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Economical aspect valuation using virtual water concept in Egypt

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نبذة مختصرة :

تشكل التجارة الافتراضية للمياه عاملاً مهماً لحل ندرة المياه التي تشكل مشكلة خطيرة في مصر من خلال حساب كمية المياه التي يحتاجها المحصول من خلال إنتاجية كل محصول خلال فترة زراعته والحصول على متطلبات مياه المحصول ومن ثم معرفة ثابت الغلة لكل محصول حصل علي طلب مائي محدد ثم يتم الحصول علي صادرات وواردات منظمة الأغذية والزراعة (الفاو) للمحاصيل المطلوبة .ولكي نتمكن من تحويل الصادرات والواردات لكل محصول بالأطنان إلي مياه افتراضية نأخذ قيمة التصدير أو الاستيراد مضروبة في الاحتياجات المائية للمحصول (م3/طن). وبهذه الطريقة يمكننا تحديد كميات المياه المطلوبة لأي محصول في حالات الاستيراد والتصدير وتحديد ما إذا كنا نريد استيراد المحصول بشكل أفضل أم يمكننا توفير المياه اللازمة للاستغناء عن ذلك. وبذلك يمكننا الوصول إلى الجانب الاقتصادي للدراسة وهو تحويل هذه الكمية إلى نقود ويختلف تقديرها بمرور الوقت ، وتهدف هذه الورقة إلى معرفة كمية الصادرات والواردات من المحاصيل المختلفة على مر السنين التي تم الوصول إليها و تحويلها إلى مياه (مياه افتراضية) ورسم منحنيات تظهر على مر السنين ما إذا كان هناك استيراد أو تصدير للمحاصيل والعمل على التنبؤ بما إذا كان هناك عجز في التصدير أم لا في المستقبل حتى عام 2050.

ABSTRACT

Virtual water trade forms important factor to solve water scarcity which forms a serious problem in Egypt by Calculation of the quantitiy of water needed by the crop by the productivity of each crop during the period of its own cultivation and obtain the requirements of crop water (CWR) and then knowledge of the yield constant for each crop obtained specific water demand (SwD).The exports and imports of the food and agriculture organistion(FAO) are obtained for the crops in request, so that we can convert the exports and imports for each crop (in tons) to virtual water (v.w) by taking the value of the export or import (in tons) multiplied by the crop's water needs (m3/t). In this way we can determine the quantities of water required for any crop in the cases of import and export and determine whether we want to import the crop better or we can provide the water needed to dispense with that. Thus, we can reach the economic aspect of the study, which is the conversion of this quantity into money and its estimation varies over time. This paper aims to know the quantity of exports and imports of the different crops over the years has been reached and converted to water

(virtual water) and the plotting of curves that show over the years whether there is import or export of crops and work to predict whether there is a deficit in export or not in the future until a year 2050.

KEYWORDS

Virtual water, crop yield, crop water req, water scarcity and water footprint.

1. INTRODUCTION

We are facing a fresh water crisis during this century. In less than two decades, by 2030, the requirements for fresh water are expected to exceed the currently available and accessible fresh water supplies by 40%. Many countries are expected to be water stressed later in this century (Charting Our Water Future, 5 (2009)).

The production of many goods and products depends on the water and the water used to produce an agricultural or industrial product with virtual water is produced in a productive form. For the production of 1 kg of crop may need 1000-2000 liters of water and may increase the rate in some products. Some water-rich countries export products that need water to poor countries and thus produce virtual water. Some countries may support other countries in their water needs. The natural trade of water between countries may be impossible to distance and cost, but trade in Products requiring water (virtual water trade) are acceptable. For the poor countries to achieve their own water security, one of the solutions available to them is to import products that need a lot of water instead of producing all the products that need a lot of water. On the other hand, water-rich countries can produce products that need water and export them to poor countries. The concept of virtual water has been presented by the British researcher Tony Allan **(***Allan*, 1993; 1994).

Definition of Virtual Water

The concept of *Virtual Water* needs to be considered in all water balance calculations and it is becoming marked that some water scarce countries will likely import food that is water intensive to produce. Virtual water is the water that is needed to produce food or a commodity, and is measured in m3 of water per ton of crop or product. To determine the virtual water use we need data on crop water requirements over the growing season, evapotranspiration rates, the annual yield and the amount of water used in processing the crop (Chapagain and Hoekstra, 2004). “Virtual Water” concept useful to water resource managers and decision makers requires that such calculations be made on a watershed or river basin scale. Conducting annual water balances are only possible in a watershed context because this allows us to determine water inputs (rainfall and snow) and outputs (discharge, groundwater losses and evapotranspiration) and this forms the basis for water allocations for several uses.

The virtual water content of a product consists of three components, namely a green, blue and gray component: (*Hoekstra* and *Hung* 2002).Firstly the green virtual-water content of a product is the volume of rainwater that evaporated during the production process. This is mainly relevant for agricultural products (including both transpirations by the plants and other forms of evaporation).secondly the blue virtual water content of a product is the volume of surface water or groundwater that evaporated as a result of the production of the product. The gray virtual water content of a product is the volume of water that becomes polluted during its production.

The following definitions were introduced by (*Allan*, 1993; 1994)
Virtual water flow is defined as virtual-water flow between two nations or regions is the volume of virtual water that is being transferred from one place to another as a result of product trade. The virtual water export of a country is the volume of virtual water associated with the export of goods or services from the country. It is the total volume of water required to produce the products for export. Virtual water import the virtual-water import of a country is the volume of virtual water associated with the import of goods into the country. It is the total volume of water used (in the exporting countries) to produce the products. Virtual water balance for the virtual-water balance of a country over a certain time period is defined as the net import of virtual water over this period, which is equal to the gross import of virtual water minus the gross export. Water saving through trade for a nation can preserve its domestic water resources by importing a water-intensive product instead of producing it domestically. The water footprint concept of an individual or community is defined as the total volume of freshwater that is used to produce the foods and services consumed by the individual or community and in this study, the water footprint of a nation is calculated as the total use of domestic water resources plus the gross virtual-water import minus the gross virtual-water export.
Internal and external water footprint, the total water footprint of a country includes two components: the part of the footprint that falls inside the country (internal water footprint) and the part of the footprint that presses to other countries in the world (external water footprint). Water self-sufficiency and water dependency, the water self-sufficiency of a nation is defined as the ratio of the internal water footprint to the total water footprint of a country or region and for the virtual-water import dependency of a country or region is defined as the ratio of the external water footprint of the country or region to its total water footprint.

Virtual Water Imports and Exports, Land rich countries with favorable climates and sufficient water resources will have the advantage to produce water intensive food and plant products, while countries with a small arable land base and scarce water resources will likely import food that is water intensive to grow. A water-scarce country might wish to import products that require a lot of water in their production (water-intensive products) and export products or services that require less water (waterextensive products). This implies net import of ‘virtual water’ (as opposed to import of real water, which is generally too expensive) and will relieve the pressure on the nation’s own water resources.

International trade in water-intensive products can save water on the global level by shifting production of water-intensive products to areas where such production is more efficient because of low rates of evapotranspiration, favorable soil conditions, other environmental conditions, or technological factors. A study by Hoekstra and Chapagain estimates that international trade in agricultural products (including crops and livestock) results in a global saving of 350 billion cubic meters of water per year.16 The estimate is based on the difference between the water needed to grow crops in the country where they are grown and the water that would be needed to grow the same crops in the country where they are consumed, due to differences in climate and rates of evapotranspiration. This figure has been generally accepted in the virtual trade research community.

The real value of the virtual water concept: first, Virtual water trade as a tool to achieve water security and efficient water use for Net import of virtual water in a water-scarce nation can relieve the pressure on the nation's own water resources. Virtual water can be seen as an alternative source of water. Using this additional source can be an instrument to achieve regional water security (Allan, 2003). Second, Water footprints making the link between consumption patterns and the effects on water, the virtual water content of a product tells something about the environmental impact of consuming this product. Knowing the virtual water content of products creates awareness of the water volumes needed to produce the several goods, thus providing an idea of which goods impact most on the water system and where water savings could be achieved. Hoekstra and Hung (2002) have introduced the concept of the water footprint, being the cumulative virtual water content of all goods and services consumed by one individual or by the individuals of one country. The water footprint can be a strong tool to show people their impact on the natural resources.

Quantifying the virtual water content of products for evaluating the virtual water content of a product is not an easy task, because there are many factors influencing the amount of water used in a production process. The following factors should be considered with the estimates, the place and period (e.g. which year, which season) of production The point of measurement. In case of irrigated crop production, the question is for instance whether one measures water use at the point of water withdrawal or at the field level? . The production method and associated efficiency of water use. A relevant question is whether wasted water is included in the estimate. The method of attributing water inputs into intermediate products to the virtual water content of the final product.

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2 Methodology

Crop-wat model is a specialized program issued by the Food and Agriculture Organization of the United Nations (FAO). We are able to calculate the quantities of water needed to irrigate different crops within it, taking into consideration weather, crop, soil factors and rain effects, and then we can reach the amount of water needed to irrigate the crop for the duration of its planting period. With export and import statistics For crops through the database on the FAO site, the quantities of water consumed by the production of tons of the crop can be calculated and compared with the cost of importing quantities of that crop.

2.1. Calculation of specific water demand per crop type

Per crop type, average specific water demand has been calculated separately for each relevant nation on the basis of FAO data on crop water requirements and crop yields:

$$SWD[n,c] = \frac{CWR[n,c]}{CY[n,c]} \quad (1)$$

The crop water requirement CWR (in m3 ha-1) is calculated from the accumulated crop evapotranspiration Et_c (in mm/day) over the complete growing period .The crop evapotranspiration Et_c follows from multiplying the 'reference crop evapotranspiration' Et_o with the crop coefficient Kc

$$ET_c = K_c \times ET_0 \quad (2)$$

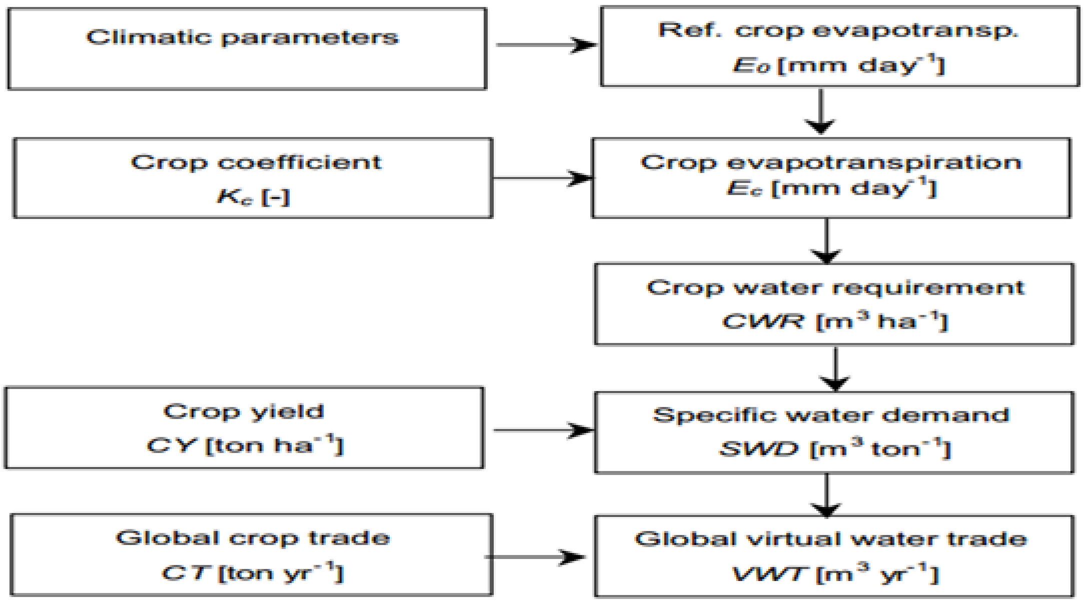


Figure (1) .

Figure (1) Introduce Steps in the calculation of global virtual water trade.

2.2. Calculation of virtual water trade flows and the national virtual water trade balance

Virtual water trade flows between nations have been calculated by multiplying international crop trade flows by their associated virtual water content. The latter depends on the specific water demand of the crop in the exporting country where the crop is produced. Virtual water trade is thus calculated as:

$$VWT[n_e, n_i, c, t] = CT[n_e, n_i, c, t] \times SWD[n_e, c] \quad (3)$$

The gross virtual water import to a country ni is the sum of all imports

$$GVWI[n_i, t] = \sum_{n_e, c} VWT[n_e, n_i, c, t] \quad (4)$$

The gross virtual water export from a country ne is the sum of all exports:

$$GVWE[n_e, t] = \sum_{n_i, c} VWT[n_e, n_i, c, t] \quad (5)$$

The net virtual water import of a country is equal to the gross virtual water import minus the gross virtual water export. The virtual water trade balance of country xfor year tcan thus be written as:

$$NVWI[x,t] = GVWI[x,t] - GVWE[x,t] \quad (6)$$

Calculation of a nation's 'water footprint'

$$Water\ footprint = WU + NVWI \quad (7)$$

The weather data are entered from an application which is a program that contains the monitoring stations in the different countries. Then the rain effect is taken (neglected as a result of the lack of rain in Egypt) and we choose the country of study. The average of min and max temperature, humidity and wind were taken. We take average for 32 stations in Egypt. The crop is determined from the crops on the FAO database and then the soil type is introduced (clay soil). It is the soil that prevails in Egypt. Thus, the quantities of water required to irrigate the crop are calculated over the period of cultivation.

2.3. Calculation of national water scarcity, water dependency and water self-sufficiency

$$WS = \frac{WU}{WA} \times 100 \quad \textbf{(8)}$$

$$WD = \begin{cases} \frac{NVWI}{WU + NVWI} \times 100 & \text{if } NVWI \geq 0 \\ 0 & \text{if } NVWI < 0 \end{cases} \qquad WSS = \begin{cases} \frac{WU}{WU + NVWI} \times 100 & \text{if } NVWI \geq 0 \\ 100 & \text{if } NVWI < 0 \end{cases}$$

Data sources

1-Data on crop water requirements are calculated with FAO's CropWat model for Windows, which is -available through the web site of FAO (www.fao.org). The CropWat model uses the FAO Penman-Monteith equation for calculating reference crop evapotranspiration as described in the previous chapter (Clarke et al., 1998).

The CropWat model calculates crop water requirement of different crop types on the basis of the following assumptions:

(1) Crops are planted under optimum soil water conditions without any effective rainfall during their life; the crop is developed under irrigation conditions.

(2) Crop evapotranspiration under standard conditions (Etc), this is the evapotranspiration from disease-free, well-fertilised crops, grown in large fields with 100% coverage.

(3) Crop coefficients are selected depending on the single crop coefficient approach, that means single cropping pattern, not dual or triple cropping pattern.

2-Climatic data

The climatic data needed as input to CropWat have been taken from FAO's climatic database ClimWat, which is also available through FAO's web site. The ClimWat database contains climatic data for more than hundred countries. For many countries climatic data are available for different climatic stations. As a crude approach, the capital climatic station data have been taken as the country representative.

3-Crop parameters

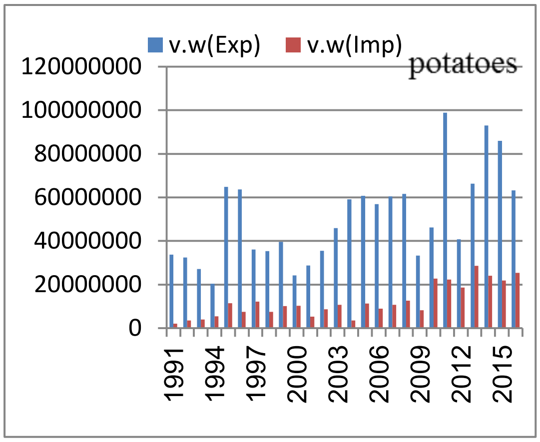
In the crop directory of the CropWat package sets of crop parameters are available for 24 different crops (Table 3.1). The crop parameters used as input data to CropWat are: the crop coefficients in different crop development stages (initial, middle and late stage), the length of each crop in each development stage, the root depth, and the planting date. For the 14 crops where crop parameters are not available in the CropWat package, crop parameters have been based on Allen et al. (1998).

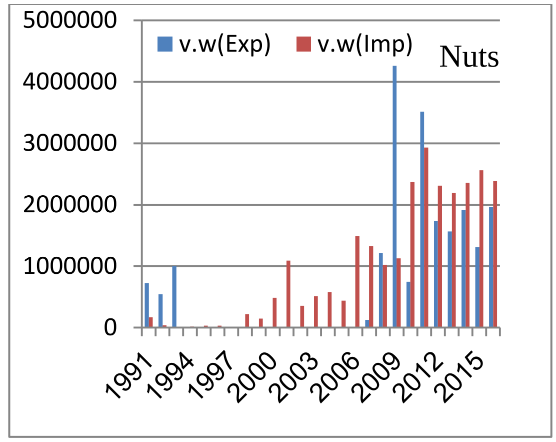
4-Crop yields

Data on crop yields have been taken from the FAOSTAT database, again available through FAO's web site.

3. RESULTS AND DISCUSSION

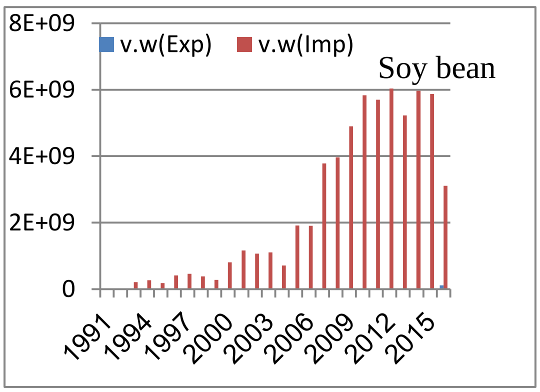
Obtaining the quantities of water needed to irrigate the crop and to get the export and import values for that crop during the year. Thus, we can know what the tonnage consumes from the water crop and compare the costs to import the quantity imported during the year. Thus, we have achieved the economic aspect of this study by introducing the virtual water In consideration of the Egyptian Water Resources Plan.

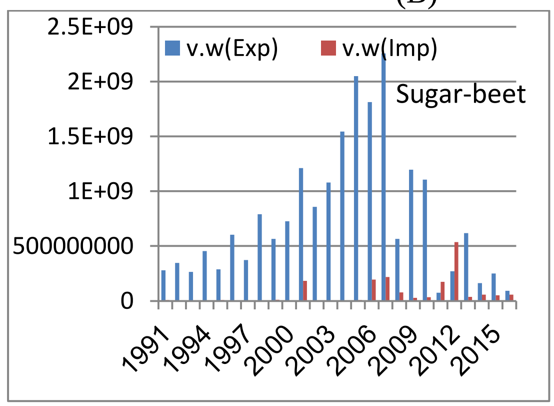




(A)

(B)





(C)

(D)

Figure (2) .

Figure (2) introduce Import and Export of virtual water of crops. Identify crops with the highest consumption and low price and calculate the total import of those crops (tons / capita) and by importing these crops are provided land and water., Identify crops with lower consumption and high price and we produce and be exported and thus provide land, water and money. We make attempts to get the best solution to achieve economic and gains. The difference between imports and exports is calculated and the impact on water scarcity curves over the years and we adjust the agricultural map.

c.y

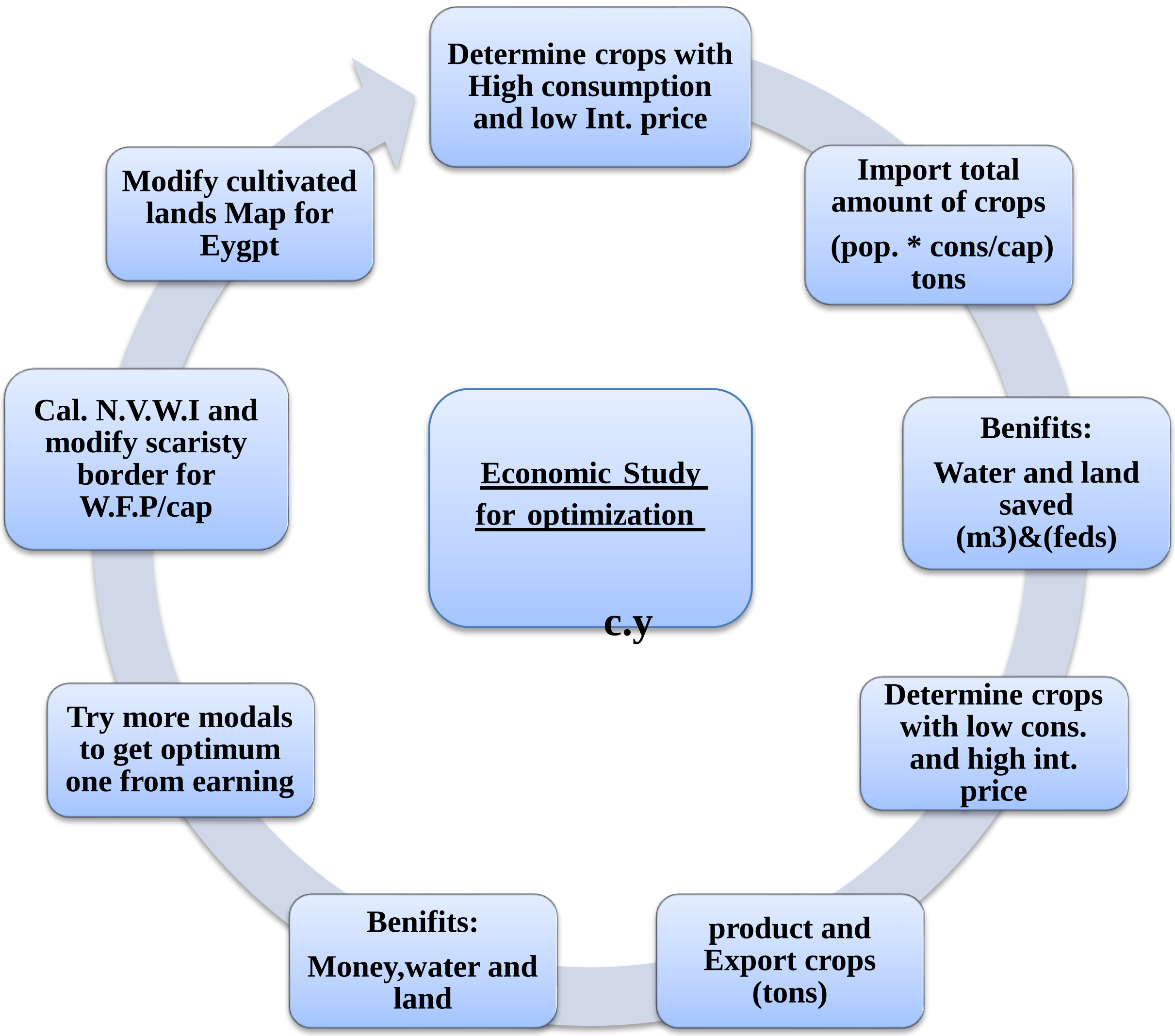


Figure (3).

Figure (3) introduce Economic study for optimization.

4. conclusions

1) Virtual water is a concept that is now being developed and refined for use by decision-makers at the strategic level in societies and determines the agricultural and industrial strategies.

2) Virtual water can be considered as an alternative source of water. Virtual water import can be used by national governments as a tool to release the pressure on their domestic water

resources as the most direct and positive impact of virtual water trade is the water saving which is related to countries that import products.

3) Virtual water trade between nations is a means of increasing the efficiency of water use.

4) Countries of the MENA region are not self-sufficient in producing food commodities to meet the national consumptive demand.

5) Agricultural water policies concerning water use efficiency are highly needed to get optimal use of irrigation water for the aim of increasing crop productivity.

6) The program implemented in this study, helps in identifying the actual water needs of different agricultural crops included in the study and therefore improves water distribution and consumption in the agricultural sector.

7) The aim of the study of virtual water is providing food security. A market of virtual water within the MENA countries will be highly appreciated.

8**)** Import of virtual water from foreign countries is very risky and if the virtual water trade is not possible within countries of the same region, then it would be better to choose to be water independent rather than self-sufficient.

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