Chapter 6

Overview of the extended water footprint in Spain: The importance of agricultural water consumption in the Spanish economy

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ABSTRACT: The Spanish economy is increasingly decoupling from water use. It has grown and progressed during 1996–2008 using less national water resources. Agriculture, the economic sector that consumes most water, provides only a small part of the GDP and employs a decreasing part of the labour force. Water has therefore a relative importance for the economy at a national level. To understand the drivers of water use, we do an analysis of the trends of agricultural production. In Spain, crop production is changing, linked to increases in irrigated land, redistributions and concentrations of production and increased international trade. As a result, its water consumption is increasing primarily in association with the import of agricultural products. Alongside, the exports of national products are increasing, and as a country, Spain is exporting ever more valuable products with less virtual water (VW) content, while increasing its imports and thus reallocating its water footprint (WF).

Keywords: national water footprint, virtual water trade, agriculture, livestock

1 INTRODUCTION

This chapter summarizes recent evaluations of the virtual water (VW) trade and water footprint (WF) in Spain, with special attention to the agricultural sector. It offers revised computations with respect to the pioneering work of Garrido *et al.* (2010), and uses longer and newer data sets and revised methods. The WF indicator makes it possible to extend the analysis of water use by the different economic sectors. By including direct and indirect uses, and taking into account both irrigation (so-called blue) water and soil (green) water, it gives a much broader picture of water consumption than the traditional water abstractions. These advantages are shown in this chapter, as well as in the following ones. These evaluations indicate the economic activities in Spain where water is consumed and virtually traded.

The chapter is organized as follows. First, we provide an overview of the agricultural sector's main economic figures and its contribution to the Spanish economy. The second section describes the methodological innovations and databases that have been used in this study with reference to Garrido *et al.* (2010). The third part analyzes the WF of the agricultural sector and its evolution over the period 1995–2009. An evaluation of the VW trade of the agricultural sector is offered in the fourth part. Finally we draw conclusions about the evolution of the WF of the sector and its VW trade.

2 MAIN FIGURES OF THE SPANISH ECONOMY AND RELATED WATER USE

Table 1 shows the relative importance for the economy and the labour force of the general sectors of the Spanish economy.

It provides information from the National Statistics Institute (INE) with the share of Gross Domestic Product (GDP) and labour force. Data for GDP and employment in the tourism sector was obtained from the Ministry for Industry, Tourism and Commerce (MITIC 2011), and subtracted from the service sector. The estimation of the water consumed in the industrial and construction sectors and the tourism sector is based on the study carried out by the Spanish Environment Ministry on the WF of Spain, applying the coefficients used for the transmission of the WF from the primary sectors to the rest of the economy (MARM, 2011a). Water consumed by the livestock sector includes the water consumed in the production of feed and forage crops.

The Spanish agricultural and fisheries sectors contributed to 2.3% of the Gross National Product (GNP) in 2009, down from 3.8% in 2000 (see Table 1). The related agri-food industry contributed with 1.77% down from 2.11% in the same period. The share of employment in 2007 in the agri-food industry is approximately 2.6% of the national total, mainly linked to the bread and pastry industries (46% of employment), the meat (14%) and the beverage industries. These industries also generate most of the added value in the agricultural sector, with the meat industry accounting for 18%, beverages 17%, and bread and pastries 12%.

Despite its importance for the rural economy, agriculture has a small importance in economic terms for the country as a whole. The importance of agriculture is linked to its local effects, its shaping of the rural society and landscape, and its provision of food security. As was already pointed out in Garrido *et al.* (2010), Spain has achieved a decoupling of its economic growth from water consumption and VW flows: increasingly less water is used to produce one euro of output. Nevertheless, agriculture remains the main water consumer with over 75% of the total WF.

Within the agricultural sector, vegetable production represents 60% of the GNP and animal products 35%, the remaining 5% includes forestry and fisheries production. Between 1995 and 2008 crop production grew by 4% in real terms whereas animal production grew by only 1% (Garrido *et al.*, 2011). Final Agricultural Production in Spain rose steadily from 1996 to 2003, but has fallen since then, with slight upturns in 2007 and 2008 as a result of price rises in agricultural products. However, the evolution of agricultural income, in constant euros, increased from 1980 to 2003, but since 2003 it has gone down steadily, reaching by 2008 similar levels as in the mid-1990s (Garrido *et al.*, 2011). The reasons for this downturn are the downward trends of agricultural prices in real terms and the increase of input prices since 2003.

Between 1995 and 2008 there was a general decrease of the cultivated rainfed surface, as well as that of irrigated arable crops and vegetables. By contrast, the irrigated surface of trees and vineyards had a tendency to increase until the 2003 reform

Table 1 Percentage of GDP, labour force and water consumption of the Spanish economic sectors.

	Sector	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*
% of GDP	Agriculture, livestock and fisheries	3.8	3.7	3.5	3.4	3.1	2.7	2.4	2.5	2.3	2.3
	Industrial	18.8	18.3	17.7	17.2	16.7	16.3	15.8	15.6	15.6	14.6
	Construction	9.3	9.9	10.5	10.9	11.4	12.1	12.6	12.4	12.5	12.1
	Tourism	11.6	11.5	11.1	11.0	10.9	10.8	10.9	10.8	10.5	10.0
	Services (except tourism)	46.9	47.3	48.0	47.8	47.8	47.4	47.2	48.6	50.8	53.2
% Labour	Agriculture, livestock and fisheries	6.1	5.8	5.8	5.6	5.4	5.1	4.7	4.5	4.4	4.3
	Industrial	19.4	19.0	18.5	17.9	17.3	16.8	16.3	15.8	15.6	13.6
	Construction	11.2	11.8	12.1	12.5	12.8	13.3	13.6	13.8	12.6	11.1
	Tourism	11.6	11.5	12.0	12.12	12.37	12.78	13.3	13.6	13.8	10.8
	Services (except tourism)	51.8	51.8	51.6	51,9	52,1	52,0	52,1	52,3	53,6	53,8
Water consumption (hm^3)	Crop production	27,206	28,855	28,795	29,126	30,899	21,037	25,819	30,681	33,077	25,145
	Livestock	40,839	42,301	42,952	43,733	44,343	44,008	42,969	49,331	42,995	42,563
	Industrial and construction	2,081	1,874	1,870	1,892	2,007	1,366	1,677	1,993	2,148	1,633
	Tourism	518	467	466	471	500	340	418	496	535	407
	Services (Urban except tourism)	1,735	1,874	2,012	2,078	2,047	2,178	2,077	1,983	1,921	1,965

Sources: INE (2011a, 2011b), MITYC (2011), MARM (2011a).

[hm^3 = cubic hectometre = million m^3 = 10^6 m^3].

of the Common Agricultural Policy (CAP) (Ruiz *et al.*, 2011). The subsequent reforms of the CAP in 2003 and 2006 have consolidated a trend initiated with the McSharry reform of 1992 to shift farm income support from price support to decoupled direct payments. With the exception of some crops, like cotton, tobacco, olives and sugar beet, which kept a variable percentage of support via prices, the majority of cultivated land is now indirectly supported with direct payments to the farmer. Ruiz *et al.*, suggest that, as a consequence of the reform, there has been some land redistribution among crops, with cereals occupying lands previously dedicated to industrial crops like tobacco or cotton, which have seen their profitability going down significantly. There has been an increase in the average yields of cereals, also linked to a price effect and to the abandonment of the least productive areas (see Chapter 11).

Barley and wheat cover 23% and 15% of the country's agricultural surface, respectively. Overall, cereals occupy 46% of the surface, but only account for 21% of the production and 14.2% of the economic value. Land devoted to rice and maize diminished after 2003, as CAP payments were totally decoupled from production. Olive trees and vineyards occupy 16% and 7.4% of the surface, respectively. Both crops more than doubled their irrigated surface during 1995 and 2008 (146% in the case of vineyards), and either maintained (olives) or decreased (vineyards) their rainfed surface. Vegetables dropped their rainfed area, maintaining its area in national terms. If we look at the value of the agricultural production, vegetables, fruits and citrus, and pork meat, account for roughly half of the total value (18.0, 14.5 and 12.5% respectively). Significant increases in production value are identified in vegetables, pork and olive oil. Cereals, grapes and citrus fruits grew from 1995 to 2000, but their value remained about the same between 2000 and 2008.

As for the animal sector, its main production, pork meat, is followed by bovine meat, milk and dairy products. Each year the sector produces more than 5.5 Mt [Mt = million tonnes = 10^9 kg] of meat, 60% of which is pig meat and 25% chicken. The largest growth in numbers of animals has been in these two species: 58% in the case of pork and 12% in poultry. The sector has grown in efficiency as well, since production of meat per animal improved, as well as the value produced per animal.

3 METHODOLOGY AND DATA

The method used to estimate the WF and VW trade of the Spanish agricultural sector builds on and improves the methodology used in Garrido *et al.* (2010). We estimated crop water consumption as a function of crop evapotranspiration, based on FAO ETO methodology (Allen *et al.*, 1998). However, in relation to the work by Garrido *et al.* (2010), our estimations have been refined to expand the studied period, as well as for better measuring water consumption by permanent crops. Significantly, an estimate of the deficit irrigation was applied, approximating the irrigation water consumed to the crop net water requirements defined by each river basin authority (RBA) as the upper limit.

The databases used included detailed annual crop production, area and economic value at provincial level, obtained from the Ministry of the Environment and Rural and Marine Affairs (MARM, 2011b). Information on the number of slaughtered animals, production and economic value was also obtained from MARM (2011b). Climatic data were obtained from the National Meteorological Agency (AEMET, 2010) and the farmers' irrigation service (*Servicio de Asesoramiento al Regante*, MARM, 2011c). Data on volume, economic value and origin of international trade was taken from DATA-COMEX, the database of international trade by the Ministry of Industry, Tourism and Commerce (MITYC, 2011). Crop net irrigation requirements in each river basin were obtained from the RBAs as given in the Water Framework Directive official documents.

To calculate the VW content of animal production, the methodology of the Water Footprint Manual (Hoekstra *et al*., 2011) was followed. The WF of livestock products calculation followed the same methodology. This WF accounts for: 1) the water consumed in animal servicing (water used in the farm); 2) the water drank by the animals; and 3) the VW included in the animal feed. This diet refers to a mixed diet of extensive and intensive production systems. These diets were designed as explained in Rodríguez-Casado *et al*. (2009). Drinking and service water used for pigs and poultry was refined from the sources used in Garrido *et al*. (2011), as well as data on age and weight at slaughter.

Trade statistics distinguishing between green and blue water, were obtained from Mekonnen & Hoekstra (2010a, 2010b) for the imported products. The VW content of the imported products (e.g. coffee) was calculated by weighing the average of the product's VW content depending on the country of origin. The VW content of exported products was considered equal to the water content consumed in the production of those products within Spain. This is mainly because Spain does not generally re-export products.

In comparison with Chapter 7, which focuses on groundwater use, the estimations of water consumption are slightly higher for this chapter (15% on average). In Chapter 7 an effort was made to work at a smaller scale (municipal and district level) in order to be capable of differentiating the origin (surface or groundwater) of the water. In this chapter the data were homogenized to the provincial level, thus introducing some level of error. Still, the estimates are in relative agreement with those showed in Chapter 7.

The evaluation of the WF of olives, olive oil and tomato production, reported in Chapter 10, was much more precise, and included in the case of olive production a limitation on the available water. Therefore, the WF calculated for olive production shows higher green water content per unit of product (m^3/t) [t = tonne = 10^3 kg] and a smaller WF of the production (hm^3) [hm^3 = cubic hectometre = million m^3 = 10^6 m^3] than in Chapter 10. Discrepancies in the results are also related to the modelling of irrigation applications and water balance. The need for modelling the whole range of production for the country in a consistent way led to some simplifications. This may have altered the calculations by as much as 35% and affected the proportion between green and blue water. Nevertheless, the relationship of water consumption and crop types, and the trends, are maintained.

4 AGRICULTURE'S WATER FOOTPRINT

As we saw in Table 1, agriculture is the main water consumer and merits a more in-depth analysis. In this section we present the results obtained on the WF and VW water trade of the sector.

Figure 1 plots the national WF of the agricultural sector along with the VW trade flows, the water needed to produce the traded goods. Crop production WF

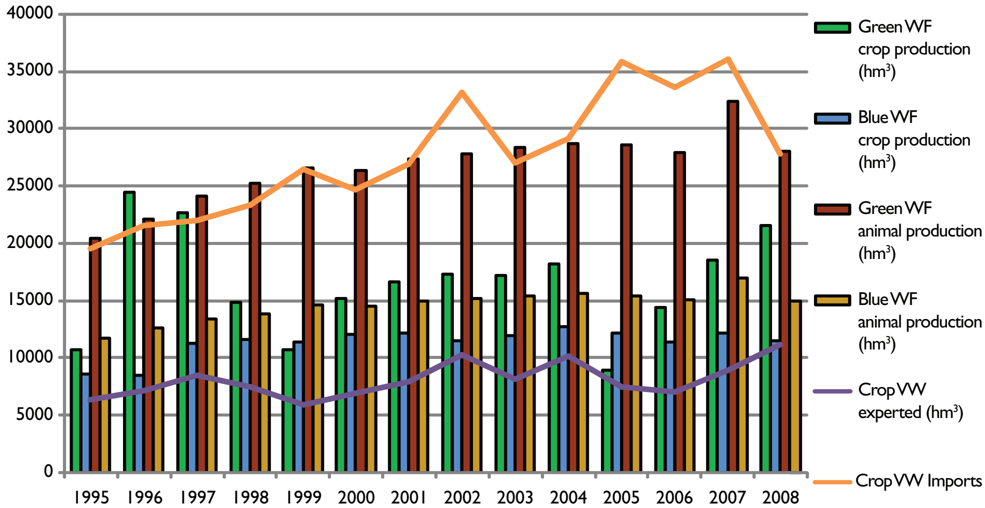

Figure 1 The internal green and blue WF (blue and green) of crop and animal production and VW flows (hm^3/year). (Source: Own elaboration).

(green and blue) has grown by 5% on the period to around 30,000 hm^3/year. Animal production WF grew by 30% to around 45,000 hm^3/year, including the WF of forage and feed. A relevant fact is the proportion of green and blue water used in agricultural production. In crop production, blue water is gaining relevance, in crops like cereals and vineyards, which increased the relevance of blue water by 20%. Olive production decreased its proportion of green water from 92 to 84%.

VW trade flows have also increased, though at a different pace. VW imports amounted to around 32,000 hm^3 at the end of the period, and nearly tripled the VW exports (9,000 hm^3); they have increased by 55% during the period of investigation and maintained a more or less stable share of green water. On the other hand, crop VW exports have also increased (23%), but the share of green water in these VW flows has decreased. The share of traded blue water is slightly gaining importance in the crop production (with the exception of citrus crops), whereas for the animals, the green water is completely prevalent, related to increasing imports of feeds. Spain imports a much higher volume of water than it exports. Virtual imported volumes are about the same than those needed to grow its own crops. Net imports have followed a clearly upward trend. The imports are mainly green water (90%). The exports have a much higher share of blue water (40%) but it is also diminishing.

Table 2 shows an overview of the WF per crop type at the beginning and end of the period of study. Cereals (38%) and olive trees (20%) account for the largest share of the national agricultural WF, followed by citrus, fruits and industrial crops. This is related to their large share in the cultivated area, and to their higher WF per unit (m^3/t). Both cereal and olive production rely mainly on green water and have a predominantly rainfed production. Nevertheless, blue water is becoming increasingly more important as the irrigated surface increases (see Chapter 8 for the case of olive sector in the Guadalquivir basin). Both olive and vineyard production doubled their

Table 2 Share of the national WF (%), WF per unit (m³/t), WAP (€/m³ green and blue water, at nominal prices), and blue water WAP (€/m³) per type of crop, at the beginning (av. 1995–1996) and end of the period (av. 2007–2009).

	Aver. (1995–1997)				*Aver. (2007–2009)*			
Type of crop	*Percentage of national WF*	*Volumetric WF (m³/t)*	*WAP (€/m³)*	*WAP blue water (€/m³)*	*Percentage of national WF*	*Volumetric WF (m³/t)*	*WAP (€/m³)*	*WAP blue water (€/m³)*
Cereals	33.9	555	0.27	0.96	39.7	534	0.33	0.84
Pulses and tuber	2.7	196	0.84	1.75	2.1	283	0.82	1.63
Industrial crops	10.3	297	0.30	0.47	4.9	273	0.33	0.59
Forage crops	4.8	46	2.22	4.79	7.2	69	1.44	2.68
Vegetables	4.8	123	2.92	3.58	5.1	123	3.71	4.30
Citrus	5.4	301	0.92	1.28	6.6	330	0.70	1.11
Other Fruit trees	8.2	674	0.60	1.33	7.4	685	0.78	1.59
Vineyard	7.2	454	1.00	10.23	6.9	357	1.03	3.98
Olive trees	22.6	1801	0.36	7.27	20.1	955	0.45	3.65

Source: Own elaboration.

WAP: Water apparent productivity.

irrigated surface over the period. Citrus and cereals increased theirs by 15% and 20%. The largest reductions in WF are related to the decrease in the surface of industrial crops, non-citrus fruit trees and pulses and tubers, whereas forages, vegetables and cereals increased their importance in the national crop WF by 51%, 145% and 16% respectively.

The products holding the largest share of the national WF (cereals and olives) have a lower water apparent productivity (WAP) whereas vegetables, vineyard and forage crops exhibit the highest WAP. As for their trend, WAPs have had a different behaviour than the WF. Fruit trees, cereals, vegetables and olives have increased their WAP (32% in the case of fruit trees), whereas that of pulses, citrus and forages decreased. Vineyards maintained their WAP.

Crop exports account for a small part of the total production but are significant in economic terms. Spain exports a small part of the total production, but at a relatively high price and at an increasing value. Agricultural exports show a positive trend. On the other hand, Spain is importing more in volume, at increasingly less value per unit, a small amount of goods compared to what is produced. This leads to positive terms of trade making agriculture a source of income for the country.

Analysing the water consumption of this trade, the VW exports grew slower than the value of the products and so the WAP of the exports has increased. VW imports are much less relevant economically than in volume (hm³) terms. This is mainly because imported products on average have a high WF per unit (m³/t) and low value. We may also see that the growth of the WAP of the exports is higher than the growth of the WAP of national production and the imports. Spain is increasing the competitiveness of its water exports, obtaining increasingly more value for its water consumption.

The main products exported are citrus, vegetables, wheat, wine, olive products and pork meat.

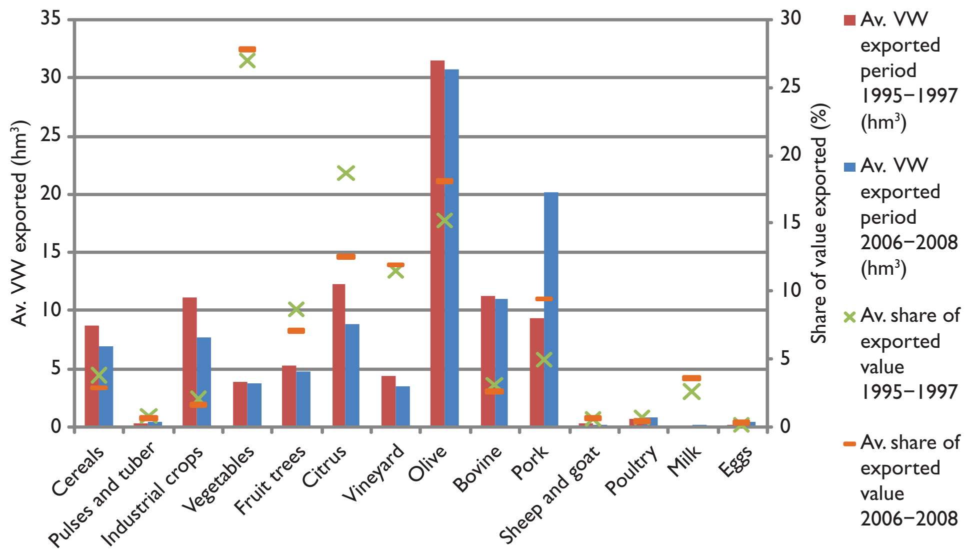

Figure 2 Average VW exported (hm^3/year, left axis), and average share of the exported value at the beginning (1995–1997) and end of the period (2006–2008) (right axis). (Source: Own elaboration).

Figure 2 disaggregates per product type the share of economic value and absolute WF (hm^3/year) of the exports. We see how pork and olives and olive oil have greatly increased their importance in exports over the period. In contrast, citrus fruits have greatly decreased their share. Vegetables and wine have maintained their share of the value alongside a small and stable part of the VW exported. Other productions decreased the VW exported (cereals, industrial crops and citrus mainly). The country is increasingly concentrating its exports in a range of products like wine, olives, vegetables and pork, which in turn are (with differences in the degree) improving their WF per unit (m^3/t) and their WAP (€/m^3).

As for the VW imports, most of them are associated with cereals (maize, wheat and barley) and oil seeds and their products (soya bean, soya cake, sunflower seeds and cassava). Annual agricultural VW imports increased from 23,500 hm^3 in 1995 to 36,300 hm^3 in 2008. Their economic value increased from 6,000 M€ to 11,234 M€, an 87% increase. They are composed of 90% green water, and originate principally from South America (Argentina and Brazil), France and the USA.

5 DISCUSSION

Imports represent less economic value per imported VW and are almost exclusively composed of green water (more than 90%). Agricultural imports are overwhelmingly linked to the imports of cereals and oilseeds (soya). These two productions are even increasing their volume (t) imported, but show different trends. Cereals seem to be increasing their share in imported economic value, because of their growth in imports, although at lower economic relative value (€/m^3). Consequently they are still gaining a larger share of the country's external WF. Oil seeds, which account for a third of the value and 40% of the VW imported, increased their volume of imports (t) less than their value, and more than their WF. Thus, there is a tendency to import more expensive oilseeds with less WF per unit (m^3/t). Should the prices of the oilseeds remain high in international markets, the downward trend followed by the internal WF of oil crops may slow down too. This growth in VW imports is related to the growth in meat production and exports, as many of the imported cereals and oilseeds are used for animal feed. Pork production has increased in the period, while its WF tripled. Pork meat exports tripled their value and their VW exports in the period. This is related to the high VW content per unit of product. A similar effect is seen in the rest of the animal production.

The increases in the WAP of the exports have not come that much from the meat sector despite its significant growth. It is the olive production that increased the most in value in the exports, but also increased significantly its WAP. The olive sector had this performance at the same time as it increased the (still low) proportion of blue water in its production (see Chapter 10). Wine on the other hand decreased its importance in the VW exports, but maintained its value, and managed to triple its WAP. Both productions also managed to lower by 30% their WF per unit of product exported. They have become more effective in the use of water for generating value. Vegetables maintained their importance, and remain the most important category of exports. They maintained their high WAP, by decreasing slightly their WF per unit of product.

While the change in CAP in 2003 reduced existing incentives to intensify production, there has been a concentration (in space and products grown) of Spanish agriculture which has brought sustainability issues in certain regions. International crop trade in Spain has increased in the period. The country is trading increasingly more, and improving its terms of trade. A certain degree of specialization has occurred in the traded goods, narrowing the range of exported products and improving the productivity of the water consumed. Agriculture, and subsequently water, is increasingly linked to international markets, and thus to its trends and growth. In consequence, the need to balance the market forces with the available local resources is becoming increasingly important.

6 CONCLUDING REMARKS

This chapter analyzed the importance of water in the Spanish economy, and in more depth the agricultural sector. The Spanish economy has gradually decoupled from water consumption, using less water per euro of output. Agriculture and agro-industry, the main water consumers, have a relatively minor importance for the economy and employment, but form the basis of food security. Spanish agriculture has experienced significant changes in the last 15 years. Main changes in crop production are giving blue water consumption an increasing importance, especially in the fastest growing sectors like vineyards and olive trees. On the contrary, in the animal sector the WF is turning greener, as the imports of feedstuff have increased significantly, to attend the increase in production and exports.

The relation between the economy and water resources has potentially damaging effects at local and basin levels. An important complement to the study presented here is the impact of agriculture on water quality. Agricultural production has evolved differently between the crop types, and accordingly between regions. Not every region is capable of competitively producing the most valuable crops, and thus, as international trade increases and competition arises, the biggest producing regions will increase their production. A view of this may be found in the analysis of the olive and tomato sectors in Chapter 10. Together with this concentration and specialization, there are issues of over-exploitation and water quality that have arisen in many of these regions. Other chapters analyze the growth in groundwater use (Chapter 7), the problem of agricultural diffuse pollution (Chapter 12), and land use changes (Chapter 11).

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