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Water Trade in Andalusia. Virtual Water: an alternative way to manage water demand

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Abstract

The main idea of this paper is to analyse the relationships between the productive process and the commercial trade with water resources used by them. For that, the first goal is to find out, by means of the estimation of virtual water, the exported crops which have the highest water consumption. Similarly, we analyse the crops that are imported and therefore, might contribute to save water. The second objective is to put forward new ways to save water by means of the virtual water trade.

This first conclusion contradicts not only the comparative advantages theory but also the environmental sustainability logic. The previous conclusion is derived from the great exports of water via potatoes and vegetables, and also via citrus fruit and orchards; and, on the other hand, from the imports, such as cereals and arable crops, with lower water requirements. The second conclusion affirms as Andalusia utilises large amounts of water in its exports, and in turn, it does not produce goods with low water requirements, the potential saving would be very significant if the terms of our trade were the other way round. We are convinced that the agricultural sector must modify the use of water to a great extent in order to reach significant water savings and an environmental sustainability path.

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1. Introduction

We might start by saying that water is nothing but a natural resource in the same way as oil or gas. However, water is much more than that. Apart from being an essential element for life, its features and functions turn water into something completely different from other natural resources. Economic science has traditionally considered that the only role of water was that of participating in the production process. Therefore, this idea never took into account the "particular characteristics that make water different from the rest of economic resources" (Milliman, 1992, 321). This line of argument is also followed by other economists such as Aguilera-Klink (1995, 15), who points out that water is "far more than a production factor". This is because it satisfies other needs beyond simple economic factors and, in addition, it performs many other functions, namely, supply in both the natural and the economic systems, means of evacuation and, finally, source of energy (Zimmerman, 1967). All in all, water is not only a resource but also a *social asset*.

This will be the outlook of this paper. If we want to manage water in a sustainable manner, we must consider it not only as production factor, in other words, as something necessary for production, but also as a social asset. This idea compels us to link water with the territory where this resource can be found. Accordingly, we must include new concepts involving economics, sociology, technology, environment, geography, institutions and regional elements. In this sense, this kind of management obviously remains within an institutional framework which must necessarily be an object of study as well. We understand water as a social asset that carries out a lot of different functions, and for that reason, we must find new ways for more sustainable uses of water. Thus, in this article we bring out a recent concept, the so-called virtual water, which deals with a sustainable management of water requirements.

In the dry regions of the planet, where the shortage is not only physical, but also social and economic (Aguilera-Klink, 1994), and where it is difficult to allocate this resource to its appropriate uses, it is absolutely necessary to discover new ways to alleviate the pressure on water resources. On the one hand, the transfer of massive quantities of water is difficult, costly, and most of the times, absolutely unsustainable. On the other hand, the building of hydraulic infrastructures is always expensive and problematical in social and environmental terms. In addition, in spite of the rise in the offer, the demand always ends up unsatisfied. This article supports the voices that defend virtual water as a means to mitigate the pressure on water resources. The most reasonable thing seems to be the import of water intensive products to areas where the cost of water is very high and the export of other products which do not require so much water.

These new lines of reasoning are linked with other studies that highlight the water-intensive productive specialisation in Andalusia (Velázquez, 2005). Accordingly, we propose in this paper an in-depth analysis of the relationship of the agrarian production and its commercial dealings with the amount of water that has been consumed. In view of that, our first goal will be to find out, by means of the estimation of virtual water, the exported crops which have the highest water consumption. Similarly, we analyse the crops that are imported and therefore, might contribute to save water. Our second objective is to put forward new ways to save water by means of the virtual water trade and to focus on the sectors where we should work to improve this water situation.

We are aware that the scope of our paper is far too ambitious and we know that it would be possible only with a more comprehensive work. Obviously, our recommendations for policies involving socio-economic and environmental aspects will be biased by economic, social, environmental, technological and institutional factors.

Nevertheless, this paper tries to go one step forward in this field by presenting new questions and breaking fresh ground for future research.

The paper is organised as follows. After this introduction, chapter 2 presents the background and the first definitions of this topic; in addition, we describe the initial approaches supporting the virtual water trade as an acceptable alternative to managing water requirements. Chapter 3 explains the methodology we have used to estimate virtual water. The results are analysed in chapter 4 and the conclusions and final remarks are included in chapter 5.

2. Background

In the last few years there has been a greater interest in the different alternatives to managing water resources. Thus, we have two apparently contrary alternatives which do not clash with each other, namely, water supply management and demand management[1]. The first choice is aimed at enhancing the availability of the resource in order to adapt it to the demand, which will probably be on the increase. Therefore, the solution proposed here is the building of huge water works (reservoirs, dams, water diversions, etc), which increase the reserve water, and consequently, the supply (Sumpsi et. al., 1998, 31). Conversely, the second option defends the reduction of water demand, so that the pressure on this resource could be on the decrease, especially in water-deficient regions. This approach proposes measures for saving water, awareness campaigns, pricing policies, modernisation of infrastructures with the aim of reducing leakage, etc (Ciriacy-Wantrup and Bishop 1992, Aguilera-Klink 1993, Naredo 1997, among others).

[1] Although the word "demand" does not exactly fit the definition of economic science, we understand "demand management" as the one that deals with different alternatives for reducing water consumption.

It is needless to say that a certain amount of water is always indispensable for producing goods and services. In the same way, if we understand water as a social asset, we will have to allocate the quantity and the quality of the water which is appropriate for any particular purpose. According to the Environmental Sustainability Index (2005), Spain has undergone an unsustainable growth based on the squandering of natural resources. In the general balance of things, we must attain new alternatives for the management and the sustainable use of natural resources, and water in particular.

These new approaches have brought about a new idea called Virtual Water (VW), which tries to give an explanation to the demand management. Allan (1993, 1994) first defined this concept in terms of the water embodied in a certain product, that is, the water necessary for creating a product. A few years before, Fisheon et al. (1989) had concluded that it did not make much sense to export goods that required a lot of water in countries with water deficits. In consequence, this new approach academically defines something these countries had already been doing, that is, to specialise in products with low water requirements and base their trade on high exports of this kind of products. On the other hand, they reduce the production and the export of the products that require a lot of water, and for this reason, they replace domestic production with goods imported from other countries where the water costs are lower. These first approaches brought about the concept of "embodied water", which will later turn into the term VW defined by Allan. These initial approaches did not take into account water saving, and they had a negligible repercussion in water policies in global, regional, and local terms, and also in the academic and research fields.

In 1993 Allan tried to develop a quantified version of the concept of Virtual Water in his work "Fortunately there are substitutes for water: otherwise our hydro-political futures would be impossible (ODA, *Priorities for Water Resources Allocation and Management:* 13-26). However, in those years it was very difficult to quantify the energy embodied in consumer goods which are petroleum derivatives. So, he decided to focus on the definition of the concept. Therefore he coined the concept of *Virtual Water,* which, after a few years of oblivion, was acknowledged by a number of selected authors as an alternative for water saving and food security.

The most widely accepted definition of VW is that given by Allan in 1998, namely, the amount of water consumed in the production process of a product, that is, the virtual water embodied[2] in the product. The concept of virtual water becomes more relevant if we relate it to trade dealings between different regions since this concept involves a virtual "transfer" of water. To put the matter differently, the exchanges of products between regions enable them to exchange water as well.

As far as VW trade, Hoeskstra (2003) suggested two branches to the concept to analyse the amount of water that can be saved if we import goods instead of producing them domestically: real virtual water and theoretical virtual water. The first involves the water that is actually used in the domestic production of goods or services. In turn, the second is the water that would have been used in the country of destination had these goods been produced there. Virtual water, whether theoretical or real, can be used in water-scarce countries so that they can use it as a way to relieve the pressure on water resources, and accordingly, as an alternative in the demand management.

Even though the concept of virtual water is rather recent, it is true that the virtual water trade is as old as the goods trade itself. Therefore, virtual water trade is somewhat a reallocation of the water associated to the products that are exchanged. This trade entails a flow of virtual water from exporting to importing regions or countries. Nowadays, all countries are both importers and exporters of this valuable resource although, from an economic point of view and following comparative advantages theory on international trade, water-poor countries should be importers and water-rich countries should be exporters.

Many of the semi arid countries in the Middle East have sorted their problems out by means of food policies and strategies inspired by common sense. Some of these countries, such as Israel or Jordan, have implemented policies that have reduced, or even abandoned, the export and the production of water-intensive crops. Therefore, they have been replaced with either imports or crops that optimise the water resources (Van Hofwegen, 2004). With relation to this, Velázquez (2005) points out the incoherence of the productive specialisation of Andalusia, where most of the produce requires a lot of water in a water-scarce region such as ours. The author points out the incongruity between the productive specialisation of Andalusia and the scarce water resources available in the region because of the water intensive production.

3. Methodology

We have defined virtual water as the water associated to products, in other words, the water which is necessary to produce certain goods. We will estimate here the amount of water used to produce, and then export, agricultural products in Andalusia. However, the estimation of the exported VW also needs a contrast with the imported VW if we want our initial approach to be relatively accurate. We will make use of the concept of real virtual water created by Hoekstra (2003) in order to estimate the virtual water that has been

[2] Allan uses the expression “VW contained in the product”. Note that “contained” does not necessarily imply

exported. We will estimate the water we have actually used in the production of the goods to be exported, that is, the water we have consumed and used up with this purpose in our region. Conversely, we will employ the concept of theoretical virtual water to estimate the virtual water imported. This means the amount of water that we would have needed had we not imported the goods but produced them instead. For the purposes of our work, the concept of theoretical VW is more suitable than the concept of real water to estimate the imports of virtual water. If we applied the latter, we would be estimating the amount of water used by the country we are importing from in order to produce the product we are buying. This amount of water does not have to coincide with the amount we would be using in our region on account of the differences in weather conditions, soil, evapotranspiration, etc. Last but not least, the water we have not used, that is, the water we have saved after importing the product instead of producing it.

The methodology we have used to estimate virtual water is quite simple from an analytical point of view. Rather than on the analytical expression, the complexity relies on the concept of virtual water itself.

The amount of water used will depend on the land area (T_i) occupied by each kind of crop –expressed in hectares- and also on the production that has been obtained (Y_i) -expressed in tons-. These parameters give us the yield of each crop, which is expressed in tons per hectare:

$$R_i = \frac{Y_i}{T_i} \qquad (1)$$

the water which is physically contained within the product but the water used to produce goods or services.

As we know the water requirements of each crop (CWR_i) -expressed in cubic metres per hectare- and given the yield obtained previously, we can estimate the specific water demand of each crop (SWD_i) -expressed in cubic metres per tons:

$$SWD_i = CWR_i / R_i \qquad (2)$$

If we multiply the specific water demand by the exportation data (*X*) -or importation (*M*) - of each of the products generated in Andalusia in a certain year –expressed in tons- (or the products we would have produced if we had not imported), we will obtain the virtual water exported (VWX_i) of each of the products that have been analysed –expressed in cubic metres-:

$$VWX_i = X_i SWD_i \qquad (3)$$

And the virtual water imported (VWM_i):

$$VWM_i = M_i SWD_i \qquad (4)$$

Finally, the net virtual water (NVW_i) is obtained by subtracting the virtual water exported from the virtual water imported:

$$NVW_i = VWX_i - VWM_i \qquad (5)$$

One of the main difficulties in estimating virtual water was the access to the necessary data as they had to be homogenised and not all of the sources could offer the same crop disaggregation. Figure 1 presents the steps we have followed to estimate virtual water as well as the differentiation between the necessary data and the calculations carried out. The coloured squares stand for the necessary data and the others represent the estimations carried out in this study. The first data we needed was the cropland area and the yearly production. This information is taken from the 2002 database of the Agriculture and Fishing Ministry. This database discriminates between irrigated and rain-fed land. We have used the data that refers to the total cropland, since the production data does not state this difference; so we have opted for making use of the lowest number possible of statistical sources, given the different accounting criteria.

INSERT FIGURE 1

With regard to water requirements for the different crops, we have used the statistics offered by the National Institute of Statistics (INE). This data displays a modest differentiation in terms of crops (arable crops, fruits, olive groves and vineyards, potatoes, vegetables, and other crops), which does not help us make an accurate estimation. In our opinion, the estimations can be much more precise if they include all kinds of crops (The *CROPWAT* program developed by *FAO* (www.fao.org/ag/agl/aglw/cropwat.stm) could help us because it estimates the water needs of the crops according to the place where they are cultivated and to other parameters such as geography, weather, edafology, evapotranspiration, etc.). Nevertheless, this initial approach could be a first step to undertake interesting future research.

Finally, the exportation and importation data has been taken from the database of foreign trade in the Customs Unit of the Tax Office. This new data provides us with very relevant information because the exports appear disaggregated according to the province of origin and the country of destination. This circumstance would enable us to investigate the interrelations of virtual water trade and, in this particular case, between Andalusia and the rest of regions, whether in Spain or abroad.

As a final point, we think that the estimation of virtual water must be studied thoroughly in the future and that can be done by means of a better crop disaggregation and by also considering some of the crops that were not included here given the absence or inaccessibility of the data.

3. Analysis of the Results

Table 1 includes the data of Exported Virtual Water (VWX) and the Imported Virtual Water (VWM) so as to determine Net Virtual Water (NVW) aggregate in terms of types of crops, together with data about yields, exports and imports. As far as yield is concerned, we can see that the best yield in 2002 corresponded to fruits and vegetables. The reasons for these good results are their high production (48% the former and 11% the latter), and, particularly, the small area they occupy (7% and 2% respectively of the total area analised). On the other hand, the low yield of olive groves stands out. Although the production is rather high (14%), the area occupied is over 50% of the area that has been analysed, this circumstance being fostered by the subsidies of the Common Agricultural Policy.

The quantitative results are positive regarding the Andalusian trade balance of the products that have been considered here. Broadly speaking, our exports of fresh products -2,704,239 tons- are higher than our imports -1,729,495 tons-. Basically, this is because of the exports of potatoes and vegetables (49% of all of the products exported) and also of cereals (42%).

INSERT TABLE 1

With the exception of arable crops, our trade balance is also positive in the rest of products (the small contribution of olive groves in this data is because we have not used the data of the olive trees meant for oil production since we have only considered the exports of raw fresh products), though to a lesser extent.

INSERT FIGURE 2

The figure above shows that the two leading crops in our trade balance –cereals and potatoes and vegetables-, have an importing and an exporting net balance respectively. That is, the potatoes and vegetables exports are bigger than the imports and the cereals exports are lower than the imports.

Before getting into a deeper analysis of virtual water, it is outstanding that our exports are focused on products with high water requirements, albeit that this region has great water shortages. On the contrary, we import products grown in rainfed land, or at least, products with lower water requirements.

With relation to VWX and VWM, a quick analysis of the figures can lead us to mistaken conclusions. At first sight, it seems that we import more virtual water than we export (240.42 million cubic metres and 65.29 respectively). These results seem satisfactory since Andalusia is a region with water deficits. Nonetheless, if we take a closer look at the results and we focus on net virtual water (Figure 3), we will appreciate that cereals and arable crops show a very negative balance, which means that our importation of virtual water is higher than our exportation on account of these crops. On the other hand, the rest of the crops reveal a very positive balance, especially potatoes and vegetables; that is, the water imports are lower due to the great volume of water exported when selling these products. At first glance, we may draw an interesting conclusion: although Andalusia suffers from a serious water problem and furthermore, despite the strong conflicts about the different allocations of this resource, this region exploits this scarce resource by producing and exporting products (fundamentally, potatoes and vegetables, and citrus fruits and orchards) which are not very suitable on a territory that requires a lot of water. Besides, strange as it may seem, we import goods (cereals and arable crops) whose water needs are not so elevated. We said before that virtual water could be an alternative method to save water by way of importing products. Notwithstanding, Andalusia keeps importing cereals and arable crops and therefore, saves very little in relation to the saving that could be obtained if we imported the products requiring more water, which are precisely the products we produce and export.

To put the matter differently, we produce and export water via the products requiring the greatest amount of water and, on the other hand, we import water via products with low water requirements. If the situation were the opposite, that is, if we imported vegetables and orchards instead of cereals and arable crops, we would be able to save a lot of water because we would not be using so much water. In addition, if the production of vegetables and orchards was to be replaced by cereals and arable crops – crops with lower water requirements- we would be able to save more water than we do in this productive specialisation.

INSERT FIGURE 3

So far we have analysed crop groups in a superficial way. Below we give further details of each of the groups that have been studied. The high importation figures of cereals are due to common wheat and barley, whereas the high exportation figures are due to durum wheat. According to the previous analysis, we think that the production of common wheat and barley should be encouraged. In the same way, the production of durum wheat should be preserved.

Unlike durum wheat, rice requires a lot of water and, so, is mainly responsible for water exports. The inconsistency is again obvious due to the gap between productive specialization and the use of water in the region. Even within the cereal group, which has low water requirements, rice has high exporting figures, that is, this crop makes us export more water than the amount of water we import.

The amount of water imported in arable crops is far higher than the water exported because of the importation of dry beans. The only arable crops which export water are peas.

INSERT TABLE 2

As for the group of citrus fruits, the water exports are much higher than the imports, particularly in the case of sweet oranges. As for orchards, the highest exports correspond to peaches and almonds, though the latter contributes to saving too because the imports are high as well.

Vineyards and olive groves have always exported a lot of this precious resource. Finally, the highest exports in the vegetables group appertain to green beans. Still, these figures do not deserve much attention on account of the low yield of this crop.

4. Conclusions and final remarks

Our first aim was to gain a deeper insight in the relationship between the use of water and the Andalusian productive system –particularly the agrarian system-. Our purpose was to find out which sectors boost a rational use of this resource and so enable us to save greater quantities of water. On the other hand, we try to detect which agrarian sectors suffer from a not very rational use of water on account of their high water requirements. It is a fact that the sustainable consumption of this resource in Andalusia will depend on changes in these sectors. At the same time, we wanted to ascertain the commercial dealings as far as water was concerned and also to suggest new productive, commercial or technological patterns to attain water sustainability.

Once the research is over, we could confirm some of the conclusions of previous works. Not only does a water-scarce region specialise in water-intensive products, but also the water trade does not seem very reasonable in terms of water resources. Our first conclusion is the following: Andalusian trade is based on water exports by way of water-intensive products, and on water imports by way of non-intensive products. All things considered, Andalusia specialises in producing agrarian goods, which are later exported, that require a lot of water for their production. Conversely, we do not produce goods with low water requirements and so have to import from other regions.

This first conclusion strikes our attention since it contradicts not only the environmental sustainability logic but also the comparative advantages theory, that is, a country should specialise and export only the products involving certain advantages in relation to other countries, and conversely, a country should import those products involving a high cost on account of its disadvantage position in relation to other countries.

The previous conclusion derives from the great exports of water via potatoes and vegetables, and also via citrus fruit and orchards; and, on the other hand, from the imports, of cereals and arable crops, which have lower water requirements.

We can draw a second conclusion. As Andalusia utilises large amounts of water in its exports, and in turn, it does not produce goods with low water requirements, the potential saving would be very significant if the terms of our trade were the other way round. In other words, if we produced cereals and arable crops rather than imported them, and if we imported potatoes and vegetables and orchards instead of exporting them, the pressure on the water resources of the region would diminish to a considerable extent.

This productive and commercial state of affairs in Andalusia raises a few questions: What are the economic, social, environmental, technological and institutional reasons for this economic and agricultural specialisation? What commercial incentives given by the institutions have brought about this specialisation? How do the measures of the Common Agricultural Policy have an effect on this specialisation process? What groups benefit from this situation and what groups lose out? What groups would benefit from this situation and what groups would lose out if our approach were to prevail? All these questions, and many others, are beyond the scope of our work. Still, we are aware that the answers to these questions can shed light on the right or wrong reasons behind this situation, and thus discover the keys of this awkward state of affairs so that we could make the necessary changes.

However, we know that the productive specialisation and the commercial dealings would be most difficult to "turn upside down" in terms of long-term politics. We might even say that it is a chimera. Nevertheless, we are convinced that the agricultural sector must modify the use of water to a great extent in order to reach both significant water saving and environmental sustainability. One could suggest that the water exports would be reduced if there were a modernisation of the irrigation systems in the crops responsible for deficits in the virtual water trade. This measure would not sort the problem out, though we do think that the sustainability of the Andalusian economy will be improved if these measures are taken. At any rate, we believe that there must be significant changes in the Andalusian productive system in order to find viability and sustainability for the water resources.

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