Water Footprint Assessment

D.2 – Conclusions and recommendations

LIFE
RESILIENCE

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Deliverable Name: Water Footprint Assessment

Action D.2: Conclusions and recommendations

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1. Summary

The following document establishes the water footprint assessment of the LIFE RESILIENCE project. This study's goal is to determine the water footprint of the crops in the demonstration sites and replication farms, after applying the project's activities.

For this end, an international accepted methodology will be used for conducting the water footprint assessment: The Global Water Footprint Assessment Standard.

2. Introduction

Water Footprint Assessment Standard is a process that measures and maps green, blue and grey water footprints, evaluates water consumption for sustainability, efficiency and equity, and determines which strategic actions should be prioritized to make a footprint sustainable.

In this case, the water footprint assessment will be used in order to analyze and obtain conclusions regarding the impact of the project on this resource. For this end, the next chapter in this document describes the methodology that was employed, the inputs and considerations that were taken, the methodology and equations for evaluating the different parameters in order to obtain water use indicators, the results and, finally, conclusions about the study.

The importance of carrying out a water footprint analysis lies in the fact that the supply of fresh water is limited. The demand for fresh water grows as the world's population increases. In that sense, to maintain freshwater availability, measures and actions to keep water footprint low are being required.

Additionally, within the framework of this project, it is important to evaluate the impact of the activities that were carried out, in order to obtain conclusions that are useful for future programs and actions implemented in farms.

3. Chapters

The report includes the following chapters:

-Chapter I: Methodology

-Chapter II: Project's water footprint accounting

- Chapter III: Water footprint accounting for regular activities

Chapter I. Methodology

For the elaboration of this document, the water footprint assessment manual, from the Water Footprint Network (WFN) (https://waterfootprint.org/en/) was consulted and used as a guideline for carrying out this evaluation.

A water footprint assessment consists in four different phases:

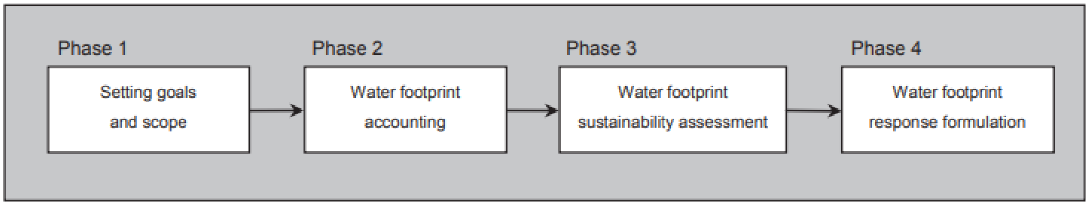

Image 1. Phases in water footprint assessment (Source: WFA Manual)

Phase 1 consist in setting the goals and scope of the study. First, it is necessary to determine the reason and interest in carrying out the analysis. This helps to define the scope of the study, such as which inputs will be considered, the geographical delimitation, between others.

Phase 2 corresponds to the phase in which data is collected and quantified. The accounting scope and level of detail in this information are determined by the decisions made in the previous phase.

In Phase 3, the water footprint is assessed from an environmental, social, and economic point of view.

Finally, in Phase 4, response options and strategies are presented as a conclusion of the study.

Due to the different reasons for carrying out a water footprint study, it is not necessary to include all the phases described above. For this assessment, since it is done at the end of the project, Phases 1 and 2 will be carried out, and then a number of conclusions influence will be formed on the results acquired.

I. Phase 1: Setting goals and scope

The objective of this assessment is to quantify the water footprint of the activities carried out within the LIFE Resilience project to analyze its impact on this resource. The scope of the study includes both the demonstration sites and replication farms.

The study's data period is one year within the project; for this, the water consumption for irrigation over a year was taken where the project actions were already implemented.

The blue and gray components of the water footprint will be quantified in this study. The volume of fresh water extracted from surface or underground sources, in this case for irrigation, is represented by the blue component. The gray component is the volume of water required to dilute the pollutants released during production to such a concentration that the water quality remains above the quality standards. Because these are pump-irrigated crops, the green component will not be considered.

Finally, in order to obtain relevant conclusions, the water footprint of the different sites and crops in a business-as-usual situation (i.e., if the activities of the project weren't implemented) will be estimated.

II. Phase 2: Water footprint accounting

The total water footprint of a crop growing process (HHproc) is the sum of the green, blue and gray components:

$$HH_{proc} = HH_{green} + HH_{blue} + HH_{gray} \text{ [volume/mass]}$$

Where:

- $HH_{green} = 0$. (For the reason explained in the previous chapter)

- $HH_{blue} = \frac{UAC_{blue}}{P}$ [volume/mass]
  - UAC_{blue}: Crop wáter use. This component is typically estimated using the crop's diary evapotranspiration. Because this requires a specific tool to compute the plant and weather parameters in order to obtain this value, the data from the water used to irrigate the crops will be used instead for this study.
  - P: Annual crop yield

- $HH_{gray} = \frac{(\alpha \times TA) / (c_{max} - c_{nat})}{P}$ [volume/mass]

- *α:* herbicide leaching into bodies of water= 10% 1
- TA= herbicide application rate
- Cmax= maximum permitted herbicide concentration
- Cnat= herbicide natural concentration=0.
- P: Annual crop yield

Presented in the following chapters are the results obtained using the previous formulas, for the demonstration sites and the replica farms, both for the project and for the business-as-usual scenario.

[1] INCAP-MDE Aspectos generales sobre los plaguicidas y su efecto sobre el hombre y el ambiente: http://200.10.250.206/bvsacd/eco/034059/034059-02.pdf.

Chapter II. Project's water footprint accounting

Project's water footprint accounting

A. Grey footprint

In this case, since the herbicide applications are eliminated, the grey footprint in both demonstration and replication sites is cero.

B. Blue footprint

Demonstration sites

In the demonstration sites, the activities were implemented in olive and almond plantations. In these sites, a deficit irrigation protocol was applied to some areas of the different farms, the sum of these areas for each farm correspond to Area 2 in the following table. The average water use for each farm was determined by averaging the water use over the course of the project's three and a half years. The same approach was used to estimate average production. Also, the area of each treatment was considered.

Demo Sites	Area (ha)		
Treatments	SPAIN	PORTUGAL	ITALY
T0	102,24	8,68	13,46
T1	14,74	18,39	12,81
T2	17,09	10,17	0
T3	24,37	15,78	13,33
T4	4,88	6,21	13,31
Total	163,32	59,23	52,91

Table 1: Area of each Treatment in the 3 demo farms.

In that sense, the blue footprint estimation (T2+T4) for the demonstration farms is presented next:

Farm	Crop	Area 1 (ha)	Average water use Area 1 (m3/ha yr)	Area 2 (ha)	Average water use for Area 2 (m3/ha yr)	Total average water use (m3/yr)	Average Production (ton/yr)	HHblue (m3/ton)
Spain	Olive	141,35	3250	21,97	2642,25	517437,73	2662,12	194,37
Portugal	Almond	42,85	3500	16,38	2600,5	192571,19	189,54	1016,01
Italy	Olive	39,6	780	13,31	634,14	39328,40	238,10	165,18

Table 2: Blue footprint in demonstration sites.

<u>Replication farms</u>

Different crops with unique watering needs are grown in the replication farms. The area of each treatment for the 13 replication farms show bellow.

COD	Farm	Location	Country	Plantation Year	Crop	Area (ha)	Treatments	T1 (ha)	T2 (ha)	T3 (ha)
1	Herdadinha	Beja	Portugal	2007	Olive	442,0	T1+T2+T3	54,3	48,1	43,3
2	Vica Belha	Beja	Portugal	2018	Almond	78,0	T1+T3	16,2	0,0	14,4
3	Herdade do Monte Branco	Aljustrel	Portugal	2019	Olive	162,0	T1+T2+T3	49,1	8,0	21,8
4	Contanda	Concelho de Campo Maior	Portugal	2015	Almond	264,0	T1+T2+T3	28,8	49,7	86,5
5	Novillero	Albuera	Portugal		Grapes	45,0				
					Pistachio	42,0				
				2015-2018	Almond	35,0	T1+T2+T3	41,7	12,0	23,1
6	Pozanco	Mérica	Spain		Grapes	120,0				
					Pistachio	36,0				
				2015-2016	Almond	59,0	T1+T2+T3	27,1	16,5	14,6
7	Torrejoncillo	Extremadura	Spain	2021	Almond	100,0	T1+T2	13,2	24,5	
8	Casa Palacios	Plasencia	Spain	2020	Almond	20,5	T1	18,5		
9	La Salgada	Riolobos	Spain	2020	Almond	100,3	T1+T3	59,5		10,6
10	San Francisco Javier	La Campana	Spain	2010	Olive	150,1	T1+T2+T3	29,3	26,0	35,3
11	Portia Winery	Gumiel de izan,Roa, Sotillo, Gumiel de Mercado y	Spain	1999-2011	Grapes	156,0	T1+T2+T3	77,6	25,1	34,9
12	Galifrut	Hondón de los Frailes (Alicante).	Spain	2003	Grapes	13,6	T1+T2+T3	4,6	2,7	6,9
				2018	Almond	9,8	T1+T2+T3	6,4	0,2	3,2
				2015	Pomegranate	14,5	T1+T2+T3	4,6	4,0	6,0
				2018	Apricot	6,1	T1+T2+T3	1,4	3,4	1,1
13	Marina di Grosseto	Marina di Gro	Italy	2013	Olive	8,0	T1+T2+T3	1,7	3,0	3,4
						1.861,9		**434,0**	**223,1**	**304,9**

Table 3: Area of each Treatment in the 13 replication farms

As a result, each farm's blue footprint (T2+T4) was assessed as follows.[2]

Farm	Crop	Area (ha)	Average water use (m3/ha yr)	Total average water use (m3/yr)	Average Production (ton/yr)	HHblue (m3/ton)
Herdadinha	Olive	442,0	2642,25	1167874,50	4066,40	287,20
Vica Belha	Almond	78,0	2600,5	202839,00	234,00	866,83
Herdade do Monte Branco	Olive	162,0	2642,25	428044,50	1490,40	287,20
Contanda	Almond	264,0	2600,5	686532,00	792,00	866,83
Novillero	Grapes	45,0	1350	60750,00	420,75	144,39
	Pistachio	42,0	4725	198450,00	84,00	2362,50
	Almond	35,0	2600,5	91017,50	105,00	866,83
Pozanco	Grapes	120,0	1350	162000,00	1122,00	144,39
	Pistachio	36,0	4725	170100,00	72,00	2362,50
	Almond	59,0	2600,5	153429,50	177,00	866,83
Torrejoncillo	Almond	100,0	2600,5	260050,00	300,00	866,83
Casa Palacios	Almond	20,5	2600,5	53279,04	61,46	866,83
La Salgada	Almond	100,3	2600,5	260955,75	301,04	866,83
San Francisco Javier	Olive	150,1	2642,25	396575,30	1380,83	287,20
Portia Winery	Grapes	156,0	1350	210600,00	1458,60	144,39
Galifrut	Grapes	13,6	1350	18306,00	126,79	144,39
	Almond	9,8	2600,5	25510,91	29,43	866,83
	Pomegranate	14,5	90	1307,70	363,25	3,60
	Apricot	6,1	3150	19057,50	39,93	477,27
Marina di Grosseto	Olive	8,0	2642,25	21138,00	73,60	287,20

Table 4: Blue footprint in replication sites.

[2] Since the measures of the water use and production parameters in the replication sites are outside the scope of the project, the values for the water use in olive and almond plantations from the demonstration sites are used as a reference in order to estimate the reduction in the water resource in the replication farms. For the rest of the crops, a conservative value of water use reduction was used: 10%.

Chapter III. Water footprint accounting for regular activities

Business-as-usual water footprint accounting

For this situation, the values used to calculate the water footprint are those of the farm prior to the project's activities being implemented. In that regard, normal fertilizer and irrigation treatments are made.

A. Grey footprint

Demonstration sites

The previous chapter's formula was used to estimate the grey footprint (T3+T4) for the demonstration and replication sites, as shown below.[3]

Farm	Crop	Area (ha)	Application rate (kg/ha yr)	Total amount of fertilizer used (ton/yr)	Herbicide leaching into bodies of water: 10% (ton/yr)	Cmax (µg/l)	Average Production (ton/yr)	Hhgrey (m3/ton)
Spain	Olive	29,25	4,32	0,13	0,013	50	476,78	0,54
Portugal	Almond	21,99	4,32	0,09	0,009	50	70,37	2,76
Italy	Olive	26,64	4,32	0,12	0,012	50	119,88	1,96

Table 5: Grey footprint for demonstration sites. Business-as-usual situation

[3] Application rate: 12 kg/ha year of glyphosate at 36%.
Cmax: 50µg/l according to the 2004 Water Framework Directive.

Replication sites

Farm	Crop	Area (ha)	Application rate (kg/ha yr)	Total amount of fertilizer used (ton/yr)	Herbicide leaching into bodies of water: 10% (ton/yr)	Cmax (μg/l)	Average Production (ton/yr)	Hhgrey (m3/ton)
Herdadinha	Olive	43,3	4,32	0,19	0,019	50	398,45	0,96
Vica Belha	Almond	14,4	4,32	0,06	0,006	50	43,14	2,94
Herdade do Monte Branco	Olive	21,8	4,32	0,09	0,009	50	473,93	0,40
Contanda	Almond	86,5	4,32	0,37	0,037	50	4298,79	0,18
Novillero	Almond	23,1	4,32	0,10	0,010	50	69,36	2,94
Pozanco	Almond	14,6	4,32	0,06	0,006	50	43,80	2,94
Torrejoncillo	Almond		4,32	0,00	0,000	50		
La Salgada	Almond	10,6	4,32	0,05	0,005	50	31,77	2,94
San Francisco Javier	Olive	35,3	4,32	0,15	0,015	50	324,67	0,96
Portia Winery	Grapes	34,9	4,32	0,15	0,015	50	326,32	0,94
Galifrut	Grapes	6,9	4,32	0,03	0,003	50	64,05	0,94
	Almond	3,2	4,32	0,01	0,001	50	9,45	2,94
	Pomegranate	6,0	4,32	0,03	0,003	50	148,75	0,35
	Apricot	1,1	4,32	0,00	0,000	50	7,39	1,34
Marina di Grosseto	Olive	3,4	4,32	0,01	0,001	50	31,28	0,96

Table 6: Grey footprint for replication sites. Business-as-usual situation

B. Blue Footprint

For the business-as-usual scenario, the same formula from the previous chapter is applied, utilizing typical irrigation amounts values for each crop.

Demonstration sites

Farm	Crop	Area (ha)	Average water use (m3/ha yr)	Total average water use (m3/yr)	Average Production (ton/yr)	HHblue (m3/ton)
Spain	Olive	163,32	3250	530790	2662,12	199,39
Portugal	Almond	59,23	3500	207305	189,54	1093,75
Italy	Olive	52,91	780	41269,8	238,10	173,33

Table 7: Blue footprint in demonstration sites. Business-as-usual situation.

Replication sites

Farm	Crop	Area (ha)	Average water use (m3/ha yr)	Total average water use (m3/yr)	Average Production (ton/yr)	HHblue (m3/ton)
Herdadinha	Olive	442,0	3250	1436500	4066,40	353,26
Vica Belha	Almond	78,0	3500	273000	234,00	1166,67
Herdade do Monte Branco	Olive	162,0	3250	526500	1490,40	353,26
Contanda	Almond	264,0	3500	924000	792,00	1166,67
Novillero	Grapes	45,0	1500	67500	420,75	160,43
	Pistachio	42,0	5250	220500	84,00	2625,00
	Almond	35,0	3500	122500	105,00	1166,67
Pozanco	Grapes	120,0	1500	180000	1122,00	160,43
	Pistachio	36,0	5250	189000	72,00	2625,00
	Almond	59,0	3500	206500	177,00	1166,67
Torrejoncillo	Almond	100,0	3500	350000	300,00	1166,67
Casa Palacios	Almond	20,5	3500	71708	61,46	1166,67
La Salgada	Almond	100,3	3500	351219,05	301,04	1166,67
San Francisco Javier	Olive	150,1	3250	487792,5	1380,83	353,26
Portia Winery	Grapes	156,0	1500	234000	1458,60	160,43
Galifrut	Grapes	13,6	1500	20340	126,79	160,43
	Almond	9,8	3500	34335	29,43	1166,67
	Pomegranate	14,5	100	1453	363,25	4,00
	Apricot	6,1	3500	21175	39,93	530,30
Marina di Grosseto	Olive	8,0	3250	26000	73,60	353,26

Table 8: Blue footprint in replication sites. Business-as-usual situation.

4. Conclusions

The conclusions drawn from this study are described in this chapter.

The sum of the blue and grey footprints for each crop in the different sites was used to compute the crop's overall water footprint. Since this was done in both pre- and post-project scenarios, before and after the project's activities were carried out, the effect that these measures had on the water footprint can be analyzed as follows.

Farm	Crop	HHtot before project (m3/ton)	HHtot after project (m3/ton)	HH reduction (m3/ton)	HH reduction (%)
Spain	Olive	199,93	194,37	5,56	2,8
Portugal	Almond	1096,51	1016,01	80,49	7,3
Italy	Olive	175,29	165,18	10,11	5,8

Table 9: Water footprint reductions in the demonstration sites.

As a starting point, we can observe that on each farm there was a decrease in the water footprint, which means that less water was required to produce the same amount of food as a result of project-related activities.

The greatest reduction, in each case, is associated with the blue water footprint of each farm. In this sense, we verified that for olive plantations, thanks to the efficient irrigation applied, the reductions were around 19% of the amounts of water applied. On the other hand, in the almond plantation in Portugal, there was an even bigger decrease in water use, around 25%.

Due to the discontinuation of fertilizer use, there were also noticeable decreases in the gray water footprint. This reduces the amount of fertilizer that enters surface and groundwater, preventing its contamination.

Another fact that may draw attention is that the water footprint of the almond plantation is significantly greater than that of the olive, despite the fact that the area of action is not very different. The almond tree's higher water requirements as a crop provide an explanation for this phenomenon. In this sense, the water footprint is calculated in relation to production, and since the tons of almond harvested per hectare are less than those of olive, more water is required to produce a ton of this product.

Finally, if we compare the blue water footprint of both olive crops in Spain and Italy, we can see that they have a similar footprint. Given that Spain has approximately double the surface area of Italy, this may come as a surprise. This is described as follows: on the one hand, the farm in Italy has very little demand for irrigation, only about 780 m3/ha, due to the land being almost at sea level. Based only on this information, its blue water footprint should be significantly smaller than Spain's. But given that Italy's production is far lower than Spain's, which is four times bigger because of its super intensive system, this does not occur. Because of this, the final water footprint of both farms is similar.

Finally, by extrapolating the data from the demonstration farms to the replica farms, we can get an idea of the situation regarding their water footprint, as shown below.

Farm	Crop	HHtot before project (m3/ton)	HHtot after project (m3/ton)	HH reduction (m3/ton)	HH reduction (%)
Herdadinha	Olive	354,22	287,20	67,02	18,9
Vica Belha	Almond	1169,61	866,83	302,77	25,9
Herdade do Monte Branco	Olive	353,67	287,20	66,46	18,8
Contanda	Almond	1166,84	866,83	300,01	25,7
Novillero	Grapes	160,43	144,39	16,04	10,0
	Pistachio	2625,00	2362,50	262,50	10,0
	Almond	1169,61	866,83	302,77	25,9
Pozanco	Grapes	160,43	144,39	16,04	10,0
	Pistachio	2625,00	2362,50	262,50	10,0
	Almond	1169,61	866,83	302,77	25,9
Torrejoncillo	Almond	1166,67	866,83	299,83	25,7
Casa Palacios	Almond	1166,67	866,83	299,83	25,7
La Salgada	Almond	1169,61	866,83	302,77	25,9
San Francisco Javier	Olive	354,22	287,20	67,02	18,9
Portia Winery	Grapes	161,37	144,39	16,99	10,5
Galifrut	Grapes	161,37	144,39	16,99	10,5
	Almond	1169,61	866,83	302,77	25,9
	Pomegranate	4,35	3,60	0,75	17,3
	Apricot	531,64	477,27	54,37	10,2
Marina di Grosseto	Olive	354,22	287,20	67,02	18,9

Table 10: Water footprint reductions in the replication farms.

Once more, it is clear that each farm where the project's actions were carried out have a decrease in its water footprint.

Finally, the total reduction of water consumption during the entire life of the project is presented next:

	Water consumption before project activities (m3/yr)	Water consumption after project activities (m3/yr)	Water consumption reduction (m3/yr)	years of implementation	Total water consumption reduction during the project's lifetime (m3)
Spain	530790	517437,73	13352,27	3,5	46732,94
Portugal	207305	192571,19	14733,81	3,5	51568,34
Italy	41269,8	39328,40	1941,40	3,5	6794,89
					105096,16

Table 11: Demonstration sites water consumption reduction during the project’s lifetime

	Water consumption before project activities (m3/yr)	Water consumption after project activities (m3/yr)	Water consumption reduction (m3/yr)	years of implementation	Total water consumption reduction during the project's lifetime (m3)
Herdadinha	1436500	1167874,50	268625,50	1	268625,50
Vica Belha	273000	202839,00	70161,00	1	70161,00
Herdade do Monte Branco	526500	428044,50	98455,50	1	98455,50
Contanda	924000	686532,00	237468,00	1	237468,00
Novillero	67500	60750,00	6750,00	1	6750,00
	220500	198450,00	22050,00	1	22050,00
	122500	91017,50	31482,50	1	31482,50
Pozanco	180000	162000,00	18000,00	1	18000,00
	189000	170100,00	18900,00	1	18900,00
	206500	153429,50	53070,50	1	53070,50
Torrejoncillo	350000	260050,00	89950,00	1	89950,00
Casa Palacios	71708	53279,04	18428,96	1	18428,96
La Salgada	351219,05	260955,75	90263,30	1	90263,30
San Francisco Javier	487792,5	396575,30	91217,20	1	91217,20
Portia Winery	234000	210600,00	23400,00	1	23400,00
Galifrut	20340	18306,00	2034,00	1	2034,00
	34335	25510,91	8824,10	1	8824,10
	1453	1307,70	145,30	1	145,30
	21175	19057,50	2117,50	1	2117,50
Marina di Grosseto	26000	21138,00	4862,00	1	4862,00
					1156205,34

Table 12: Replication sites water consumption reduction during the project's lifetime

In this sense, the total water consumption reduction achieved thus far as a result of the project's implementation is:

1.261.301,50 m3

The aforementioned information demonstrates how the LIFE RESILIENCE project's actions had a positive impact on the environment. It is also advised to replicate it in all the regions and crops where it can be used successfully.

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