countries, World Development, 30: 1413-1430.

Yang, H., Reichert, Peter; Abbaspour, K.C. and Zehnder, A. J. .B. (2003) A water resources threshold and its implications for food security, Swiss Federal Institute for Environmental Science and Technology (EAWAG), 37: 3048-3054.

Yang, H., Wang, L., Abbaspour, K.C.; Zehnder, A.J.B. (2006) Virtual water trade: An assessment of water use efficiency in the international food trade, Hydrology and Earth System Sciences, 10: 443-454.