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The Impact of Virtual Water Trading on the Water and Agricultural Policies in the Semi-Arid Regions; The Case Study of Cyprus

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The Impact of Virtual Water Trading on the Water and Agricultural Policies in the Semi-Arid Regions; The Case Study of Cyprus

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Abstract

Most Middle Eastern, North African, and Mediterranean countries are facing chronic and severe water shortage problems. Such problems are exacerbated by increasing populations and growing economic activity. Although many semi-arid countries have been taking a series of technical measures to safeguard their water supply such as building of reservoir dams and introducing new irrigation techniques, or to develop new water supply sources such as desalination, few countries are taking enough steps in curbing their water demand. Taking the island of Cyprus as a case study, this paper investigates the impact that virtual water trading can have on the water management and agricultural policies of such semi-arid countries. This study presents a complete fresh-water, including both natural and artificial sources, balance for Cyprus, examines various water saving techniques already implemented or proposed for the country, a virtual water trade map and finally it re-examines the water balance for the island while taking virtual water trade into account. The results of this study lead to various suggestions, including an increase of the net virtual water imports in Cyprus, different water allocation scenarios that connect the agricultural, domestic, industrial, and tourism sectors of the economy, while considering the respective economic and social benefits and costs for the country.

Keywords: virtual water; water management; agricultural policy

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Introduction

For about 80 countries in the world, which carry more than 40% of the earth's population, water demands exceed water supplies. The limited nature of water is exacerbated by the uneven distribution of water resources and population densities worldwide (Bennett, 2000). This situation necessitates the sustainable management of available water resources in water scarce nations, among which are the countries in the Middle East and part of North Africa (MENA), which are unable to meet their food requirements from available water resources (Allan, 2001).

Most of these countries have implemented different water management practices to meet their reasonable water needs for domestic agricultural, industrial and environmental purposes. These practices include, among others, the construction of reservoir dams, desalination plants, sewage water treatment units, the application of innovative irrigation techniques, and other water-saving practices.

Added these water management options, in the late nineties, a virtual water metaphor was created to guide the policy makers in the sustainable use of water in arid regions (Wichelns, 2000). Virtual water is defined as the water needed to produce agricultural, mainly, commodities and the concept behind virtual water trading is that water-short countries can save more of this valuable resource by importing agricultural products whose, cultivation is water-intensive, from water-rich regions, as opposed to producing them locally. So, the virtual water metaphor that aims at optimizing the use of the water resources can be involved in the integrated water management plan of any country (Bouwer, 2000), (Velazquez, 2006), (Novo et *el*, 2009), (Mao & Yang, 2011).

Several countries in the Middle East and North Africa (MENA) region have been implementing a "virtual water" strategy implicitly for many years like Israel, Jordan, Egypt, Tunisia and Morocco (Allan, 2001). While large population countries like India and China are still afraid of becoming dependent on global trade. They are trying, as far as possible, to fill their own food needs and ensure food security to their people (Hoekstra, 2003). In short, the integration of this virtual water approach in the water and agricultural policies of any country can't be generalized, and it is restricted to the situation or the case study of each country (Ansink, 2010), (Verma et el, 2009).

Cyprus is not an exception in this region as it also suffers from similar problems of chronically limited water resources and the per capita water availability with the current population, drops under the benchmark '1000 m^3/year', thus putting Cyprus in the list of water-scarce countries (UNEP, 2004). This paper presents the significance of introducing virtual water metaphor to the water resource and agricultural management strategies on the national level in Cyprus.

Cyprus Overview

Cyprus is the third largest island in the Mediterranean with an area of 9 251 square kilometers, out of which 47% is arable land, 19% is forestland and the remaining 34% is uncultivated land. The main features of the island's topography include: The Troodos Mountains that cover most of the southern and western portions of the island, the narrow Kyrenia Range which extends along the northern coastline, the Mesaoria plain – the agricultural heartland of Cyprus- that lies between the two mountain ranges and by the sea there are narrow fertile coastal plains that surround the island.

Cyprus has a typical Mediterranean climate with a regional and annual variation in rainfall. The average annual rainfall for the last forty years is 464mm while consecutive droughts are observed on the island with annual precipitation less than 390mm and repeated each 4-5. The mean annual temperature for the island as a whole is about 20°C (WDD reports).

Natural Water Resources

Rainfall is the main source of water on the island; there are 14 main rivers, none of which provides perennial flow. The Water Master Plan for the country, that was lunched 1974 aimed at surface water harvesting and provided for the construction of Dams. In 2012 the number of big Dams (higher than 15m) has reached 56 added to 52 smaller dams and ponds (WDD reports). These 56 Big Dams are included in the Register of the International Committee on Large Dams (ICOLD), of which Cyprus has been a member since 1969.

As for groundwater, it remains the main, most secure and low-cost source of water for both irrigation and domestic supply on the island. Nearly all the water for the non-governmental irrigation sector stems from underground. The biggest and most dynamic aquifers are phreatic aquifers developed in river or coastal alluvial deposits. For sustainable aquifer management and protection of groundwater resources, it is estimated that extraction from all aquifers should not exceed 81.3 MCM annually. On-Land the pumped water reaches 130-140 MCM in some years (Wulf, 2002). Under such a scenario the groundwater resources in Cyprus are overexploited by about 40% of sustainable extraction taking into account 10 MCM supplied to aquifers as artificial recharge. The existing conditions have resulted in saline water intrusion and consequent quality deterioration in coastal aquifers and depletion of inland aquifers (Farmer, 2002). According to a recent study prepared in 2012, 80% of the underground water in Cyprus is classified as "*not good*" (Demetriou, 2012).

Unconventional Water Resources

The decrease in the surface water, the depletion of the aquifers and the increase in the water demand necessitated a change in the water policy and the development of new water resources. Desalination and wastewater reuse were the potential alternatives. Other option like transport of water from

Crete through special tankers, was rejected in the past because of its high cost (Vassilou, 2000), but later implemented in 2009 during a drought year.

The first desalination plant, Dhekelia plant, was introduced to Cyprus in 1997, and now 6 desalination plants (about 54 MCM) operates partially or totally to secure a reliable source of water for domestic, public and industrial purposes, independent of the climatic change (WDD reports). As for the water reuse, the first large sewage treatment plant started operation in summer of 1995 (Papaiacovou, 2001). New projects are now lunched for building more treatment plants and in the context of the harmonization with the European acquisition, a relative program have been prepared aiming at the installation of sewage collection systems in all agglomerations in population equivalent of more than 2000 (WDD reports).

Water Budget in Cyprus

Rainfall is the main source of water in Cyprus feeding the surface and the ground water on the island. The mean annual long-term precipitation, as previously mentioned, is 464mm [1971-2012]. Then the total quantity of water reaching the Government-controlled part of the island is 2690 MCM. The large quantity, 2300 MCM, returns to the atmosphere as evapo-transpiration and the remaining quantity, 390 MCM, represents the water balance in the area under the government control. These 390 MCM are divided between the surface runoff, which occupies 63.5 % of this water, and underground recharges, which take 36.5% (WDD reports).

The surface runoff is calculated to be 247 MCM and is utilized as follows: Rivers diversions for direct irrigation accounts for 15 MCM, the underground aquifers are estimated to be recharged by 50 MCM, a considerable quantity will flow into the dams and the quantity used after evaporation losses which is already considered is 135 MCM. Finally the part that cannot be captured and completes its way to the sea is 52 MCM.

Water Supply and Demand

Domestic use and irrigation are the two main sectors of water demand in Cyprus. Industrial and environmental sectors are of less contribution. The average annual water supply varies according to the average annual inflow to the dams, which differs in drought years from years with high level of rainfall. Table 1 shows the distribution of the average water supply for the last 12 years.

Table 2 shows the water Demand in the previous years and a projection for the year 2020. The projection shows that the agricultural sector that constituted 68 % of the water demand in year 2000 will stay the largest consumer in the 2020 (58 %), if the demand remains the same. The domestic water demand that include inhabitants and tourists will increase in a natural manner, While droughts which decrease the available water from one side, will increase the demand on water for protection of special ecological areas and landscapes on the other side. These conditions will widen the gap between the supply and demand in the future and the government is working on projects to increase the water availability from constant unconventional water resources like desalination and recycled water to cope with droughts expected each four to five years.

Table 1. *Water supply for different sectors*

Sector Sources of water supply		Agriculture (MCM)	Domestic (MCM)	Amenities and aquifer recharge (MCM)	Total (MCM)
Private supply	Boreholes and springs	110	3.5	N	113.5
	Recycled water	N	N	19	19
Government water supply	Dams and boreholes	42	25.5	3.3	70.8
	Desalination	N	52.8	0.7	53.5
	Recycled water	6	N	N	6
Total		158	81.8	23	262.6

The average (1991- 2008) is taken for the natural resources (Dams, boreholes, springs)
Data obtained from (Wulf, 2002) and (WDD reports)

Table 2. *Water demand and future projection*

Sector of demand / year	2000	2005	2010	2020
Agriculture (MCM)	182.4	182.4	182.4	182.4
Domestic				
Inhabitants (MCM)	53.4	58.4	63.2	73.5
Tourism (MCM)	14.1	18	22.9	30.8
Industry (MCM)	3.5	5.0	6.0	7.0
Environment (MCM)	12.5	14.0	16.0	20.0
Total (MCM)	265.9	277.8	290.5	313.7

Data were obtained from the (Wulf K., 2002)
MCM million cubic meter

Agricultural Sector

The crop production is the major contributor (60%) to the agriculture in Cyprus followed by the livestock production, which contributes by 30% to the value added of the broad agricultural sector (Markou, 2006). The agricultural sector is the biggest consumer of water, absorbing two thirds of the total water budget, where irrigation consumes most of this water. The most important crops, by economic valuation standards, produced in Cyprus are fruits (primarily citrus), vegetables and potatoes. The vegetables other than potatoes include: tomatoes, cabbage, cucumber, pumpkin, cauliflower, onion green, dry, garlic, carrots, leafy vegetables (celery, radish, Lettuce Spinach), peppers, egg-plant, water melon, sweet melon, strawberries, okra, artichoke, green peas, french beans, green beans, dry beans, taro coco yam, alfalfa. The deciduous fruits include: peas, apricot, cherries, peaches and nectarine, plums, kiwi, fig.

These crops are either irrigated (mainly citrus, potatoes, other vegetables and melons, deciduous fruit, table grapes and bananas) or rain-fed (mainly cereals, fodders, olives, carobs, almonds and wine grapes), while irrigated crops accounted for half of the total agricultural production. The irrigation techniques in Cyprus are improved, modern, but simplified in accordance with the local prevailing conditions and requirements. The low-pressure micro-irrigation systems cover nearly the 90% of the area under improved irrigation practices. The agricultural sector occupies a considerable space in the domestic exports and imports of the country. The raw and the processed agricultural products contribute on average by 18.7% and 12% respectively to the total domestic exports in Cyprus (Agricultural Statistics, 2010).

Table 3 shows the distribution of the crops among the cultivated area which is classified according to four agro-economic zones: coastal, dry land, vines and mountain zones, with an indication to the mode of consumption, if provides self-sufficiency, if partially exported or cover part of the local consumption. The table also includes the actual water used for irrigation where the average production 1997- 2012 is considered, so that drought years will be included. For accuracy the irrigation water demand is calculated for each crop type alone (e.g. each of the orange, grape fruits, mandarin..etc.) and t hen summed up. It was based on the average water requirements (1990-1996) as estimated by (Papayiannis, 1998).

Table 3. *Distribution of the cultivated area among the crops*

Crops	Area ha	Average production 1000 tons (1997-2010)	Water demand for irrigation [2] (MCM)	Main consumption	Main cultivation area
Citrus	7200	97	48.9	SS + EXP (56%)	S-w coast; mountainous area
Olives	5800	13.8	7.6	SS + EXP	Spread all over the island
Vines	19300	68.5	Table grapes 6.2	SS + EXP	RF grapes in vines and mountainous area Ir grapes in S-w coast
Bananas	260	10.8	6	SS	Southwest coast
Deciduous fruits	4007	46	31.2	PLC+ EXP (50%)	Mountainous area
Nuts & almond	3730	15	12.9	PLC	Mountainous area with other crops

Potatoes and Vegetables	16000	Potatoes 118 Veg. and other seasonal crops 106.7	Potatoes 20 Veg. 21.9	SS + EXP (%56)	Coastal Zone, mainly eastern coast
Other seasonal crops[1]	10000		Included in the above quantities	PLC	All over the island
Field crops	78800	112.5	RF	PLC	Dry lands all over the island

Data were obtained from (Papayiannis, 1998) and (Phocaides, 2002)
Ir 10% irrigated & 90% rain-fed
SS self sufficient; Exp exports; PLC part of the local consumption; RF rain-fed
[1] Food and feed legumes, green fodder, melons, industrial crops & others that depend on the availability of water each year.
[2] Actual water used for irrigating the different crops or (real virtual water)
S-W south-west

Results and Analysis

Our main concern is studying the applicability of virtual water metaphor in the case of Cyprus. For this purpose the virtual water content in the main agricultural exports and imports is calculated. As shown in Table 4, the virtual water (VW) balance shows that Cyprus is a VW importer regarding the agricultural products. The imported VW exceeds the VW exports by more than 7-8 times. This ratio is relatively low for a water stressed country. Cyprus is a potential virtual water ***importer*** according to Turton's classification, which is based the nations’ water need, economic strength and the water consumption in the agricultural and industrial sectors (Turton, 2000). Comparing this ratio to other countries in the region clarifies the point. For example, Lebanon, which is a potential virtual water ***exporter***, the imported virtual water exceeds the exported virtual water by 8-9 times (El-Fadel & Maroun, 2003).

On the other hand and to better see the issue from an economic point of view, we can look at these numbers: The total quantity of water exported in virtual form is approximately 52 MCM (actual water used for irrigating agricultural exports (average of 1997-2012) (Table 3). The value of agricultural exports in 2010 (annual precipitation is near the average) is about 86 million € (Agricultural services, 2010). To buy the same quantity of water from the desalination plants the government must pay 86 million € ($52x10^6$ m^3 x1.65 €/m^3) (WWD reports). This dictates a real revision for the water consumption pattern on the island and a more rational use for this precious resource.

Table 4. *Average annual virtual water trade balance*

Primary Agricultural Products		Exports[1] (1000 t)	Virtual water content[2] (m^3/t)	Virtual water embedded in the exports MCM	Imports[1] (1000t)	Virtual water content[3] (m^3/t)	Virtual water embedded in the imports MCM
Cereals	Wheat	0.5	1845	0.9	97.5	1334	130
	Barley	N	-		285	1388	395.6
	Maize	0.3	909	0.3	188.6	909	171
	Breakfast cereals	N	-		2.83	2050	5.8
Citrus	Oranges	13.2	380	5	N	-	-
	Grape-fruit	19.7	268	5.3			
	Lemon	7.1	421	3			
	Mandarines, Tangeries, Mandora	21.4	489	10			
Grapes	Table grapes	1.5	1333	2	N	-	-
Vegetables		12.5	258	3.3	2.2	273	0.6
Potatoes		81	307	24.8	7.6	255	1.9
Coffee extract		N	-	-	1.77	17373	30.7
Fruit & vegetable fruit juice		16.8	1404	23.6	6.5	1404	9.1
Carobs		3.9	5765	22.5	N	-	
Tobacco nes		N	-	-	1.5	2213	3.3
Total				100.7			748

[1] These values are the average 1997-2010 obtained from statistical division FAO

[2] Values are based on the crop water requirements in Cyprus obtained from (Chapagain A., Hoekstra A., 2004)

[3] Values are the global average crop water requirements obtained from (Chapagain A., Hoekstra A., 2004)

N negligible

Dealing with this water situation from the virtual water trade perspective, should be through increasing the net flow of virtual water to Cyprus. This can be studied in two proposed water saving scenarios through the agricultural policy; the first, suggests decreasing the irrigated agricultural production to meet the local consumption needs only. Saving the exported water can alleviate the pressure on the ground water aquifers in the coastal region where most of the exported crops are cultivated and decrease the salt-water intrusion. The second scenario, suggests relying on imports in water intensive crops like potatoes and citrus for domestic use while keeping on other leafy- day by day-vegetables.

In the proposed scenarios the solution shouldn't hurt the agricultural sector on the island especially what concerns the farmers if owners or operators of farms. Instead the goals can be achieved by shifting from irrigated crops to rain fed crops or less water intensive crops and financially viable. Of course, it is not easy for the farmers to shift from one crop to another new one, but negative and positive incentives should be introduced by the government to guide them in this direction. These are respectively, raising the water tariffs and providing markets for the alternative crops. Although the water tariffs for government water supply were recently raised but it should include private wells too, since underground water is a public property. Raising water price should be accompanied with a mix of policies to smoothen out its impact on the farmers and consequently on the underground water which becomes the cheaper alternative. Those policies should promote agronomical research and extension services covering a large diversity of suitable crops for each region. It is the mission of the Agricultural Research Institute of the republic of Cyprus to provide agricultural methods that are financially, environmentally and socially sustainable. On the other hand food security can be sustained by relying on more than one source for importing the basic irrigated crops. This not difficult because the open nature of the economy in Cyprus gave the country the access to the international markets and the agricultural trade is taking place with about 25 different countries as reported by FAOSTAT .

The water saved in any of the two scenarios, can be allocated to an alternative more efficient consumption pattern. The allocation of water use should depend on the priorities of the country's water policy through an integrated approach that can include one of the following scenarios or a combination of them. The first water allocation scenario suggests that the priority should be releasing the pressure on the underground water. A considerable quantity of water, about 100 MCM, which comes from private wells and bore-holes, is used for irrigation, and most of the irrigated crops are cultivated in the coastal plains where the underground water and the aquifers are deteriorated. Daring steps should be done for closing, recharging and protecting these aquifers. This scenario also proposes, thereafter, the use of part of the underground water as a water reserve to cope with seasonal severe droughts that characterizes the history of Cyprus. The second scenario proposes for the water saved to be used to dam the gap between the supply and demand in the future water balance. In this scenario, water consumed in irrigation can be reduced gradually according to the increase in the demand in other sectors. A gradual shift from irrigated to rain-fed agriculture can provide sufficient water to ensure the sustainability of water supply for the coming years. The third water allocation scenario proposes the allocation of irrigation water to development projects of higher economic benefit in the industrial and the tourism sectors, which contribute by 23% and 22% to GDP respectively (Smid & Zwart, 2002). Table 5 shows a comparison between the above scenarios with an indication to their strong and weak points.

Finally, crop shift and water allocation are the two options in any water saving policy. Before any decision or action, specific data are needed for each agricultural land to facilitate achieving best choices that limits external and internal migration and keeps on the country's food security. In this context the first step should be further research including a complete profile for each agricultural holding – of certain contributing size- covering the following points:1) Source of the water for irrigation, 2) Destination of the agricultural products, if exported or locally consumed, 3) Farmers' and holders' file that include mainly their financial dependence (partial or complete) on the agriculture and their level of education, 4) The suitability of the land for alternative crops and the potential markets for the new ones, 5) The suitability of the land for other investments like tourism.

Table 5. *Comparison between the three water allocation scenarios*

Criteria / Scenario	Alternative usage of the water	Economic benefit	Environmental benefit	Social acceptance
WAS 1	Underground recharge and decrease pollution	Low	High	Low
WAS 2	Domestic & industrial future demand	Moderate	Low	High
WAS 3	Touristic projects	High	Low	Moderate
WAS Water allocation scenario				

Conclusion

The future of sustainable water management in Cyprus presents both challenges and opportunities. Over the years, the Government of Cyprus has put emphasis on increasing the supply of water, while less effort was put in decreasing the water consumption regime. The demand for water is expected keep on increasing in the following years, placing additional pressure on the already limited water resources of the island.

The development of the conventional surface water sources in the last two decades proved to be insufficient for facing successfully the extreme climatic conditions of the country. Although desalination and wastewater reuse ensures a constant source of water independent of the meteorological conditions, but the high cost of water from the desalination plants, limited use options of the treated water and the continuous increase in the water demand dictates a management option from the water demand side. With the high irrigation efficiency in Cyprus, the potential of saving more water in irrigation is relatively low. The virtual water metaphor can provide a new agricultural and water management option through crop adjustment and water allocation. Table 6 shows a comparison between the different water resources in Cyprus and the contribution of implementing the virtual water approach to the water availability on the island. The comparison is based on four different positive and negative criteria and shows that the virtual water approach can be ranked first among the different water management options in Cyprus.

Table 6. *Comparison between the different water resources in Cyprus*

Criteria / Resource	Contribution to the available water (%)	Dependence on rainfall (-)	Environmental Impact (-)	Cost to the government (-)	Social acceptance (+)
Surface water	30%	High	Low	Low	High
Ground water	40%	Moderate	High	Low	High
Desalination	25%	N	Low	High	Moderate
Water reuse	6%	N	Low	High	Moderate
Virtual water approach	22%	Low-Moderate	N	N	Moderate
N negligible Low 1 Moderate 2 High 3					

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