LIFE 14 ENV/ES/000538

Final Report

Covering the project activities from 01/09/2015[1] to 30/12/2018

Reporting Date[2]

<31/03/2019>

LIFE PROJECT NAME or Acronym

LIFE DRAINUSE

Data Project

Project location:	Murcia, Spain
Project start date:	01/09/2015
Project end date:	31/08/2018 **Extension date:** <31/12/2018 >
Total budget:	993.596 €
EU contribution:	596.157 €
(%) of eligible costs:	60%
Data Beneficiary	
Name Beneficiary:	CEBAS-CSIC
Contact person:	Vicente Martinez
Postal address:	Campus Universitario de Espinardo
Telephone:	968 396 200 + ext: 6301
E-mail:	vicente@cebas.csic.es
Project Website:	www.drainuse.eu

[1] Project start date

[2] Include the reporting date as foreseen in part C2 of Annex II of the Grant Agreement

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2. List of key-words and abbreviations

BOD5	Biochemical Oxygen Demand
CAP	Common Agricultural Policy
CARM	Regional Community of Murcia
CU	Electrical
EC	Electrical Conductivity
GA	Grant Agreement
MB	Management Board
PA	Partnership Agreement
PLC	Programmable Logic Controller
PS	Pilot system
PU	Purification Unit
RO	Reverse Osmosis
UV	Ultraviolet System

3. Executive Summary

Project Objectives

LIFE DRAINUSE project proposed the conversion of open cycle systems for soilless productive crops to close cycle systems, with the objective of improve the effectiveness of the processes. Specific project objectives are the following ones:

- To demonstrate through the design, construction and set up of a full re-circulation pilot system the technological possibility for Euro-Mediterranean regions of drainage reuse. The pilot system will be assayed in tomato plants, one of the most economically important and extended crops in south Europe.
- To propose a legal and regulatory framework for drainage recirculation to Euro-Mediterranean regulatory bodies
- To disseminate to all interested stakeholders, the benefits of full recirculation systems as an environmentally friendly solution for drainage release of hydroponic greenhouses.

Key Deliverables

The key deliverables enclosed to the present Final Report in Annex V *List of Deliverable*s are:

- DB4 Pilot Plant Report
- DB5.1 Report in nutrient concentration and volumes of the drainages obtained from coco peat substrates. *Update*
- DB5.2 Report in production, yield and quality of tomato in a closed system. *Update*
- DB5.3 Report in water, fertilizers and energy consumption in a closed system. *Update*
- DB5.4 Report of the software efficiency in the management of climate conditions. *Update*
- DB6 Economic report of the ressources costs (water, fertilizer, energy personnel..) and market product value at the end of the first and second culture cycle.
- DB6 Economic report of the system construction costs
- DB6 Final Economic report
- DB7 Legal Feasibility Report
- DB8 Transferability Report
- DC1.1 Impact of project actions effectiveness Report
- DC2.1 Socio-economic impact Assessment Report
- DD1.5 Dissemination Porfolio Report
- DD3.1 Layman´s report
- DE2 Networking report
- DE3.1 After Life Plan

Key Outputs

The most important result of the project will be the demonstration of the feasibility of the transformation of open soilless production farms into close soilless production farms. The following results for the pilot were expected:

- 1.700 m3 of water per ha per year reused (19.040 tomato plants/ha x 1l/tomato plant/day =19.04 m3/ha/day x 30% drainage on average = 5.7m3/ha/day x 300 days of crop/year)
- 165.000 Kg crop production/ha that represents no reduction of production or quality respect to open soilless cycle.
- 30-46 Kg crop production/m3 water (which represents an increase in Water Use Efficiency of 20-50%)
- 35% of saving of Nitrogen, 20% of saving of Phosphorus, 17% of saving of Potassium in terms of fertilizer used per ha.
- Environmental enrichment and protection, resulting from the fertilizers not drained to ecosystems, avoiding the possible eutrophication.

With the above mentioned results, the project LIFE DRAINUSE should generate real data to propose a legal and regulatory framework for drainage recirculation for Euro-Mediterranean regulatory bodies and Policy Makers.

Achievements, deviations, important problems and difficulties during the project

The project was composed of four main stages:

- Characterization of nutrient cycle for soilless tomato production
- Set up the pilot plant close cycle soilless culture.
- Implementation of the close cycle during different crops in different seasons.
- Analytics about the feasibility and the transferability of the results.

The optimal nutrient solution for running the demonstrator on tomato grown with cocopeat had been determined and the detailed design of the pilot plant had been produced. Once the design has been ready, the construction of the system has been implemented in order to test, the proper functioning of the system as a whole. It was needed to build a house of 60m2 because the system didn't fit in CEBAS-CSIC's greenhouse premises.

Two programmed harvest took place, by using the final nutrient solution. Due to the poor results (related with plagues and low temperatures) obtained in the two programmed harvest, a third one, not foreseen in the Proposal was decided to be implemented. The results of this third harvest were successful and they demonstrated the potential of the recirculation of the drainage.

Considering the expected results, these are the final improvements of the project:

Concept	Expected Results	Initial situacion	Final situation (third cycle)
Water reused (M3/ha/year)	1,700	0	6,844
Crop production (kg/ha)	165,000	0	373,353
Crop production (kg/m3 water)	30-46	0	13.82
Nitrogen savings (% used/ha)	35	0	60

Phosphorus savings (% used/ha)	20	0	12
Potassium savings (% used/ha)	17	0	48
Water drained (m3/ha/year)	0	1,700	0
Nitrogen released (kg N/ha/year)	0	1,824	0
Phosphorous released (kg P/ha/year)	0	3,011	0
Potassium released (kg K/ha/year)	0	98	0

In a closed system, water consumption is **41% lower** than in an open system, whithin a consumption of 22,813 m^3/ha/year to 13,457 m^3/ha/year.

Fertilizer consumption is **reduced by 60% N**, **12% P** and **48% K,** in terms of **amount** per ha and year.

The dumping of fertilizers into the medium **passes from 749,813 tons of fertilizers/year in Europe to 0 tons of fertilizers/year.**

By reducing the consumption of fertilizers, **36,928 kg CO_2-eq/kg fertilizer/ha/year** are no longer emitted to the atmosphere. Considering that in Europe the greenhouse area under soilless conditions is 152,000 ha, this figure amounts to 5,613,056 tons CO2-eq/kg saved fertilizer/year.

In parallel, a web-based application (SCADAweb) and hardware control unit to control and monitor the nutrition system has been developed, with the necessary options to introduce initial data to configure the system. Moreover, it allows visualizing data on real time and history data. The SCADAweb has been installed in a server, at the pilot plant facilities, and connected to Internet. The software can be accessed anywhere connected to Internet, PC or mobile device (Tablet or smartphone).

From this first agronomic experiment it can be said that the system has operated acceptably and the fruits at the final stage presented good quality, being suitable for commercial purposes. The main difficulty observed was the disinfection system. The UV lamp was not effective in the first crop cycle, since some microorganisms such as fungi, yeast and bacterium were detected in the drain water after the UV disinfection. To solve this problem, CEBAS installed a new disinfection system based on electrolysis (Biodyozon system) and the whole circuit was adjusted. The product obtained is a powerful disinfectant that does not cause corrosion or leaves residues of salts or chemical residues.

4. ntroduction

- **Environmental problem/issue addressed**

Greenhouse industry is widely extent in Europe and modern agriculture aims at increasing crop yield in terms of production and quality, which requires an intense use of water and fertilizers. In open hydroponic systems, where drainages are released into the environment, a 31% of nitrates, and a 48% of potassium applied are discharged into the environment, with the concomitant pollution and eutrophication of land and water. European Union policies try to reduce the environmental costs of intense agriculture.

Although the recirculation of drainages among the producers of the Mediterranean area is not very extended, it is predicted to be expanded in the near future as European policies like the Common Agricultural Policy (CAP), Nitrates Directive or the Water Framework Directive (2000/60/IEC) will force these countries to design laws to converge to a common European legal frame.

Another important reason is making the producers to consider moving from production under an open system to a closed-recirculating one, as current practices are increased the prices of fertilizers and water. This is the case of southeaster Spain, where a great deal of the water used for irrigation comes from water basis from the producer raising the costs of water.

- **Outline the hypothesis to be demonstrated / verified by the project**

As an alternative to open hydroponic systems, a full re-circulation system, also known as closed system, has been developed in The Netherlands, but the percentage of producers that use it in their greenhouses in the rest of Europe is very low mainly because these systems need to be specifically designed and adjusted to the specific conditions where production is taking place.

The advantages, economic as well as environmental, of transforming an open soilless system into a closed system, overpass the investment costs that the modifications require. For that reason, this project proposes to demonstrate the technical and economic feasibility of such transformation.

To achieve this aim, a modular pilot has been tested to evaluate and validate the reuse of drainage, as well as identifying potential problems, costs and energy consumption.

The pilot plant is being specifically designed to overcome the South-Mediterranean constraints where the existing solutions for Northern European countries are a non-viable solution.

- **Description of the technical / methodological solution**

The pilot system proposed here is able to collect the drainages coming from the normal irrigation of the tomato plantation, to disinfect them and to adjust the nutrient concentration, pH and electrical conductivity with the purpose of making drainages re-usable for a new irrigation cycle.

To avoid discharges of the drainages and maintain the EC of the NS at optimal levels for plant growth in the Mediterranean area, the addition of low EC water as fresh water is needed. To obtain this low EC water, we propose to attach to the current North European Close Systems a Purification Unit (PU) with a Reverse Osmosis System. Reverse osmosis (RO) is a water purification technology that uses a semipermeable membrane. This membrane technology is not properly a filtration method. In RO, an applied pressure is used to overcome osmotic pressure, a colligative property that is driven by chemical potential, a thermodynamic parameter. RO can remove many types of molecules and ions from solutions, and is used in both industrial processes and the production of drinking water. RO is commonly known for its use in drinking water purification from seawater, removing salts and other effluent materials from the water molecules.

Besides, the pilot plant has been tested in a representative agronomic area typical of the Mediterranean region. Other areas within this region have similar problems regarding climate and availability of good quality water is a problem. Therefore, the pilot plant tested in these conditions can be implemented in these other areas.

Additionally, the pilot system has been assayed in tomato plants, one of the most economically important and extended crop in south Europe. The tomato crop is produced in the 38% of the European greenhouse surface.

On the other hand, the substrate used in the demonstration is coco peat, which among all substrates may produce the most problems regarding turbidity of the drainages and the microbial content. Therefore, the demonstration is performed with the least favourable case in order to facilitate its transferability and replicability.

All in all, the above aspects will make the pilot plant to be easily transferred to other areas of the Mediterranean region, with greenhouses of different sizes, producing any other species under soilless culture with substrates such as coco peat, perlite, vermiculite or other substrate.

- **Expected results and environmental benefits**

- The main result is the demonstration of the feasibility of the transformation of open soilless production farms into close soilless production farms.
  The pilot system with its technology underlying will be able to collect the drainages coming from the normal irrigation of the tomato plantation, to disinfect them and to adjust the nutrient concentration, pH and electrical conductivity with the purpose of making drainages re-usable for a new irrigation cycle.
  With the project's real data collected, a legal and regulatory framework for drainage recirculation to Euro-Mediterranean regulatory bodies has been proposed.

- Environment enrichment and protection: less contamination and higher protection of the aquifers and ecological niches by reducing the drained fertilizers and applying more sustainable techniques, which will increase quality of life by allowing access to a cleaner a safer environment.

- Reactivation of the local economy: taking into consideration that the contamination of the aquifers and ground water with different drained fertilizers (as nitrates) affects the eutrophication of the local seas, and one of its consequences is the increasing in the population of jellyfishes, by reducing the drainages, the touristic sector will be reinforced, which will reactivate the local economy of this area.

- **Expected longer term results (as anticipated at the start of the project)**

With the previous results, the Project will generate real data to propose a legal and regulatory framework for drainage recirculation to Euro-Mediterranean regulatory bodies and Policy Makers. The regulatory framework will allow the development of specific regulations and laws to encourage producers to transform open producing systems into closed recirculating systems.

These results will also reduce the operating costs of the production farms, demonstrating the feasibility of close soilless systems in the South of Europe.

Under closed-systems the increase in the irrigation frequencies allows the use of nutritional solutions of lower EC, which at the same time will increase productivity of crops and the production and fruit quality

Also, environmental enrichment and protection is expected. The amount of fertilizers not drained to the environment, are not only translated into euros, but also into less contamination and higher protection of the aquifers and ecological niches avoiding eutrophication.

By reducing the drainages, the touristic sector will be reinforced, which will reactivate the local economy of this area

On the other hand, it will contribute to climate change mitigation. Because it leads to a reduction of fertilizers use because of their recirculation, fewer fertilizers will be needed, contributing to reducing their demand, their production and the greenhouse gases emissions derived from their production.

5. Administrative part

LIFE DRAINUSE Project is based on a simple management structure due to the fact that the consortium is formed by 4 beneficiaries: RITEC, UMU, FECOAM, and CEBAS-CSIC. The operational Management structure of the Project has been established taking into account the three main aspects of the project: technical, financial and dissemination. The following diagram shows the Management Board Structure with the personnel categories involved in the project.

The **Management Board (MB)** has been responsible for decision making regarding the execution of the project activities, control and supervision as well as for the fulfillement of the Partnership Agreement. It was chaired by CEBAS-CSIC, coordinator beneficiary, and representatives from each partner involved in the Project: Mr. Vicente Martínez, Project Manager (CEBAS-CSIC); Mr. Pedro Sánchez Seiquer (FECOAM); Mr. Francisco Sánchez Millán (RITEC) and Mr. Miguel Angel Zamora (UMU). Each beneficiary has had one vote of equal value, with the casting vote reserved for the leading beneficiary. **Dr. Vicente Martinez** (CEBAS-CSIC) has been the full time **Project Manager**, responsible for the day by day project's follow up, management and control in terms of time and budget. In addition, **Francisco Rubio** (CEBAS-CSIC) has acted as a Technical Manager.

To ensure the correct monitoring and implementation of the project, the MB has been held every 6 months in specific coordination meetings; coinciding with the Technical meetings to discuss the progress of the running actions. These sessions have been the most relevant decision-making forum during the project.

The most relevant meetings held during the Project have been the following:

- Kick off Meeting at CEBAS-CSIC´s premises on October 21st, 2015
- Meeting on 22nd June 2016 at the premises of CEBAS, coinciding with the visit of the EMT
- Project Progress Meeting at CEBAS-CSIC´s premises on November 25th, 2016
- Meeting on the 4th of May 2017, at the premises of CEBAS coinciding with the visit of the EMT
- Project Consortium Meeting at CEBAS-CSIC´s premises on June 13th, 2018, coinciding with the visit of the EMT.
- Project Final Meeting in Brussels on December 12th, 2018

A list gathering all the meetings held during the Project together with the agendas and minutes of each one of these meetings are included in **"Annex III Meetings" .**

The key documents to facilitate the cooperation within the consortium and assure the quality of the work carried out were: The Project Management Guidelines, **(**DE.1**);** The Grant Agreement (GA) and its annexes including the General Conditions, the Partnership Agreement (PA) and the various LIFE guidelines (Guidance for financial management and reporting 2015, etc.).

CEBAS-CSIC, coordinating beneficiary, internally collected financial and technical reporting information from associated partners every six months. This reporting was used to track project progress and identify rapidly problems and risks, in order to enforce pro-active management. The other beneficiaries have had a specific role in the different actions of the project, and there was a good communication between partners that positively contributed to the success in the conclusion of the different tasks and actions.

<u>Project Progress:</u> In relation to the project progress, it has been executed normally and few deviations from the foreseen planning can be found below:

- The troubles caused by the hiring of external staff and assistance have meant a time delay of 1 month for the A1 action, 4 months for A2 action, 2 months for B3 action and 2 months for D2 action, regarding the planned schedule. The reason for this delay is that CEBAS-CSIC is a public research institution so the procedures for contracting external staff and external assistance are lengthy and bureaucratic. To overcome the problem and to avoid further delays, senior staff was involved in the implementation of these actions. Regarding the external assistance, CEBAS CSIC was initially in charge of the design and launching of the LIFE DRAINUSE website (Action D2) but due to this circumstance, the consortium agreed to move the budget for the website to RITEC. This beneficiary assumed this Action in order to delay the launching of the website but CEBAS-CSIC remained the leader of this action.

  Additionally, FECOAM had some difficulties in action A1 to identify enough producers willing to provide their data and samples which caused a delay in action B1. However, FECOAM managed to collect enough data for the analysis, and action B1 was successfully completed and its results were used in Action B2.
- Action B.2 started on time but were necessary 4 extra months to complete the design of the system planned in this action. Since some changes in the design had to be implemented. Two more irrigation sectors were added which made UMU add more automata for the correct operation of the prototype.
- B3 had a 2-months delay as there were some technical problems and changes compared with the initial design. Finally, this action finished only one month after it was expected (7 months instead 6 months). It must be noted, that it was foreseen with a buffer period of three months so it was possible to catch up and start with the first tomato crop in autumn.
- Action B4 also had a delay in starting of 5 months. It began in June because the installation of the system in B3 finished with delay, but it was managed to begin just in time for the harvest as planned. B4 finished at the same time that the demo (B5) in august 2018, in order to implement any possible adjustment in the system and test it until the end of the harvest. B4 and B5 Actions are complementary, so that, the correct functionally of the Pilot plant could be monitored.
- Actions C1 and C2 started in April 2016 when introducing the initial situation of the project indicators in Neemo website and December 2016. There was a delay as consequence of the previous actions and due to the fact that the project did not produce new and actual data until the prototype was built and the cultivation started so that we could analyse it. However we did started earlier with the elaboration of protocols of measurement, indicators definitions, etc
- Regarding D4, this action started later than the scheduled date because of the lack of consensus about the corporative image and logo.
- E4 It was planned to begin in January 2016 but it was finally started in June 2016. The reason for such delay was because we had no data from the pilot system before June 2016. Although it was started before to work on how the tables were to be developed and what data collection would consist of, the data collection actually began to be collected when the set-up of the pilot system started.

Due to the delay in the commencement of some of the Actions of the Project, an amendment was requested to extend the Project 4 months so that the Project could be completed successfully. The Project was extended until December 31st., 2018. Some of the pending deliverables due dates were updated in line with the extension of the pertinent Actions. We include below the updated deliverables submission dates and milestones .

Milestones:

Milestone	Number		
Workshop organization	D 1	30/04/2018	17/12/2018
Final Infoday organization	D 1	01/07/2018	17/12/2018
Final-Term indicators values obtained	C 1	31/08/2018	31/12/2018

Final-Term socio-economic indicators	C 2	31/08/2018	31/12/2018
Socio-economic Impact Assessment	C 2	31/08/2018	31/12/2018

The wokshop took place on November 29th, 2018 and the Final Infoday Organisation on December 12th, 2018.

Deliverables:

Deliverable title	Number		
Impact of project actions effectiveness	DC1.1	31/08/2018	31/12/2018
Socio-economic Impact Assessment Report	DC2.1	31/08/2018	31/12/2018
Dissemination portfolio report	DD1.5	31/08/2018	31/12/2018
Scientific publications report	DD1.6	31/08/2018	31/12/2018
Layman's report	DD3.1	31/08/2018	31/12/2018

Communication with the EASME and Monitoring team

There has been a fluid communication with the External Monitoring Contact: Mr. Cristóbal Ginés, who is regularly informed regarding technical and financial progress. After his last visit, on June 13th, 2018, we received a letter from EASME with some comments on Deliverables related to the Actions B6; B7 and B8. We have duly implemented these comments in the correspondent Deliverables. We received as well a Letter dated December 8th, 2017 after submitting the Mid Term Report, which response and correspondent documentation requested has been included in Annex I of this Report.

6. Technical part

o Technical progress, per Action

6.1.1. Action A1 Assessment of soilless cultures in European countries; crops, Technologies and operating conditions.

Beneficiary responsible		Status
CEBAS-CSIC		Finished
Time schedule per Annex I	Starting date	End
2 Months	September 2015	October 2015
Real time schedule	Starting date	End
3 Months	October 2015	December 2015

Description of the action: One of objective of this action was to obtain relevant information on agricultural production in greenhouses in Europe, focusing research on the Mediterranean area. This information was going to be used to assess the transferability of the results of the demonstration phase to the rest of the Euro-Mediterranean countries. A detailed report can be found as Deliverable A1.1. CEBAS-CSIC was responsible of this characterization.

The second objective was the identification and characterization of different local farmers using soilless cultures. Despite some local producers were unwilling to make public their company's name and data in the report. FECOAM managed to identity enough producers for a successful characterization in the following actions.

A1 action results showed that many of the producers in Murcia did not use soilless systems for tomato cultivation. And when producers used soilless system they used perlite and coco peat substrates and pepper was the chosen crop. These results are useful for transferability of the B8 action plan, in order to adapt the pilot system to other crops such as pepper and with other clean substrates like perlite, as well as increase the area of cultivation with larger greenhouses, going from 500 m2 (like the prototype) up to 2.5 ha as some commercial farms in Murcia.

On the other hand, samples collected from nutrient solution, water and drainage, were used to develop Action B1, where the mineral composition (cations and anions) of these samples was analyzed. This data served as example of probable situations/problems that could happen when preparing different nutrient solutions. A report with the characterization of the nutrient solution of drainage was prepared (deliverable DB1: "Characterization of waste nutrient solution for cycle production of 15 greenhouses tomato soilless close"). Moreover, these data were very useful for the design of the nutrient solution unit in the intelligent control unit (software) in Action B2.

Taking into account variables like the concentration of nutrients in drainage, possible nutritional imbalances and different qualities of water, we prepared a set of nutrient solutions. The results of the study carried out in Action A1 allowed us to understand the initial situation in a greenhouse production with open system. It was necessary to gather these initial indicatos to develop the indicators of progress in action C1, so that we were able to compare the data in an open system with the data that obtained throughout the project with a closed system.

The data obtained from action A1 has also been used in Action C2 to analyse the socio economic impact which would have on the population, the transformation from open to closed system, as well as all the benefits for the environment.

Comparison of progress The results allowed the characterization of the ideal nutrient solution in action B2 and to be used in the demonstration phase.

Problems (Problems encountered / solutions proposed): It was planned to hire of a bachelor to perform part of the action, but, CSIC internal procedures delayed the effective starting date of the action. To overcome this problem and to avoid further delays, senior staff was involved in the preparation of the Deliverable A1.

FECOAM has been in contact with local producers and some farmers were unwilling to make public their company´s name and data in the report, which delayed the identification of enough producers. However, it was managed to collect enough sampling of data for the analysis.

Deliverables: A1.1: Final report on "Agricultural production under greenhouse conditions in Europe, Mediterranean areas and southeaster Spain and existing legal normative" an A1.2 "Records of local producers".

6.1.2. Action A2: Definition of nutrients solution for soilless horticulture production

Beneficiary responsible		Status
CEBAS-CSIC		Finished
Time schedule per Annex I	Starting date	End
2 Months	September 2015	October 2015
Real time schedule	Starting date	End
4 Months	January 2016	April 2016

Description of the action: The objective of this action is to study the nutrition, irrigation, substrates and nutrient solution used in soilless crops, both in Europe and in the Mediterranean area. And to identify the economic advantages in the use of the different nutritional balances with different substrates (yield and quality). The study describes the essential nutrients for plants and among others their function in different metabolic and physiological processes and symptoms of deficiency.It also details the different types of substrates used in Europe, describing their characteristics and differences.It also includes a study of soilless cultivation systems and different types of substrate. If this affects the production and final quality of the product, that should mean benefits or economic disadvantages for the farmer. With this information the nutrient solution for the demonstration phase can be prepared

The conclusions obtained in the A2 action are being applied in the Action B5. With the conclusions of the study on nutritive solutions, modified Hoagland nutrient solution was chosen to grow tomato plants. As it is indicated in the DA2.2 report, it is the principal species of plants that could grow without problems and without any deficiencies in this nutrient solution.

Depending on the type of substrate is necessary to wash the substrate, greater or lesser frequency of irrigation, etc. The substrate chosen in the demonstration has been coco peat because was dirtier than others like perlite, so the irrigation frequency should be moderated with a percentage of drainage between 25-30% to prevent the salts accumulation and CE increase.

The chosen nutrient solution for soilless horticulture production is presented in the following table:

Table 1. Nutrient solutions for soilless horticulture production. H&A Hoagland and Arnon (1950), S&S Sonneveld and Straver (1994).

Macronutrient	H&A	S&S (cucumber)	S&S (tomato)	Micronutrient	H&A	S&S (cucumber)	S&S (tomato)
	mmol per litre				µmol per litre		
NO_3^-	14.0	16.00	17.00	Fe	25.00	15.00	10.00
$H_2PO_4^-$	1.0	1.25	1.50	Mn	9.10	10.00	10.00
SO_4^{2-}	2.0	1.375	2.50	Zn	0.75	5.00	4.00
K^+	6.0	8.00	8.00	Cu	0.30	0.75	0.75
NH_4^+	1.0	1.25	1.00	B	46.30	25.00	20.00
Ca^{2+}	4.0	4.00	5.25	Mo	0.10	0.50	0.50
Mg^{2+}	2.0	1.375	2.00				

Comparison of Progress : With this information the nutrient solution for the demonstration phase can be prepared, and can be applied in Action B5. Hoagland nutrient solution was chosen to grow tomato plant.

Problems (Problems encountered / solutions proposed): No mayor problems were encountered.

Deliverables

- DA2.1: Final report on: "Definition of nutrients solution for soilless horticulture production".
- DA2.2: Report on: "Economic advantages of the different nutritional balances substrates. Yield and Quality".

6.1.3. Action B1: Characterization of nutrient cycle for soilless tomato production

Beneficiary responsible	Status	
CEBAS-CSIC	Finished	
Time schedule per Annex I	Starting date	End
2 Months	September 2015	October 2015
Real time schedule	Starting date	End
4 Months	January 2016	April 2016

Description of the action: The principal objective of this action is to perform the characterization of drainage of a closed-loop solution. The samples to be used were these ones collected from the 15 local producers (A1 action) identified by FECOAM.

The samples arrived at the facilities of CEBAS-CSIC by intermediation of FECOAM and they were refrigerated and analyzed. The analysis of microbial activity by BOD5 drainage solution was planned but eventually was not measured. The samples arrived at the facilities too late to perform the analysis since it requires measuring the biological oxygen immediately.

Dispite this fact, analysis of the electrical conductivity between the drainage and the nutrient solution shows that there are some differences depending on the percentage of drainage applied, the substrate used and the age of the crop.

The electrical conductivity of the drainage, that is recirculated back to the water system, sometimes was higher for the tomato crop (> 5000 µS/cm) than for the pepper crop (> 3000 µS/cm). This could affect the commercial production of the producers.

With regard to the composition of the drainages, depending on the concentration of Na and Cl in irrigation water, it would be necessary to replenish certain nutrients or dilute with water occasionally. On the other hand, irrigation water used has been of good quality, going from 500 to 1600 µS/cm. In most cases was about 1100 µS/cm, which is water of good quality suitable for all types of crops.

Table 2. Drainage composition.

Nutrients	Drainage 30-	Drainage 25-	Drainage 20-	Drainage 15-
B (µmol/L)	6,59	28,67	21,77	26,77
Ca (meq/L)	2,53	6,55	7,50	6,32
Cu (µmol/L)	0,68	0,79	0,49	0,70
Fe (mmol/L)	4,90	31,87	20,40	27,61
K (meq/L)	16,86	3,33	3,48	3,01
Mg (meq/L)	5,80	6,00	5,96	6,03
Mn (µmol/L)	9,80	7,07	6,12	7,05
Mo (µmol/L)	nd	0,53	0,28	0,53
Na (meq/L)	12,11	11,81	11,74	11,41
P (meq/L)	0,35	0,57	0,83	0,72
S (meq/L)	17,55	11,66	11,71	11,27
Zn (µmol/L)	0,41	1,03	1,18	0,76
Cl^- (mmol/L)	11,67	12,55	12,37	12,36
NO_3^- (mmol/L)	2,01	7,14	8,61	6,82
PO_4^{3-} (mmol/L)	0,04	0,66	0,81	0,80
SO_4^{2-} (mmol/L)	7,53	6,36	6,04	5,86

Comparison of Progress: Deliverable B1, a detailed report of the characterization of waste nutrient solution for closed cycle production of 15 greenhouses tomato soilless has been produced, including: Measuring of the drainages and water consumption volumes; Analytical report of drainages; Detailed Report table of the Characterization of waste nutrient solution for close cycle soilless tomato production

All this information has been useful to test to the formula of the Unit Nutrition (software) of Action B2.Since data collection is real, it has ensured the possibility to prevent possible deviations from the nutrient solution in Action B5.

Problems (Problems encountered / solutions proposed): The difficulties encountered by FECOAM in action A1 delayed the analysis. CEBAS-CSIC completed this action, with follow-up meetings, analysis of samples, drafting and interpretation of results and correction of the deliverable that includes this action.

It turned out that the BOD5 data was not essential for the design of the pilot plant and taking again the samples for this analysis, along with the accumulated delay of the previous action, resulted in an unforeseen delay in the action. This delay do not caused a project delay as the results gathered were used in action B2.

Deliverables: DB1: “Characterization of waste nutrient solution for close cycle soilless tomato production of 15 greenhouses”.

6.1.4. Action B2: Pilot plant design of the integrated system for water reuse and recycling

Beneficiary responsible		Status
RITEC		Finished
Time schedule per Annex I	Starting date	End
3 Months	November 2015	January 2016
Real time schedule	Starting date	End
7 Months	November 2015	May 2016

Description of the action: In this action UMU, CEBAS and RITEC had several meetings to prepare the design of the prototype pilot plant. This design included all the technical details for achieving its development in Action B.3. Interactions between modules were also defined in this action. Basically, the design was divided in four different subsystems composed by:

- **Nutrition and irrigation unit.** This unit is controlled by a PLC that prepares the nutrient solution with the required concentration of fertilizers and acid, according to the set points for pH and different nutrients concentration. The unit is composed of the following elements: tank (irrigation, fertilizer, mix, drainage collection), hydraulic component (tubes, valves, etc.), pump, electrovalves, sensors, volumetric counters and electric panels.
- **Purification unit**. This unit consists in a reverse osmosis plant type HRO 20 P produces 12 m^3/day of low conductivity water.
- **Disinfection unit.** The disinfection was initially performed by an UV equipment. In the UV disinfection process, water is purified as it runs through a stainless-steel chamber (also called a "reactor") that contains a special UV-producing lamp. As the water flows past the lamp, the microbes in the water receive a lethal dose of UV. It should have an electrical consumption of 30 W and a nominal flow of 19 L/m. A filter to eliminate the main particles that come from the Raw Drainage Tank was included. The disinfected water is stored in a 5000-l tank with control level, where the quality of this water is analysed. As described below, the disinfection system performed by an UV equipment didn´t work as expected and an alternative desinfection system was used.
- **Control unit**. The control unit consist in two main parts. The software for configuration, data recording, support decision system, user web interface, and the hardware, with the necessary electronic component for communication and control all the units.

The system uses water from tap, but when necessary, it could use water from the purification unit too. The collected drainage after irrigation is disinfected (initially with an UV system that had to be changed later), creating a closed loop for the irrigation procedure.
The design was adjusted in Action B3 and B4, where the whole system was assembled, and set-up was done.

Comparison of Progress: The action B2 started on time but there were necessary four extra months to complete the design of the system planned in this action. Actions B1 and B2 have been developed simultaneously from January to April. The information from the analysis of Action B1, added to the results from Action A2, have been used in the design of the nutrition unit and the Control Unit. The design of the Disinfection Unit was performed by RITEC. RITEC has a proven historical record of soilless installations. RITEC carried out the descriptive drawings relating to the purification and disinfection systems. Modifications in the disinfection unit affected the design and were carried out in actions B3 an B4.

Problems (Problems encountered / solutions proposed): The pilot system, including nutrition, irrigation, disinfection and purification unit did not fit into the current facilities of CEBAS-CSIC. It was needed to design and extent the warehouse another 60 m^2. UV lamp performance wasn't as good as expected and it was replaced by an ozone equipment for disinfection, that reached the expected disinfection objectives without damaging the installation.

Deliverables: **DB2.1**, Technical detailed document of the disinfection unit; **DB2.2** Technical detailed document of the CU: **DB2.3** Technical detailed document of the purification unit; **DB2.4** Technical detailed document of the pilot system.

6.1.5. Action B3: Construction of the integrated system for water closed cycle

Beneficiary responsible		Status
RITEC		Finished
Time schedule per Annex I	Starting date	End
6 Months	February 2016	July 2016
Real time schedule	Starting date	End
7 Months	Abril 2016	October 2016

Description of the action: The objectives of the action B.3 were the construction of the whole system (nutrition, purification, disinfection and control units) designed in action B.2 in the warehouse, and the verification of the commissioning and management with the unexpected events. The first step was a revision of the CEBAS-CSIC facilities. In this revision, two changes were needed respect the foreseen plan. An extension of the greenhouse of 60 m2 was needed. In addition, the greenhouse was prepared to carry out the agronomic assays. The module of greenhouse to be used for the project was cleaned, emptied, and raked the gravel and the weeds, etc. It has been placed a tarp covering the floor in order to avoid weeds growth in the future. From this point, it was started the building of the channels of culture which were also assembled with blocks, clay bricks and bards. In addition, panels of the cooling system were switched since the old ones were in poor condition and the system was out of service. Hangers and clips of staking for two cycles of tomato crop under B5 activity were acquired. Bags of coco peat substrate for both culture cycles were also bought. Moreover, sensors of humidity-temperature were renewed for the irrigation house climate control, as well as the nozzles and sprinklers system fog-system.

RITEC installed the irrigation facility for water-closed cycle. This part involved the nutrition unit, osmosis plant, irrigation system, disinfection unit, pipes and pumps connection, as well as electrical and mechanical connection. In parallel, UMU responsible for the integration of information from different components, developed and implemented a web-based application (SCADA web) and hardware control unit to control and monitor the nutrition system including the infrastructure built by partner RITEC. Moreover, UMU has built the control unit that manages the other processes of the system.

Comparison of Progress: Based on the pilot plant design and technical documentation from Action B2, the whole pilot plant with all units and components physical and digitally connected were installed. Finally, the correct functioning of the system was tested in action B4.

Problems (Problems encountered / solutions proposed): There were several design changes during the construction phase. First, we realized that there was no place to build the prototype in the warehouse and we had to expand the warehouse in 60m^2. Following the instructions of the EC, the costs of this extension were included as “infrastructure” in the Financial Statement. At the same time,the Consortium did not have to incur in some of the costs foreseen in the budget for the greenhouse conditioning: ceiling of the greenhouse, new mesh plastic of shade, frequency variators and propagation chamber. Therefore the costs of the extension were compensated with these savings. It is described in detail below.

The second change was the number of irrigation sectors. Initially, we considered one irrigation sector (one treatment tank). After discussing with the partners, it was decided to work with three irrigation sectors (it permits the use of three treatments during the agronomic assays). This decision implied some changes respect to the initial design. Three tanks had to be used to irrigate with different treatment (different water quality). More tanks implied more pumps, valves, sensors, and a considerable modification in the hydraulic installation. In addition, we had problems with the electrical installation because there were a lot of signals coming from different PLCs and we had to separate them in different blocks. Finally, we had to change some flow meters and a pump that did not worked properly.

Despite the increase in the number of automata devices and electric panels (more sensor/actuator signals to monitor the system), there were not any additional technical problems, mainly due to the scalability of the system. The only consequence was a small increase in time and cost that were assumed by the Consortium. Another change implemented was the management of the process by the automata. Initially, we defined the management of the whole process with two master automatas, but afterwards, once the system was implemented, we decided to control the management only with one master automata. The new hardware architecture allows simplifying the intra-communications among the different automata and keep the distributed nature of the system through the master-slave CAN bus communication.

Deliverables: **DB3**. Report on different unit's assembly and whole pilot plant construction.

6.1.6. Action B4: Pilot plant set-up, and follow up

Beneficiary responsible		Status
RITEC		Finished
Time schedule per Annex I	Starting date	End
20 Months	Mayo 2016	December 2017
Real time schedule	Starting date	End
24 Months	October 2016	October 2018

Description of the action: The aim of this action was to complete the final prototype, the Pilot plant set-up and the follow up. B4 and B5 Actions are complementary, so, the correct functionally of the Pilot plant should be monitored to ensure the correct performance.

Production system in greenhouse was connected to Pilot plant by means of the irrigation system and drainage cubes. Irrigation system was designed in 3 irrigation sectors. This action has been carried out to verify all units of the pilot system worked properly.

The different units integrated into the Pilot plant and monitoring have been: Irrigation and Nutrient solution unit, purification unit, disinfection unit and control unit. The drained water was collected and analysed for nutrients concentrations, pH, EC and microbiological analysis (bacteria, fungi and yeast).

This action covered pre-commissioning, commissioning, start-up of the installation and test of the equipment, to prove that was functioning correctly. Pre-commissioning involved the electrical, instrumentation and mechanical verification of the installation, according to the design.

After commissioning, the plant was ready to work according to the specification of the project. The start-up procedure continued until it reached a safe level of operation and guaranteed stability operational. The principal activities to be implemented are the following: check-up, collecting data, start-up system, adjustment of the equipment, instruments and system. When the commissioning was ended, we had to continue adjusting equipment, sensors, flow meters and components that gave us problems during the firsts tests of the new plant.

In parallel, Action B4 involved the completion of the backend software of the control unit which included the development of the specific software modules and the tuning of the whole system considering the expected behaviour of the system. During the B3 Action, UMU installed four electric panels with the automata of the control unit, the web-based SCADA and the interface application for user monitoring and control.

Comparison of Progress: A new disinfection system based on electrolysis had to be installed due to the problems encountered. The initial UV lamp couldn't guarantee that the storage drainage would be free of microorganism contamination.

Action B4 and B5 have run parallely. The set up of the pilot plant was not completed until the third cycle which required some specific adjustment were implemented.

Problems (Problems encountered / solutions proposed): Disinfection with UV lamp was not effective in the first crop cycle, since some microorganisms mainly fungi, yeast and bacterium were detected in the drain water after the disinfection. To solve this problem and for the following cycle, it was needed to purchase a new system of disinfection (biodyozon system, see for technical data DB4.1) to be able to compare both systems. So, it was necessary to modify the piping in the house

system for separate collection and disinfection of drainage and be able to apply different disinfection systems. The irrigation was separated in 3 different sectors, where drainage were collected and disinfected separately with two different systems.
On the other hand, we had many problems with flow meters whose flow was too high, and they had to be replaced, with signals. The pump that feeds the Osmosis Plant did not supply enough water pressure and also had to be replaced. The delays in the installation of the system caused a delay in the following action. Anyway, it was managed to start the data record with the harvest in September/October 2016.
The new disinfection system has worked better than the UV system. The bacterial and fungi charge was much lower with the new disinfection system. The results of the second and third tomato cycle can see in the deliverable DB5.
Deliverables: DB4.1: Pilot plant report.

6.1.7. Action B5: Demonstration of water closed cycle in soilless tomato production

Beneficiary responsible		Status
CEBAS-CSIC		Finished
Time schedule per Annex I	Starting date	End
18 Months	October 2016	March 2018
Real time schedule	Starting date	End
18 Months	October 2016	July 2018

Description of the action: The aim of this action was to demonstrate the water closed cycle in soilless tomato production (Pilot plant).
The project planned to carry out two growing cycles at different times of the year. **The first cycle** started at October 2016. Tomato seeds were germinated in artificial substrate (rockwool) under controlled conditions. The seedlings (the dimensions of the greenhouse allowed to plan 1026 seedlings) were transplanted to bags with substrate of coco peat, which is undesirable substrate because it is highly water contaminant. Therefore, an effective disinfection of water drained form coconut substrate is considered a good system for disinfection.
The plants were daily irrigated with nutrient solution. Irrigation system was controlled by a developed software. Drainage volume, pH and EC in the greenhouse were daily controlled. Drained solution was stored in a container of 2000 L. Afterwards, it was disinfected, during the first cycle with an UV lamp and then it was stored in a deposit of 5000 L to be used later on. Mineral composition (anions and cations) and microbiologic control of the nutrient solution of irrigation and drainage were analysed weekly to ensure that the calibration of the software was correct. Plants were too close to each other and presented too much density. This situation, made that the ventilation between the plants was not optimal, together with the climate, high relative humidity, led to the fact that the crop had a severe fungal infection. This situation made the first fruits and the size of the fruits of the first clusters not commercially suitable.
On the other hand, we found that the UV disinfection system, although it was able to decrease the microbiological load, was not a final solution to the problem of disinfection (further information can be found in DB5). We noted that when drainage passed through the UV lamp, this solution was disinfected, but when analysing the storage tanks we saw that the microbial load increased with days. Although we put automatic recirculation through the UV lamp, this was not able to put an end to the microbiological load.
For the second cycle, it was planned to use the three sectors of irrigation. Two different qualities of water and two disinfection system, UV and a second one that synthesizes a liquid oxidizer with electrolysis from salts. The aim of this change was to obtain more information about the prototype working with both types of irrigation sectors. In the second cycle, the production was higher than in the previous one. The production of tomato was 7,4 Kg of tomato per plant. The quality of tomato fruit improved regarding its color, texture, flavor and nutritive value.

Tomatoes had good quality, and they had a pleasant taste and aroma. The differences between water treatments and disinfection had an impact in the production and the quality of the fruits.
Even if not foreseen in the Grant Agreement we decided to carry a third cycle to consolidate the objectives of the Project. During the **The third cycle** , the system operated acceptably, however, we realised the need to improve and optimeze some of the processes. Concerning the development of the crop during the first stage of development the plant grew, and no significant problem was detected.
The results of consumption must be observed with reservations by the problems discussed previously with the crop. The water and fertilizers saved have been substantial. Control of nutrition and the preparation of nutritive solutions have been satisfactory.
Three different treatments were applied in this cycle. Each treatment had a different Electrical Conductivity (EC) in order to reuse the drainage as much as possible for the preparation of the nutritive solutions. During crops development the drainages nutrients concentration increased. It lead to an increase of the electrical conductivity of drainage. Therefore, in each treatment, a maximum EC value was established for the nutrient solution: T1, 3 mS / cm; T2, 5 mS / cm and T3, 7 mS / cm. Each treatment was applied in 3 rows with 54 plants each row.
In this cycle, the production of tomato was 14.5 Kg / m2, higher than in the first and second cycle. At the beginning of harvest, the treatment with the highest CE in the nutrient solution (T3) had the highest production of tomatoes. However, at the end of the experiment, tomato production was reduced in treatments with a higher CE (T2 and T3). Tomatoes had good quality, and they have a pleasant taste and aroma.
More detailed data of the analysis performed, and results can be found in the Deliverable DB5

Comparison of Progress:

In the first cycle, the saving of water and fertilizers was higher; however, optimal values of production and tomato quality were not obtained due to the problems with the disinfection of the drainage. Therefore, this cycle was not representative of the crop.
In the second cycle, different disinfection treatments were tested, in order to study which one was the most appropriate for the crop. The results of the production were better than in the previous one, however, it still did not reach the characteristics of a commercial exploitation, so a third extra cycle was designed to prove that the system worked appropiately.
In the third crop cycle, the disinfection system that had worked best in the second cycle was used. In addition, 3 different saline treatments were added. The best production values were obtained, Based on the results obtained with the indicators, the third crop cycle was the most satisfactory in terms of saving water, fertilizers and harvest production.**Problems (Problems encountered / solutions proposed):** The principal problems detected in the B5 Action were related to the first crop cycle and are detailed below:

1. Tomato crop was affected by plague, principally by fungi attack. The reason suspected for the plague was a problem with the UV disinfection system: some microorganisms such as fungi and bacterium were detected after the disinfection.
2. Desirable quality: Only the fruits collected from the 1 to 7 cluster were small (non-commercial). The reason may be due to the low temperatures of winter and this factor coincided with the setting of the first clusters). After that the following fruits were of good quality and commercial.
3. Plant density was far from the optimal values.

Belos, the solutions proposed to each problem that were implemented in the second crop cycle:

1. Since it did not work very well and there was still microbial load, the UV was programmed to recirculate the drainage deposited in the tank of 5000 L two hours each day. This happened the last two months of the experiment at the first cycle.
2. This solution lower the microbiological charge of the reservoir, but do not solve the problem. For the second cycle, and after evaluation of different alternatives, we considered to try the

disinfection with a German machine (SOB) that synthesizes a liquid oxidizer with electrolysis from salts. During this cycle we compare the effectiveness of both disinfection system.

3. In order to improve the second cycle, the plant density was changed with fewer plants per m^2. This allowed better air recirculation between the plants and less probability of disease by fungi.

Deliverables: **DB5.1.** Report of the Software Efficiency in the Management of nutrients, drainages corrections and irrigation in tomato plants; **DB5.2.** Report in production, yield and quality of tomato in a closed system; **DB5.3.** Report in water, fertilizers and energy consumption in a closed system; **DB5.4.** Report in nutrient concentration and volumes of the drainages obtained from coco peat substrates. With this Final Report we have updated these 4 Deliverables gathering the results of the Third cycle. In each of the deliverables, the values of the first, second and third cycle are collected in order to improve the understanding of the results.

6.1.8. Action B6: Economic feasibility analysis

Beneficiary responsible		Status
CEBAS-CSIC		Finished
Time schedule per Annex I	Starting date	End
3 Months	January 2018	March 2018
Real time schedule	Starting date	End
3 Months	January 2018	December 2018

Description of the action: This action is an economic analysis on the costs of design, installation, commissioning and operation of the pilot system DRAINUSE. A Deliverable to gather al this analysis has been prepared. In this Deliverable the study has been structured going from small scale into a big picture were several factors has been considered. First step has been to calculate the price that an hypothetical installation of the closed cycle system developed during the project would be for a farmer in scenario of a 1 Ha greenhouse of tomato soilless crop and the costs of energy and supplies that it would imply. As a result, 72.220 €/Ha is the cost of the implementation with a complete close system.the investment to convert an open cultivation soilless system into a closed system, it will depend on the units that already have the exploitation.

The operating cost of the facility would be of 805 €/year·Ha, from this amount, 614€/year Ha would correspond to the energy costs of the plant and 191 €/year·Ha would correspond to the costs of the disinfection and purification product. The estimated costs for fertilizers and irrigation water would be of 4636€/year Ha. Adaptation to multiple scenarios is possible due to the modular nature of the system. The final price of the installation will be in any case determined by the different conditions of each scenario.

For that reason, the second step in this economic analysis is to describe the factors that will condition the final configuration of the closed system. As a result of the study of different sources, it can be concluded that the quality of the water, climatic region, type of substrate, type of crop, the original facilities and its size are the most important factors that will influence the final set up of a new installation of the closed system.

As the Mediterranean region is the most common area and where RITEC has an important part of their commercial activity, a study of the implementation of the system in a Mediterranean scenario with a tomato greenhouse, has been chosen. The simulation of the implementation of the closed system in a Mediterranean climate during the first year of operation has determinate an estimate of € 126,761 taking into account the cost of the Life-Drainuse System, its running costs, crop energy cost, water cost and fertilizers, costs derived from the cultivation and personnel of the greenhouse. If the project was developed outside Spain, the total would be € 131,341, mainly due to the increase in the cost of installation for labor.

If the case of the study implies the setting up from no previous installation, which means building the entire high-tech greenhouse from cero, the cost of the closed system will represent only the 8,9% of the total investment.
A good replicability degree of the closed system can be achieved if an exhaustive preliminary study of the starting conditions is carried out in order to be able to design and configure the different modules and its capabilities.
The sales study of the prototype is presented upwards with a few units sold in the first years up to an average of 25 units per year once the brand is consolidated in the market.
And finally, the 10-year study of profitability of the design and construction of the system shows a NPV of 305.678 € and an IRR of 18.53% with an investment recovery period of 4-5 years, for which the operation is considered profitable.
Problems (Problems encountered / solutions proposed): No problems have been faced in this action
Comparison of Progress: Action B6 started when the action B5 (second cycle) finished, in order to complete the costs of the prototype and the demonstration.
Deliverables:DB6.1. Economic report of the resource costs (water, fertilizer, energy, personnel…) and market product value at the end of the first and second culture cycle; **DB6.2**. Economic report of the system construction costs; **DB6.3**. Final economic report

6.1.9. Action B7: Legal feasibility analysis

Beneficiary responsible		Status
CEBAS-CSIC		Finished
Time schedule per Annex I	Starting date	End
3 Months	January 2018	March 2018
Real time schedule	Starting date	End
3 Months	January 2018	December 2018

Description of the action: In this action, an exhaustive study of the existing national and international normative on water protection and nitrate pollution has been carried out in order to guarantee that the pilot plant proposed in the project is completely legal. The Legislation was studied at a Community Level, National Level and Regional Level.
In each one of the sections, laws related to the implementation of the pilot plant were studied, such as the regulations on water, the use of fertilizers and the dumping of waste.
To accomplish this study, each of the four units that compose the system were studied separately: control unit (UC), (ii) disinfection unit (UD), (iii) purification unit (UP) and (iv) unit of nutritious solution (USN).
Finally, it was concluded that none of the four units require any special permission for their installation and it is completely legal in Spain and in the rest of the countries of the European Union. The pilot system can be installed without having to request any permission for its use.
LIFE-DRAINUSE project has proposed legislative measures that require the joint action of regional, national and European government. In this way, sustainable agriculture and soilless culture will be promoted, in order to achieve a management of natural resources that provide benefits both to our environment and our economy, as well as to social welfare and ultimately to the health of people.
Problems (Problems encountered / solutions proposed): No problem was encountered.
Comparison of Progress: When the project began there was no law in the Region of Murcia that regulated the discharge of drains in soilless culture. At the end of the project, the law 1/2018 has been approved prohibiting the use of fertilizers highly soluble in soilless culture without a closed recirculation system.
Deliverables: DB7: Legal Feasibility report.

6.1.10. Action B8: Transferability of LIFE DRAINUSE results

Beneficiary responsible		Status
CEBAS-CSIC		Finished
Time schedule per Annex I	Starting date	End
3 Months	January 2018	March 2018
Real time schedule	Starting date	End
3 Months	January 2018	December 2018

Description of the action: The objective of this deliverable was to carry out an evaluation of the LIFE-DRAINUSE system transferability to other scenarios, taking into account the characteristics of the system, the cultivated species and the scalability to the dimensions of other greenhouses. After the study, it was concluded that the transferability of the LIFE-DRAINUSE system to other European countries is supported by the directives in relation to the reuse of water and the environmental concerns arising from intensive agriculture.
In addition, due to its modular, scalable and adaptable nature, the pilot system is ready to be installed in any country because it is easily implemented and transferable to any type of climate and exploitation increasing the dimensions of the units that will be installed.

Problems (Problems encountered / solutions proposed): Before the transfer of the pilot system into other areas or countries:

- It is necessary to study the characteristics of the area where the pilot plant will be implanted.
- Have a technical knowledge about the agronomic requirements of the crop.

In this way, the cost of implementing the pilot plant could vary, because it is possible to dispense with any of the units that make up the system. In any case, the cost of implementing the system would be more expensive in other countries than in Spain, because it would increase the cost of labor.
Comparison of Progress: To raise awareness of the system and increase its transferability, LIFE-DRAINUSE project has had meetings with stakeholders such as farmers and government agencies. On the other hand, the results obtained in the LIFE-DRAINUSE project has been published in media such as newspapers, radio and television and in networking with other projects.
Deliverables: DB8.1: Transferability report

6.1.11. Action C1: Effectiveness of LIFE DRAINUSE actions are compared to the initial situation

Beneficiary responsible		Status
CEBAS-CSIC		Finished
Time schedule per Annex I	Starting date	End
36 Months	September 2015	August 2018
Real time schedule	Starting date	End
28 Months	April 2016	December 2018

Description of the action: The aim of this action has been to develop and implement a set of indicators that have allowed us to measure the impact of the project in a real way in terms of environmental impact, basically. Initially some the indicators were initially selected to be able to evaluate the impact of the project, during the project duration, we considered that there were other indicators which could be even more interesting to evaluate the positive effect of closed systems on the environment. In April 2016 all these indicators were uploaded to the NEEMO website.
In addition, monitoring protocols have been developed to follow the correct operation of the pilot plant during the whole cycle. These protocols have been aimed at checking and correcting the instrumental material of each of the sections, to avoid errors in the measurement of values and to check if they were being measured correctly.

Comparison of Progress:
After the problems with the fungi in the first cycle, the second one was carried out without problems except for a problem with the low temperatures.
It was not cultivated in the right season. Because of the incomplete results in these two cycles, a third one was required. This last cycle was very successful and demonstrated the potential of the proposed solution.
As general conclusions of the impact of the project we can highlight the following:

- In a closed system, water consumption is 41% lower than in an open system, from a consumption of 22,813 m3 / ha / year to 13,457 m3 / ha / year.
- Fertilizer consumption is reduced by 60% N/ha/year and 12% P/ha/year and 48% K/ha/year.
- The dumping of fertilizers into the medium passes from 749,813 tons of fertilizers/year in Europe to 0 tons of fertilizers/year.
- This reduction in the consumption of fertilizers in turn means a reduction in the kg of CO2 that are emitted into the atmosphere. By reducing the consumption of fertilizers, 36,928 kg CO2-eq/kg fertilizer saved/ha/year are no longer emitted into the atmosphere. Considering in Europe the area of horticultural crops without greenhouse soil is 152,000 ha, this figure amounts to 5,613,056 tons CO2-eq / kg saved fertilizer/year.

After monitoring the evolution of these parameters during the project implementation, we can conclude that the recirculation of drainages in soilless agricultural systems has direct and indirect environmental benefits.
Problems (Problems encountered / solutions proposed): The defined indicators are parameters that control the system and it has not been difficult to define them. We only had problems when measuring indicators of water consumption, because the counters sometimes were clogged. The solution was to measure these parameters more often and adding protection filters before the counters.
Deliverables: DC.1 Report on Impact of project actions effectiveness report

6.1.12. Action C2: Monitoring the socio-economic impact of the project on the local economy and population.

Beneficiary responsible		Status
FECOAM		Finished
Time schedule per Annex I	Starting date	End
36 Months	September 2015	August 2018
Real time schedule	Starting date	End
21 Months	December 2016	December2018

Description of the action: The aim of this action has been to develop and implement a set of indicators that would allow us to measure the socioeconomic impact of the project. All along the Project indicator have been selected to effectively monitor the impact of the project in these terms.
Problems (Problems encountered / solutions proposed): No problem was found in the monitoring of the socioeconomic indicators.
Comparison of progress: At the end of the project, the socioeconomic indicators demonstrate the effectiveness of the implementation of the systems developed in LIFE DRAINUSE project. After the two programmed cycles and an extra third one, the main effects can be found in cost reduction, production increase and job creation. Main results are described below:

- The production cost decreased due to the reduction of water and fertilizer use. For example, the productivity in terms of water usage was 7.2 kg tomato/m^3 at the beginning of the project. At the end of the project, it was 20 kg tomato/m^3 . In terms of fertilizer usage, the costs in nitrogenous fertilizer were reduced from 9,695 €/ha to 3,296 €/ha. Considering water and fertilizer reduction, the total savings reached 18,056€/ha/year.

- The productivity of the crops also increased from 165,000kg/ha/year in the start of the project, to 368,827 and 373,353 kg/he/year in the second and third cycle respectively.
- The implementation of LIFE DRAINUSE recirculating system creates employment due to the requirements of qualified workers for the correct management of the installations. The recirculating system requires 2 or 3 new employees so, considering in Spain there are 640 SME dedicated to soilless agriculture, the implementation of LIFE DRAINUSE system in these SMEs could create around 1280 and 1920 new job positions.

In conclusion, the actions carried out in the project not only entail environmental benefits, but also an improvement of the socioeconomic environment.

Deliverables: DC.2: Socio-economic Impact Assessment Report

6.1.13. Action D1: Dissemination of the project results

Beneficiary responsible		Status
FECOAM		Finished
Time schedule per Annex I	Starting date	End
36 Months	September 2015	August 2018
Real time schedule	Starting date	End
36 Months	September 2015	December 2018

Description of the action: The dissemination of the project at national and international level aims to raise awareness and demonstrate the effectiveness of the results to implement close systems technology in southern Europe area. With that purpose the following activities were carried out:

Corporate image: Once the corporate image was defined we started with the production of printed and audiovisual material:
1) 1000 notebooks and 1000 pens with the DRAINUSE logo;
2) Project leaflet: Leaflets with basic information about the project. 2000 units were printed in Spanish and English

Roll-up stands and Poster: The poster was displayed among others events, in **iWARESA 2018**. 350 posters and 4 roll-ups were printed. Both are available in Spanish and English (parallel texts in same support).

Demo Film : It was distributed during the Workshop and the Final Infoday events. It has been disseminated in online means and during events to wide audience as well as it has been available at DRAINUSE website to all visitors. The film is in MPEG format for easy viewing on the Internet and lasts about 10 minutes. available in the project website and Youtube (https://www.youtube.com/watch?v=t3kAhEcf9AQ). The video is available in Spanish and subtitled in English.

Media: Press releases have been prepared and distributed to the general media with information of interest to reach to wide audience. All the articles published have been gathered in the D1.5 "Dissemination Portfolio Report". On top of these publications, press conferences and important interviews with journalists have been held.

Table 1. List of press releases referred to LIFE DRAINUSE project

Source	Date	Description	Aproximated audience
Diario de Murcia	18-Sep-2015	FECOAM participates in the LIFE DRAINUSE project with CEBAS, the University of Murcia and the company RITEC	-
La Verdad	19-Sept-2015	Cooperatives seek to reduce pollution from drains crops.	127 000 readers
La Actualidad	28-Sep-2015	Fecoam seeks to reduce contamination of soils and aquifers by crop drainage	-
Mercados de Medio Ambiente	28-Sep-2015	28 Spanish LIFE projects, among them LIFE DRAINUSE, has been financing by EC	-
La Verdad	30-Sept-2015	Research systems to reuse flows used in fertigation.	127 000 readers
La Verdad	15-Dec-2015	A padlock to pollution and waste of water	127 000 readers
Universidad de Murcia	15-Dec-2015	A padlock to pollution and waste of water	-
TENAGA INGENIEROS	17-Dec-2015	The Life Draunuse project will end the waste of water and its contamination.	-
La Verdad	10-Jan-2017	The change towards zero agricultural drainage.	127 000 readers
La Verdad	15-Feb-2017	The agricultural companies consolidate 1500 customers in Fruit Logistica	127 000 readers
La Opinión	26-Feb-2017	Special Fruit Logistica.	63 000 readers
Murcia Televisión	30-Jan-2017	TV report	-
Región de Murcia	03-Jul-2017	Road to agricultural drainage.	-
La Verdad	31-Jan-2018	Murcia field will show its potential in Fruit Logistic.	127 000 readers
La Opinión	06-jun-2018	Water recirculation systems to optimize irrigation.	63 000 readers
La Verdad	28-Nov-2018	The reuse of intensive irrigation saves resources and protects the environment.	127 000 readers
La Verdad	05-Dec-2018	The Drainuse project develops an irrigation system that saves water and fertilizer	127 000 readers
Cooperativas agroalimentarias de España	2018	Closed systems of crops without soil. Towards zero agricultural drainage.	-

Technical Visits: CEBAS-CSIC has carried out several demonstration activities at the prototype venue to show DRAINUSE progress and outcomes. University of Alicante, University of Miguel Hernández as well as a professor form the University of Iran attended these Demonstrations. Further information and pictures of the visits are available in the Deliverable DD1.5.

Events, exhibitions and fairs: FECOAM has programmed and carried out several informative meetings as well as taking part in different events in which has disseminated the Project as listed below.

Type	Date	Place	Name	Message	Public
Fair	09/11/2017	Murcia (Spain)	SEPOR 2017	General overview of the Drainuse project and protoype and benefits	Agro-Producer
Fair	06/02/2017	Berlin (Germany)	Berlin Fruit Logistica	General overview of the Drainuse project prototype and benefits	Export-Companies
Fair	31/03/2017	Murcia (Spain)	FAME INNOWA	General overview of the Drainuse project prototype and benefits	Agro-Producer Export-Companies
Event	10/05/217	Murcia (Spain)	FOOD BROKERAGE	General overview of the Drainuse project prototype and benefits	
Fair	08/02/2018	Berlin (Germany)	Berlin Fruit Logistica	General overview of the Drainuse project prototype and benefits	Export-Companies
Fair	23/10/2018	Madrid (Spain)	Fruit Atraction	General overview of the Drainuse project prototype and benefits	Agro-Producer Export-Companies
Fair	08/11/2017	Murcia (Spain)	SEPOR 2018	General overview of the Drainuse project and protoype and benefits	Agro-Producer

Table 2.Exhibitions and Fairs attended by LIFE DRAINUSE Project

Pictures and description of the different fairs could be found in Deliverable D1.5.

Conferences organized to promote LIFE DRAINUSE: FECOAM, throughout the project, has organized information sessions to present the Project. Below the list of events organised. All of the events were attended by relevant end users and stakeholders.

Date	Location	Country
28/04/2017	Asamblea Fecoam, Salon Restaurante Pedro Marin, Caravaca	Spain
11/07/2017	Centro De Formación Y Empleo De Alhama, Alhama, Murcia	Spain
25/07/2017	Cooperativa Alimer, Cieza	Spain
07/09/2017	Ayuntamiento De Caravaca, Caravaca	Spain
11/09/2017	Infoem, Cieza	Spain
27/09/2017	Cooperativa Thader, Cieza	Spain
14/03/2018	Cooperativa Alimer, Lorca	Spain
20/03/2018	Producciones Biologicas S.L., Aguilas	Spain
05/04/2018	Cooperativa Thader, Cieza	Spain
27/04/2018	Asamblea Fecoam, Auditorio Y Centro De Congresos Victor Villegas, Murcia	Spain
08/05/2018	Info, Murcia	Spain
16/05/2018	Cooperativa Thader, Cieza	Spain
18/06/2018	Jornada Aquemfree, Parque Cientifico Del Info, Murcia	Spain
11/07/2018	Ayuntamiento De Cehegin, Cehegin	Spain
10/09/2018	Infoem, Cieza	Spain
24/09/2018	Casa De La Juventud, Calasparra	Spain
27/09/2018	Frutas Caravaca, Caravaca	Spain
28/09/2018	Cooperativa Agricola Levante Sur, La Puebla, Cartagena	Spain
09/10/2018	Infoem, Cieza	Spain
06/11/2018	SEPOR. Feria Ganadera, Industrial Y Agroalimentaria, Lorca	Spain
29/11/2019	Jornada DRAINUSE, Parque Cientifico Del Info, Murcia	Spain
12/12/2019	Jornada Drainuse, Oficina CSIC, Bruselas	Belgium

Table 3.Conferences to disseminate LIFE DRAINUSE project

Scientific Publications: A scientific article has been published in Bio systems. The title is “Smart farming IoT platform based on edge and cloud computing” and the authors are: Miguel A. Zamora-Izquierdo, Jose Santa, Juan A. Martínez, Vicente Martínez, Antonio F. Skarmeta

Technical Publications: A technical article was published in the technical journal of Agrifood Cooperatives, published in December 2018.

Bilateral meetings were organized the 23th of June 2016, in order to share knowledge and analysed the progress of each project as well as reached results. The program of the event consisted of a presentation on the LIFE programme in the period 2014-2020, with the news of the call. Then, a roundtable discussion was held with success cases.
DRAINUSE´s profile has been published in Facebook and LinkedIn: The links are the following: https://www.facebook.com/drainuse // https://www.linkedin.com/in/life-drainuse-8a8aa7187/
Problems (Problems encountered / solutions proposed): No problem was encountered

Progress Comparison

- The national Workshop was organized in Murcia on November 29, 2018. 50 attendants were in the meeting on behalf of different scientific stakeholders, industry and regional and national administrations. Each DRAINUSE partner shared the details of their tasks in the project, and other LIFE projects were invited to explain their actions. The projects that were invitated were LIFE REUSAGUA, LIFE AQUEMFREE, LIFE DESEACROP and LIFE AGUAINNOVA

- The Final Info Day was held in Brussels on December 12, 2018. It was open to general public as well as relevant stakeholders at international level. A total of 17 attendants participated in the Infoday. Between the attendants there were representants of different Spanish institutions with presence in Brussels like CDTI- SOST (Spanish Office for Sciente and Technology) and the highlighted presence of Alex Schiphorst, from EUChemS (European Chemistry Society).

  Further information about these two infodays could be found in Annex/II. Dissemination .

- Roll-ups, posters and leaflets have been printed and distributed in different events
- Great effort has been done in terms of dissemination. DRAINUSE has been presented in fairs, conferences and exhibitions focusing on its technical aspects and environmental and economic benefits.

Deliverables: **D1.1** Leaflet and roller panel; **D1.2.** Communication and Dissemination Plan; **D1.3** Project's corporate image design; **D1.4** demo video: Transferability report

6.1.14. Action D2: Elaboration of project website

Beneficiary responsible		Status
CEBAS-CSIC		Finished
Time schedule per Annex I	Starting date	End
36 Months	September 2015	August 2018
Real time schedule	Starting date	End
33 Months	November 2015	December 2018

Description of the action: Since all the partners agree that internet is a great source of information and dissemination it was agreed that it would be the main tool of communication of the project. The web page of the project LIFE DRAINUSE is already up and running and is available in English and Spanish. Despite that change, CEBAS-CSIC remains the responsible of this action. The website is regularly updated; it can be checked at http://www.drainuse.eu. The project and LIFE logo are both visible in the website.

Comparison of progress: Currently, the website contains information on the following sections: Partners; General description of the project ; Project objectives; List of the actions; List of the expected results; Progress performed of each phase; Public deliverables; Published articles and News about the project; Multimedia material about the project: Demo video

The number of visits has been gradually increasing, up-to 3865 until May 2017 and 4425 until July 2017. The last update showed a total of 5587 visits and more than 20.000 impressions at the end of the project.

Problems (Problems encountered / solutions proposed): No major problems have been encountered.

Deliverables: There are no deliverables associated to this action

6.1.15. Action D3: Elaboration of the Layman's Report

Beneficiary responsible		Status
FECOAM		Finished
Time schedule per Annex I	Starting date	End
36 Months	September 2015	August 2018
Real time schedule	Starting date	End
36 months	December 2015	December 2018

Description of the action: FECOAM was the partner in charge of carrying out this action. A report has been produced and distributed according to the Communication and Dissemination Plan at the

end of the project. This report has been set up for LIFE DRAINUSE project in order to introduce a general vision of the objectives and results into the society in order to increase its awareness in the environmental problem addressed. It has been printed 200 paper copies to be distributed to journalists, decision makers, business, stakeholders and ordinary citizens.
Comparison of Progress: The final version has already been printed and delivered.
Problems (Problems encountered / solutions proposed): No major problems have been encountered.
Deliverables: DD.3.: Layman's report

6.1.16. Action D4: Elaboration and maintenance of Notice Boards

Beneficiary responsible		Status
FECOAM		Finished
Time schedule per Annex I	Starting date	End
36 Months	September 2015	August 2018
Real time schedule	Starting date	End
33	December 2015	December 2018

Description of the action. A noticeboard design has been chosen in order to draw public attention. Useful links to let people know about more information of the project are also included. The noticeboard is located in Finca Tres Caminos (CEBAS-CSIC) since October 2016, next to the greenhouse.

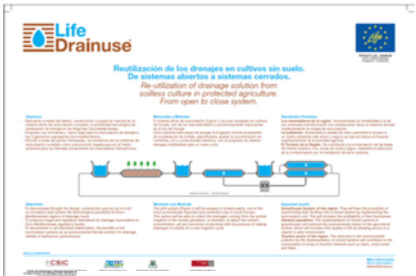


Figure 2. Poster

Figure 1. Noticeboard in CEBAS-CSIC facilities

Comparison of progress: 4 notice boards have been strategically set up in the beneficiaries' facilities, so the information is visible to provide general public an understanding of what is happening in the pilot plant. These noticeboards are located in each partners workplace: UMU, FECOAM, RITEC and CEBAS-CSIC.
Problems (Problems encountered / solutions proposed): This Action started later than the scheduled date because of the lack of consensus about the corporative image and logo. Eventually, the consortium agreed about these issues and noticeboards are already displayed.
Deliverables: D4.4 Notice boards

6.1.17. Action E1: Project management by CSIC

Beneficiary responsible		Status
CEBAS-CSIC		Finished
Time schedule per Annex I	Starting date	End
36 Months	September 2015	August 2018
Real time schedule	Starting date	End
35 Months	October 2015	December 2018

Description of the action CEBAS-CSIC, as project coordinator has kept daily control of the project and organised peridodic

meetings with the consortium to track and plan the project. Further information can be found on section 5. Administrative part.
Despite the great effort invested in creating the External Advisory Board, we did not manage to create it successfully. We contacted RUFEPA TECNOAGRO dedicated to greenhouse construction; the center of research of the Region of Murcia (IMIDA); Concierge of Agriculture of the Region of Murcia and the General Director of Research. Nevertheless all the effort made to build it, allowed the Consortium to increase its visibility among potential users and strengthen future collaborations.

CEBAS-CSIC has been collecting internally financial and technical information from all the partners every six months. This information has been used to track the project progress and identify rapidly problems and risks. It also helped to keep control of the budget expenditure.
Comparison of progress:

- Periodic meetings have been organised to solve technical issues, to track project´s progress and take Consortium´s decisions.
- "Consortium Agreement" (milestone E1) was signed by coordinator (CEBAS-CSIC), and all the project partners.
- CEBAS-CSIC has delivered the "Project Management Guidelines" (deliverable E1).
- CEBAS-CSIC has produced the "Progress Report", the "Mid Term Report" and the Final Report
- CEBAS-CSIC has been the responsible for internal meeting organizations, and for the External Monitoring Team visits (June 2016 and May 2017 and June 2018).
- An amendment requesting the extension of 6 months to the Project has been requested and approved.

Problems (Problems encountered / solutions proposed): No problem was encountered.
Deliverables: **DE1.** Project Management Guidelines

6.1.18. Action E2: Networking activities with other projects

Beneficiary responsible		Status
CEBAS-CSIC		Finished
Time schedule per Annex I	Starting date	End
35	October 2015	August 2018
Real time schedule	Starting date	End
34	November 2015	December 2018

Description of the action: This action is important to exchange good practices and generate synergies or opportunities regarding the scope of the LIFE DRAINUSE project. Networking activities include visits, meetings and exchange of information.
CEBAS-CSIC already took the opportunity to get in contact with the following projects at the Kick-of-meeting of LIFE 2015. These projects were the following: LIFE STO3RE LIFE14 ENV/ES/000150 - Synergic TPAD and O3 process in WWTPs for Resource Efficient waste management; LIFE CELSIUS LIFE14 ENV/ES/000203; LIFE SIAMEC LIFE14 ENV/ES/000849 - Innovative solutions to generate bioenergy and reusable water from residual wáter; LIFE EFFIDRAIN LIFE14 ENV/ES/000860 - Efficient Integrated Real-Time Control in Urban Drainage and Wastewater Treatment Plants for Environmental Protection.They exchanged information about the thematic projects and have some relation in the future for possible meetings, workshops, networking, etc.

Regarding the networking activities with other projects, the following were already carried out (all the details can be found in Deliverable E2):

Type of Event	Date	Place	Name
Networking	**27/09/2016**	**Murcia (Spain)**	**Proyecto LIFE OFREA**
Networking	**23/06/2016**	**Murcia (Spain)**	**Programa LIFE en el periodo de programación 2014-2020**
Networking	**28/10/2016**	**Murcia (Spain)**	**CEBAS (CSIC)-Italian LIFE projects**
Networking	**Feb 2017**	**Murcia (Spain)**	**LIFE DRAINUSE (CEBAS) y LIFE AQUEMFREE (IMIDA)**
Networking	**Ap 2018**	**Murcia (Spain)**	**LIFE DESECROP-LIFE DRAINUSE**
Networking	**May 2018**	**Murcia (Spain)**	**Meeting LIFE**
Networking	**18/06/2018**	**Murcia (Spain)**	**INFODAY AQUEMFREE INFODAY**
Networking	**29/11/2018**	**Murcia (Spain)**	**INFODAY LIFE DRAINUSE**
Networking	**12/12/2018**	**Brussels**	**INFODAY LIFE DRAINUSE**

Table 4. List of networking events with LIFE DRAINUSE participation

Comparison of progress: Networkings activities carried out during the Project open wide range of contacts with policy decision makers at all levels and public funding authorities for example: **Miguel Ángel del Amor** (*Agriculture Minister of Región de Murcia),* **Miguel Ángel Rodenas** (*President of Segura river hydrographic conference)* and **Dr. Emilio Nicolás** (*Member of Scientist Assessment Committee for the Mar Menor*).
New collaborations had been set and this has led to the development of new European, national and business projects to continue advancing in the search for new applications of technology and its transfer in relation to the reuse of water for agriculture. Among the projects achieved we can mention:
• **HIDROLEAF** Project (New cultivation systems RTC-2016-4827-2).
• **BERRIES** 4.0 Project (Greenhouses 4.0 for the production of superfoods 2I18SAE00060).
• Development of a commercial software for the reuse of the ducts of crops without soil (20528 / PDC / 18),
• **Prima WATERMED** 4.0 (efficient use and management of conventional and non-conventional water resources through intelligent technologies applied to improve the quality and safety of Mediterranean agriculture in semi-arid areas)
• **PRIMA Precimed** (precision irrigation management to improve water use) efficiency in the Mediterranean region).
These new projects are financed with European funds and will allow us to continue collaborating with UMU and RITEC.

Problems (Problems encountered / solutions proposed): Not problems were found
Deliverables: DE.2: Networking report

6.1.19. Action E3: After LIFE Plan

Beneficiary responsible		Status
CEBAS-CSIC		Finished
Time schedule per Annex I	Starting date	End
35	Abril 2018	August 2018
Real time schedule	Starting date	End
34	Abril 2018	December 2018

Description of the Action: FECOAM was the partner in charge of carrying out this action.The main objective was to prepare a report with the plan to disseminate the project results for 5 years after the end of DRAINUSE actions. All partners will be involved
Comparison of progress: The final version of the After LIFE Plan has already been printed and delivered to all the partners to carry out the action. In this action all partners are involved.

Problems (Problems encountered / solutions proposed): No problems were found.
Deliverables:DE.3: After LIFE Plan

6.1.20. Action E4: Compilation of information for indicator tables

Beneficiary responsible		Status
CEBAS-CSIC		Finished
	Starting date	End
31 Months	January 2016	August 2018
Real time schedule	Starting date	End
26 Months	Mayo 2016	December 2018

Description of the action: This action is focused on the compilation of information needed to complete the indicator tables (quantitative and qualitative) to be submitted with the official progress reports. The Coordinator is in charge of gathering this information from partners to correctly fill in the mentioned tables.

During the set-up of the first crop cycle, tables of values were elaborated where the data of interest related to this first test has been collected. These tables include data related to irrigation of the plants, reused drainage, amount of used water and fertilizers, biometrics, phytosanitary treatments and production.

Subsequently, these tables have served as a basis for studying the data contained therein, so that we can reach the relevant conclusions contained in actions B5, C1 and C2.

Many of the data has been extracted from the database, where it has been automatically stored in the software. Later, this have been interpreted and reordered for later study. Other data, however, has been collected manually during the course of the cycle, such as biometric parameters of plants or phytosanitary treatments.

Comparison of progress: It was planned to begin in January 2016 but we officially started in June 2016. The reason for such delay is because we didn´t have any data of the pilot system before June 2016.

The data collection actually began to be recorded when the set-up of the pilot system started. The KPI selected have been: Project area/length; Humnas (to be) influenced by the project; Water (including the marine environment); Envioronment and health (including chemicals and noise); Climate change mitigation; Governance; Information and awareness raising to the general public; Capacity building; Jobs, Contribution to economic growth.

Problems (Problems encountered / solutions proposed): No problems has been encountered
Deliverables: **DE4.1** Mid-Term Indicators Table ; **DE4.2** Final Indicator Table.

6.2 Main deviations, problems and corrective actions implemented

During Action A1 the internal procedures of CSIC **delayed the hiring of a bachelor** and finally senior staff was involved in the Deliverable A1. Also FECOAM had problems with the collection of the producer's data. Some **local producers were unwilling** to make public their company's name and data in the report. However FECOAM managed to identity enough producers for a successful characterization in the following actions.As consequence, Action A2, B1 and B2 also started later than initially foreseen and finished with some delay. Apart from the hiring inconveniences and sample collection difficulties, it turned out that the BOD5 data was analysed but not essential in the end for the design of the pilot plant. Despite this, CEBAS-CSIC was willing to maximize results of its dedication and optimize the efforts by its senior staff to gather and produce the results needed for action B2.

On the other hand, some changes were done in Action B2 that also caused some delay. The changes involved **the introduction of three solution tanks** instead of one tank as foreseen, as well three

sectors in order to allow testing different treatments in each sector of irrigation, combining two methods of disinfection with different qualities of water.
Therefore, more equipment was installed during action B3 and tested in the set up, although it resulted in an improvement of the project since now different crops can be irrigated from three different sectors and treatments.
B3 also had a 2-months delay due to the technical changes implemented in B2 compared with the initial design. Also, we had problems with the electrical installation because there were a lot of signals coming from different PLCs and we had to separate them in different blocks. Finally, some flow meters and a pump needed to be changed because they did not work properly.
In spite of the increase in the number of automata devices and electric panels as a consequence of more sensor/actuator signals to monitor the system, this fact has not involved any additional technical problem due to the scalability of the system. Only a slightly increase in time and cost that was assumed by the project.
Another change performed is the management of the process by the automata. Initially, we defined the management of the all process between two master automatas, but afterwards, when we have implemented the system, we have decided to allow all management over one master automata. The new hardware architecture allows simplifying the intra-communications among the different automata and keep the distributed nature of the system through the master-slave CAN bus communication
Besides, in Action B3 it was **needed to build an additional house of 60m^2** as the system didn't fit in CEBAS-CSIC greenhouse premises.The cost of this extension has been reported according to the instructions of the EC.
Regarding B4 and B5, since the microorganisms such as fungi and bacterium were detected and caused a decrease of tomato production, it was decided to use a different disinfection method (UV system and electrolysis system). Thanks to that corrective action we were able to determine if the plague was an isolated problem or if the problem was the UV method. The irrigation was separated in 3 sectors and the drainage was disinfected separately using the two different systems.
The results determined that the mentioned plagues and the low temperatures of winter were the reasons for the low production rate and the quality. The corrective action for the first problem was described hereunder. Regarding the temperatures, the second crop had different maturing conditions and we were able to discern that temperatures have a big influence. Also, we decided to lower the density of the plants to avoid further problems.
The alternative disinfection method was a German machine (SOB) that synthesizes a liquid oxidizer with electrolysis from salts. This new system is composed of a reactor of electrolysis that produces a substance gas-liquid, composed of 4 elements ($HClO$, ClO^-, O_3 and H_2O_2) from water and NaCl. The product obtained is a powerful disinfectant that does not cause corrosion or leaves residues of salts or chemical residues.
Initially the system had to operate in a manual mode and during the first months of operation and after the initial tuning of the control unit the processes turned to automatic mode. The sensor measurements of the whole plant were stored from the first day of operation.
In Action C1, we only had a problem when measuring indicators of water consumption, the counters sometimes were jammed. The solution was to measure these parameters more often ant put filters before the counters.
About the Communication and Dissemination activities, the lack of initial consensus about the project logo provoqued a slight delay in the dissemination activities at the beginning of the Project. Once the first productive cycle was finished, the promotion of the project increased.
In relation of Action E1, RITEC faced some internal organization problems that affected the coordination. The communication was not fluid and great effort had to be done to coordinate the agendas.

6.3 Evaluation of Project Implementation

Act	Foreseen in the revised proposal	Status	Evaluation
A1	Objectives: (i) obtain relevant information on agricultural production in greenhouses in Europe, focusing research on the Mediterranean area. (ii) identification and characterization of different local farmers using soilless cultures Expected results: The collected information will be essential to design the optimal nutrient solution.	Finished 100%	A report gathering the information on the composition of the nutrient solution was produced. The results allowed the characterization of the nutrient solution and were also used to develop the action B1and C2.
A2	Objectives: (i) Prospective study of nutrient solutions used for different crops and substrates in Europe and local area (ii) Economic advantages of the different nutritional balances, different substrates. Expected results: (i) Determination of the ideal nutrient solution to be used in the demonstration phase. (ii)Nutrient solution of different crops under soilless greenhouse conditions in Europe to ensure the correct transferability of the results	Finished 100%	The ideal nutrient solution for soilless horticulture production was chosen and applied in action B5. 2 Reports were produced: Prospective study of the nutrient solution used for different crops and substrates in Europe and local area, as well as efficient protocols for irrigation, and economic advantages of the different nutritional balances, different substrates.
B1	Objectives: (i) to perform the characterization of drainage of a closed-loop solution Expected results: Complete characterization of the drainage solution in tomato crops.	Finished 100%	Characterization of waste nutrient solution for close cycle soilless tomato production was defined, including, the measuring of the drainage, water consumption volumes and analytical reports.
B2	Objectives: design of the pilot plant. Expected results: The expected outcome of this action is the complete design definition of the pilot plant.	Finished 100%	The pilot plant design has been developed. The main elements are control unit, nutrition unit, disinfection unit, purification unit.
B3	Objectives: Pilot plant construction Expected results: Construction of the whole pilot plant.	Finished 100%	The pilot plant construction was finished and working, according to the design defined in the previous Action B2. Though some changes had to be implemented for the proper functioning of the plant. First one, extension of the greenhouse in 60 sqm. And second, instead of the use of one irrigation sector, three irrigatin sectors in order to be able to apply different treatments.
B4	Objectives: Pilot plant set-up, and following up of functioning and software depuration Expected results: Achievement of steady state operation of the pilot plant	Finished 100%	A new disinfection system based on electrolysis had to be installed due to the problems encountered. The initial UV lamp couldn't guarantee that the storage drainage would be free of microorganism contamination. Action B4 and B5 have run parallely. The set up of the pilot plant was not completed until the third cycle which required some specific adjustment were implemented.
B5	Objectives: Real demonstration of the water closed cycle in soilless tomato production Expected results: Validation of the proper functioning of the system, including prototype for drainages recirculation and crop production.	Finished 100%	From this first agronomic experiment it can be said that the system has operated acceptably, however, three cycles had to be necessary to get proper conclusions. The proposed disinfection system did not get the results expected and an electrolysis equipment was implemented to achieve proper results. After that, the best production values were obtained in the third crop cycle, wich was the most satisfactory in terms of saving water, fertilizers and harvest production.

			This third cycle had the characteristics of a commercial exploitation.
B6	Objectives: This action is an economic analysis on the costs of design, installation, commissioning and operation of the pilot system DRAINUSE Expected results: study the most important factors that have influence in the final arrange of a new installation of the closed system of the project.	Finished 100%	As a result of the study of different sources, it can be concluded that the quality of the water, climatic region, type of substrate, type of crop, the initial facilities and its size are the most important factors that have influence in the final set up and price of a new installation of the closed system of the project.
B7	Objectives: To elaborate an exhaustive study of the existing national and international normative on water protection and nitrate pollution has been carried out in order to guarantee that the pilot plant proposed in the project is completely legal Expected results: Finally, it was concluded that none of the four units require any special permission for their installation and it is completely legal in Spain and in the rest of the countries of the European Union.	Finished 100%	It was concluded that none of the four units require any special permission for their installation and it is completely legal in Spain and in the rest of the countries of the European Union. The pilot system can be installed without having to request any permission for its use.
B8	Objectives: The objective of this deliverable was to carry out an evaluation of the LIFE-DRAINUSE system transferability to other scenarios, considering the characteristics of the system, the cultivated species and the scalability to the dimensions of other greenhouses. Expected results: Conclude if the LIFE DRAINUSE system is ready to be transferred to other scenarios.	Finished 100%	The transferability of the LIFE-DRAINUSE system to other European countries is supported by the directives in relation to the reuse of water and the environmental concerns arising from intensive agriculture. In addition, due to its modular, scalable and adaptable nature, the pilot system is ready to be installed in any country because it is easily implemented and transferable to any type of climate and exploitation.
C1	Objectives: to develop and implement a set of indicators to measure the impact of the LIFE DRAINUSE project Expected results: Definition and application of a set of Impact indicators that allows the measure of the quality and quantity of the project results	Finished 100%	The set of indicators have been defined and applied to the three tomato crops. The expected improvements in quality and quantity were visible only with the third crop. The main indicators evaluated have been consumption of water and fertilizers, observing a substantial reduction on the consumption of both elements.
C2	Objectives: To develop and apply a set of indicators that allows measuring the socio-economic impact of the LIFE DRAINUSE project. Expected results: Definition and application of a set of Socio-economic Impact indicators that allow the measurement of the impact of the project in the targeted socio-economic problems.	Finished 100%	The indicators monitorised in Action C1 have a direct socio-economic impact evaluated in Deliverable C2. Moreover other parametres have been evaluated as it is job creation and number of potencial end-users.
D1	Objectives: This action is focused on the efficient knowledge dissemination and other types of communication in order to assure the social and environmental impact of the results of the project. Expected results: A project dissemination portfolio including all the dissemination impacts throughout the project (reports, publications, dissemination elements, etc.). Production and dissemination of a set of dissemination elements. Diffusion of press release and attendance to European and National Events.	Finished 100%	Dissemination of the Project has had good impact among stakeholder that have been showing interest on the Project. FECOAM has participated in different events and numerous press releases have been published. Promotional material has been produced and distributed: leaflets, notebooks, pens. And a Demo video has been made available in the Project Website and youtube. The Project has facebook and linkedin public profile.
D2	Objectives: Notice boards will be designed and displayed during the project in strategic visible places on the beneficiaries' premises	Finished 100%	The notice boards were printed and sent to all partners so that it could be placed in their facilities.

	Expected results: 4 notice boards will be set up.		
D3	Objectives: Elaboration and maintenance of the project website. Expected results: Website contents elaborated.	Finished 100%	Website has been updated periodically with news about the Project, Deliverables and any information that could be relevant for the Public.
E1	Objectives: Elaboration of the project management Guidelines. Expected results: A serie of documents to ensure appropriate management throughout the project life: Consortium Agreement, PM Guidelines deliverable, Meeting minutes.	Finished 100%	The coordinator has carried out successfully the management and coordination of the project.
E2	Objectives: Networking activities with other projects (visits, meetings, exchange of information other relevant LIFE projects). Expected results: This networking action will permit to exchange experiences and establish synergies with positive repercussions between similar projects.	Finished 100%	During the evolution of the project, CBAS-CSIS has contacted with other projects LIFE and invite them to participate jointly in networking activities. Networking activities have been specially successful, important agreement collaboration and Projects have raise from this networking. See description in Action E2.
E3	Objectives: The main objective is to prepare a plan so as to disseminate the project results after the end of DRAINUSE actions. Expected results: Involve partners to maintain it the dissemination for 5 years after the project.	Finished 100%	The after-LIFE plan has been planned and prepared adecuately. Printed version
E4	Objectives: This action is focused on the compilation of information needed to complete the indicator tables (quantitative and qualitative). Expected results: Submission of indicators tables with the final Report.	Finished 100%	The Coordinator has revised and updated the table of indicators according to the recommendations of the EC. The KPI selected have been: Project area/length; Humnas (to be) influenced by the project; Water (including the marine environment); Envioronment and health (including chemicals and noise); Climate change mitigation; Governance; Information and awareness raising to the general public; Capacity building; Jobs, Contribution to economic growth.

Table 5. Evaluation of action implementation

– **Effectiveness of the dissemination**

During the life of the Project, all the partners of the Consortium have participated in many dissemination activities and events. The Project has raised a lot of interest among other Projects, stakeholders and end users. The results of this Action have been presented in Section 6, Actions D1 to D4. Among the most significative activities carried out: attendance to trade fairs and exhibition, publication of the Demo Video; Noticeboards and Website of the Project.

– **Policy impact**

The project is relevant for different policy areas. The main instrument for this purpose is the Common Agricultural Policy (CAP), but more specific instruments have been developed as the Nitrates Directive (91/676/EEC) and Groundwater Directive (2006/118/EC) both integrated in the Water Framework Directive (2000/60/IEC).
The Groundwater Directive aims to preserve groundwater as the most sensitive and the largest body of freshwater in European union, and it identifies a maximum of 50mg/L of nitrates while the soilless drainage waters contains between 500-1.000mg/L.
The Nitrates Directive aims to protect water quality across Europe by preventing nitrates from agricultural sources polluting ground and surface waters and by promoting the use of good farming practices. This directive has resulted efficient since nitrate concentrations have been importantly reduced in some EU countries. For the first time mineral fertilizer consumption

registered a progressive reduction in the early 1990s and stabilized during the last four years in the EU-15, but across all 27

Member States nitrogen consumption has increased by 6%. Generally, farming remains responsible for over 50% of the total nitrogen discharge into surface waters. Annual N fertilizer consumption in the EU is currently about 11 million tons – almost 30% below the peak of twenty five years ago. The use of P and K fertilizers was about 2.5 million tons in 2010 – almost 70% down on their peaks of the late 1980s. The full implementation of the Nitrates Directive is expected to contribute to the reduction of ammonia emissions by 14% on 2000 levels by 2020. A goal of zero emissions from greenhouse horticulture for 2020 has been put forward.

EU state members develop action programmes to include a set of measures laid down in the Directive. In Spain, the Nitrates Directive was incorporated into the legal system (Real Decreto 261/1996, de 16 de febrero). Following the Nitrates Directive, state members have designated territories that are or could be affected by high nitrate levels or eutrophication as vulnerable zones. As compared to 2008, the total area in the EU designated as vulnerable zone has increased. In Spain several zones have been designated as vulnerable, including important agricultural areas of south eastern Spain (Murcia and Almeria) as for example the seacoast area of Mar Menor (B.O.R.M. - 10/03/2009) where we tested the pilot plant.

Although the recirculation of drainages among the producers of the Mediterranean area is not very extended, it is predicted to be expanded in the near future. Nowadays, no law exists in these countries that enforce the recirculation of drainages; however, the European policies (CAP, Nitrates Directive, Water framework directive) will force these countries to design laws to converge to the European legal frame. This will prompt to develop specific regulations for drainages release in the environment in a close future.

In this regard, LIFE DRAINUSE has contributed to propose a legal and regulatory framework for drainage recirculation to Euro-Mediterranean regulatory bodies. In particular in Action B7, *Legal Feasibility analysis*, an exhaustive study of the laws and normative that regulated the fabrication, installation and exploitation of the product has been made in order to guarantee that the product is completely legal. The final report, which will include the advantages and the inconvenient of the use of this system, will help to the regional, national and EU authorities to implement the regulation of the drainages leakage in different agriculture areas, using The Netherlands experience and the viability demonstrated in the project.

In Spain there are not laws concerning/regulating the reuse of drainages. The only legal constrain may be related to the EU Nitrates Directive. In this sense, the project is in perfect consonance with these regulations, since it aims to protect water quality and prevent nitrates from greenhouse irrigation sources polluting ground and surfaces waters, by the recirculation of the resulting drainages.

During and after the system development, the generated results from the first and second cycle have been published and presented to the regional minister responsible of the environmental regulations, in order to force a regional regulation for nitrates and other contaminant fertilizers released to ground and surface and ground waters When the project began there was no law in the Region of Murcia that regulated the discharge of drains in soilless culture. At the end of the project, the law 1/2018 has been approved prohibiting the use of fertilizers highly soluble in soilless culture without a closed recirculation system.

6.4Analysis of benefits

- Environmental benefits

The project generated direct (quantitative) and indirect (qualitative) benefits. The recirculating systems avoid draining fertilizers to ecosystems while reducing the total volume of water to use. These actions could be measured in terms of quantities (kgs, litres) that could be translated in direct costs (so, economical benefits) and also could be translated into carbon dioxide emissions related with the amounts of water and fertilizer that are not necessarily due to recirculating.

Besides the measurable impacts, these actions had an indirect effect because of the risk reduction inherent to these actuations. The recirculation of the water and the total reduction of the drainage reduces drastically the possibility of introducing fertilizers in surrounding ecosystems. Fertilizers drainage is the main reason for ecosystems eutrophication, so the reduction of these risks could suppose huge amounts of money in terms of ecosystems restoration.

- Economic benefits

The economic benefits are related to the saving of water and fertilizers that is achieved during the implementation of a closed cycle of cultivation. On one hand, the consumption of quality water represents a very important expenditure in the agricultural sector, so if a part of it can be reused, it will mean a final saving. On the other hand, the saving of fertilizers is also considerable when it comes to extensive plantations. So far, the closed cycle represents a significant economic saving in the volume of water destined for irrigation, since it is reusing 38% of the total water needed. The closed cycle means a significant saving in the amount of fertilizers used in the nutrient solution.

- Social benefits

The social benefits of the project are related to the environmental concerns present today in the region of Murcia. One of the causes of the contamination and degradation of the Mar Menor has been the leaching of the agricultural residues of the zone. Reducing these spills would reduce the pollution in the area, and also, could recover the ecosystem. Also, by reducing the drainage, the environment is protected which at the end would enhance the tourist sector, and would help reactivate the local economy of this area

- Replicability, transferability, cooperation: Potential for technical and commercial application

Transferability and replicability will be guarantee on one hand, by the consortium, FECOAM is the Federation of Agricultural Cooperatives of Murcia. It includes 75 agricultural associations representing about twenty thousand farmers only in the Region of Murcia which is about 90% of agriculture cooperatives in the Region. It also belongs to the Confederation of Agricultural Cooperatives of Spain (CCAE) to the national community and to the Committee of the General Union of Agricultural European Cooperatives (COGECA), based in Brussels. In this sense, they will promote the Project among their contacts, most of them, agricultural cooperatives. Moreover, RITEC is a recognized company with relevant knowledge and infrastructure in all the processes related to irrigation, water treatments and water management in greenhouses, etc. RITEC will hold and important marketing campaign at regional and nation level to boost the commercialisation and installation of the system. The transferability study was done during the B8 action. It was concluded that the pylot plant, designed as a modular and scalable system, can be easily implemented for any type of crop. None of the four units that form the whole system require any special permission for installation, and comply with the current legislation both in Spain and in the rest of the countries of the European Union.

The substrate used in the demonstration is coco peat, which among all substrates may produce the most problems regarding turbidity of the drainages. An added problem is the microbial content. Therefore, implementation into greenhouses with other substrates such as perlite, that produces less turbidity and microbial contamination, should be easier.

The tomato is produced in the 38% of the European greenhouse surface. So, this demonstration project can be readily implemented in other greenhouses that are producing tomato. However, because the system is adaptable, it can be easily installed for other crop species. The control unit, that commands the formulation of the nutrient solutions, can be easily adapted to the nutritional needs of other crops. Moreover, specific nutritional needs for each crop may be installed into the software databases, so the adaptation to different crops can be easily performed.

Besides, from Action A2 the ideal nutrient solution for different crops was identified. With the conclusions of that study on nutritive solutions, modified Hoagland nutrient solution was chosen to grow tomato plants. As is indicated in the DA2.2 report, main plant species could grow without problems and without any deficiencies in this nutrient solution. Other characteristic that also benefit the replicability and transferability is that system is modular, scalable and adaptable. This means that it can be implemented in greenhouses of different sizes by simply increasing the number of units to be installed.

It must be noted also that DRAINUSE consortium will continue to implement the system developed during the project by implementing the following actions: New research projects by CEBAS-CSIC and UMU; Website maintenance;RITEC will install the systems in other areas; FECOAM dissemination and diffusion; Maintenance of the demonstration pilot system; Participation in Social Networks.

- Best Practice lessons: briefly describe the best practice measures

During the two cycles programmed, poor results were obtained due to different problems that affected the crops. After each cycle, measures were taken in order to solve the problems observed. After two cycles, results weren't enough in order to ensure the project success, so a third cycle was required. The third cycle was successful because water reused and fertilizers reductions complied with the expected results, without affecting the crop productivity and fruit quality. These results were possible because of the lessons learnt in the first two cycles.

- Innovation and demonstration value

The recirculation of drainages in soilless culture supposes a great technological advance for agriculture. The innovation values of the system supposes an improvement in the conditioning and the automation of the greenhouses. The use of software and hardware for control irrigation contribute to the development of a very precised agriculture.

- Policy implications

Within the region of Murcia, the policy of waste disposal should be controlled in order to improve the Mar Menor area and avoid future problems arising from these bad practices. On the other hand, the laws of the government of Spain should regulate and legislate the implementation of crops, providing economic aid to farmers who would like to implement this new method or aggravating the penalties for breaching the laws that regulate the conservation of the environment. European legislation should also regulate the use of these systems in order to reduce water expenditure and derby pollution from agriculture.

When the project began there was no law in the Region of Murcia that regulated the discharge of drains in soilless culture. Researchers and related scientific involved in LIFE DRAINUSE project have had some meetings with the authorities of Region of Murcia in agricultural and environmental topics, in order to promote the LIFE-DRAINUSE closed system that allows farms to be more respectful with the environment. Law 1/2018 of "Urgent measures to ensure environmental sustainability in the Mar Menor environment" has been recently approved by the Regional Government. The law prohibits the use of high soluble fertilizers in soil crops without a recirculation system.

7. Key Project-level Indicators

The environmental and socioeconomic impact of LIFE-DRAINUSE has been monitored during the project. The indicator values have been measured through a series of selected verification sources and protocols in three different moments of the project: at the beginning of the project, at the end of the project, and in 5 years. The impact has been studied in Murcia and the Mediterranean area.

The following indicators values have been selected in the KPI online database.

Table 6. Indicator selected in the KPI online database

Indicator No.	Indicator
1.5	Project area/length
1.6	Humans (to be) influenced by the project
2.3.5.1	Drought risk/water scarcity risk
2.3.5.2	Water abstraction/diversion
2.3.5.3	Water consumption for production
5.1	Chemicals released
8.1	CO_2 greenhouse gas emissions
10.2	Involvement of non-governmental organisations (NGOs) and other stakeholders in project activities
11.1	Website
11.2	Other tools for reaching/raising awareness of the general public
12.1	Networking
13	Jobs
14.1	Running cost/operating costs during the project in case of continuation/replication after the project period
14.3	Future funding
14.4	Continuation/replication/transfer after the project period

7.1. Project area/length (indicator number 1.5)

In Table 3, tomato crops in greenhouse and soilless production in Mediterranean area and Region de Murcia are shown in three different project stages: at the beginning, at the end and in a five-year estimation after project.

Regarding to greenhouse area in Region de Murcia, about 40% of the total (5,584 hectares), with 940 ha used in an open soilless growth system and no data in closed system production.

At the end of the project, only the LIFE-DRAINUSE project has a closed recirculation system, with a total area of 0.05 ha. It is estimated that in five years, 300 ha of a total of 940 ha will be transformed into closed systems in Region de Murcia.

A similar situation occurs in the Mediterranean area. The total area of greenhouse crops is 159784 ha. Among them, 31,044 ha are tomato crops. 17576 in soilless culture (open cycle). At the end of the project, it is estimated that 10 ha will turn into a closed drainage recirculation system. In 5 years, it is expected that 1500 ha will be transformed in a closed system.

Table 7. Region de Murcia and Mediterranean area data for different land uses

Area length	Murcia	Mediterranean area
Greenhouses	5,584 ha	159784 ha
Soilles culture (open cycle, beginning of the project)	941 ha	17576 ha
End of the project	0.05 ha	0 ha
In 5 years	300 ha	1500 ha

7.2. Humans (to be) influenced by the project (indicator 1.6)

There are two main groups influenced by the project. In the other hand, people who have visit the pilot plant, which have been students, companies or other researchers. On the other hand, people who have been working throughout the project LIFE-DRAINUSE.
At the end of the project, 120 people visited the pilot plant, and the LIFE-DRAINUSE project generated 6 jobs through the CEBAS-CSIC, 1 jobs the UMU, 1 jobs RITEC.
In 5 years, it is estimated that the values will be the same, because the LIFE-DRAINUSE pilot plant will no longer be in operation. Even so, CEBAS-CSIC will continue to carry out projects based on the recirculation of drainages, such as Berries 4.0 or PRIMA WATERMED.

Tabla 3: Humans to be influenced by the project in Region de Murcia

Humans influenced	Murcia
Visitors and others regulary present to the project area (beginning of the project)	0
Visitors present to the project area (end of the project)	120
Visitors present to the project area (5 years beyond)	120
Other regulary present to the project area (end of the project)	8
Other regulary present to the project area (5 years beyond)	8

7.3. Drought risk/Water scarcity risk (indicator 2.3.5.1)

Both, Región de Murcia and Mediterranean area, are semi-arid areas in which drought risk causes large losses in crop productions. It is estimated that, in these regions, scarcity water for irrigation causes around 10% of agricultural losses in total production.
In the Región de Murcia, soilless culture produces about 99605 tons of tomato, pepper, cucumber and other crops per year, of which 9960 tons are lost due to problems caused by or related to water scarcity. With the implantation of the LIFE-DRAINUSE system these losses would not take place, because It has been proved that the drainage recirculation lead to saving of almost 40% of the irrigation water.

At the beginning of the project, assuming that, in the market, the average price of a kilogram of tomato, pepper and cucumber is around € 0.80, more than 8 million euros of annual losses are estimated. At the end of LIFE-DRAINUSE, the pilot plant did not generate a commercial impact, since only 0.05 ha of crop was cultivated. But, if 300 of the 940 hectares become in recirculation soilless culture, the economic losses would be reduced by more than 30% in the next five years.

In the Mediterranean area, annual losses are estimated over 150 million euros. The drainage recirculation in an 1500 ha would reduce in more than 40% the production losses within 5 years.
The following table collect the losses values caused by water scarcity in Murcia and the Mediterranean area.

Table 4. Drought risk/water scarcity values in Murcia and Mediterranean area

Drought risk/Water scarcity risk	Murcia	Mediterranean area
Tomato soilless culture (open cycle)	941 ha	17576 ha
Annual production	99605 tn	1860000 tn
Estimated losses (beginning of the Project)	71715600 €	1339200000 €
End of the project	71715600 €	1339200000 €
Beyond 5 years	79684000 €	1488000000€

7.4. Water abstraction/diversion (indicator 2.3.5.2)

Water abstraction refers to the process of taking or extracting water from a natural source (rivers, lakes, groundwater aquifers, etc.) for various uses, from drinking to irrigation, treatment, and industrial applications.
Tomato soilless culture in open cycle consume 22813 m^3 of water per hectare per year, and more than 30% is discarded to the environment without the possibility of being reused. The implementation of the LIFE-DRAINUSE system reduces water consumption to 13,457 m^3 per hectare, which represents a reduction of 41% of total water consumption.
Since the pilot system has an area of 0.05 ha, the water saving does not cause a great impact on the total water consumption in the Region de Murcia. Assuming that in 5 years, 300 hectares of crops in Murcia, and 1500 hectares in the Mediterranean area, will turn into closed system, the reduction in water abstraction will be around 20%.

Table 5. Water abstraction/diversion values in Murcia and Mediterranean area

Water abstraction/Diversion	Murcia	Mediterranean area
Water abstraction (Open cycle)	22,816 m^3/ha	22,816 m^3/ha
Water abstraction (closed cycle)	13,457 m^3/ha	13,457 m^3/ha
Beginning of the project	21.44 million m^3/year	400.96 million m^3/year
End of the project	21.44 million m^3/year	400.96 million m^3/year
Beyond 5 years	118.63 million m^3/year	386.93 million m^3/year

7.5. Water consumption for production (indicator 2.3.5.3)

Tomato soilless culture in open cycle consume 22813 m^3 of water per hectare per year, and more than 30% is discarded to the environment without the possibility of being reused. The implementation of the LIFE-DRAINUSE system reduces water consumption to 13,457 m^3 per hectare, which represents a reduction of 41% of total water consumption.

In Murcia, soilless crops produce 99605 tons per year. In the Mediterranean area, tomato soilless crops produce 1860000 tons. This approximately supposes more than 200 m^3 of water to produce a tons.
Assuming that in 5 years 300 hectares in Murcia, and 1500 in the Mediterranean area will turn into closed system, the assumed reduction in water consumption per ton of tomato will be approximately around 20%.
The following table shows the annual production values in Murcia and Mediterranean area based on the water used for tomato soilless culture.

Table 6. Water consumption for tomato production in Murcia and Mediterranean zone

Water consumption for production	Murcia	Mediterranean area
Anual production (beginning of the project)	99605 tn	186000 tn
Water abstraction (Open cycle, beginning of the project)	22,816 m^3/ha	22,816 m^3/ha
Water abstraction (closed cycle)	13,457 m^3/ha	13,457 m^3/ha
Beginning of the project	215.25 m^3/tn	222.75 m^3/tn
End of the project	215.25 m^3/tn	222.75 m^3/tn
In 5 years	187.03 m^3/tn	203.31 m^3/tn

7.6. Chemicals released (indicator 5.1)

Open hydroponic systems are widely present in modern agriculture. However, in an open hydroponic systems drainages are released into the environment with the concomitant pollution and eutrophication of aquifers, land and water surfaces.
The amount of fertilizer released to the environment is estimated at an average of 28053 Kg per year per hectare of crop. At the end of the project, the LIFE-DRAINUSE system reduced the consumption of fertilizers but did not suppose an impact on the total savings in Murcia, just as it happened in the Mediterranean area.
It is estimated that in 5 years, 300 ha in Murcia and 2100 ha of the Mediterranean area could turn into closed system, which would reduce chemicals released around 30%.

Table 7. Chemicals released in Murcia and Mediterranenan area

Chemicals released	Murcia	Mediterranean area
Chemicals released (beginning of the project)	43045 tn/year	804874 tn/year
End of the project	43045 tn/year	804874 tn/year
Beyond 5 years	34629 tn/year	762795 tn/year

7.7. Greenhouse gas emission CO2 (indicator 8.1)

Although agriculture is essential in sustaining human life, the practices associated with it have been known to have impacts on the surrounding environment. The most notable of these effects includes deforestation, pollution, environmental degradation and have been a key factor in global warming.

In Murcia, the fertilizers used in the 940 hectares of tomato soilless culture produces 65798 tons of CO_2 per year. In the Mediterranean area, this value reaches 1230305 tons of CO_2 per year.

Comparing these values with tomato soilless culture production, producing a Kg supposes an impact of approximately 0.7 kg of CO_2, both in Murcia and in the Mediterranean area.
Taking into account the hectares that could turn into closed system, in Murcia and Mediterranean area, a reduction of 15% in the emission of CO_2 to produce a kilogram of tomatoes is estimated.

Table 8. CO2 gas emission in Murcia and Mediterranean area

CO_2 gas emission	Murcia	Mediterranean area
CO_2 emission at beginning	65798 tn/year	1230305 tn/year
CO_2 emission End of the project	65798 tn/year	1230305 tn/year
CO_2 emission Beyond 5 years	58625 tn/year	1175423 tn/year
CO_2 emission/production	0.7 kg CO2/Kg production	0.71 kg CO2/Kg production
CO_2 emission/production beyond 5 years	0.63 kg CO2/Kg production	0.65 kg CO2/Kg production

7.8. Involvement of non-governmental organisation s(NGOs) and other stakeholders in project activities (indicator 10.2)

During the project, CEBAS-CSIC has been in touch with a nongovernmental association. It is expected that in 5 years, CBAS CSIC will be in conctact with two more associations (Grupo Ecologista Mediterráneo and Asociación de Naturalistas del Sureste, "**ANSE")**.
CEBAS-CSIC is part of the Scientific Advisory Committee of the Mar Menor. This Committee was approved by the following legislation Orden de 29 de julio de 2016, por la que se crea el Comité de Asesoramiento Científico del Mar Menor and Orden 30 de diciembre de 2016 de la Consejería de Agua, Agricultura y Medio Ambiente, que modifica la Orden de 29 de julio de 2016, por la que se crea el Comité de Asesoramiento Científico del Mar Menor.
The aim of this Committee is to improve the ecological status of the Mar Menor. In January 2018, a meeting with Dr.Emilio Nicolás (a colleage from CEBAS-CSIC who belongs to "Scientific Advisory of The Mar menor" association) was arranged, in order to share the results of the Drainuse system and to promote it as a sustainable alternative of soilless culture..In February 2018, the Law 1/2018 of urgent measures was approved to guarantee environmental sustainability in the Mar Menor environment, which prohibits the use of fertilizers highly soluble in crops without soil that do not have a system closed recirculation.

Tabla 9: Involvement of non-governmental organisation s(NGOs) and other stakeholders in project activities

NGOs activities	Murcia (end of the project)	In 5 years
Mar Menor Scientific Advisory Committee	1	3

7.9. Website (indicator 11.1)

The web page of the project LIFE DRAINUSE is running and is available in English and Spanish since october 2016. The website was regularly updated. The url address is: http://www.drainuse.eu.

The project logo and the LIFE logo are both visible in the website. The following graph shows clicks and impressions from the last year.

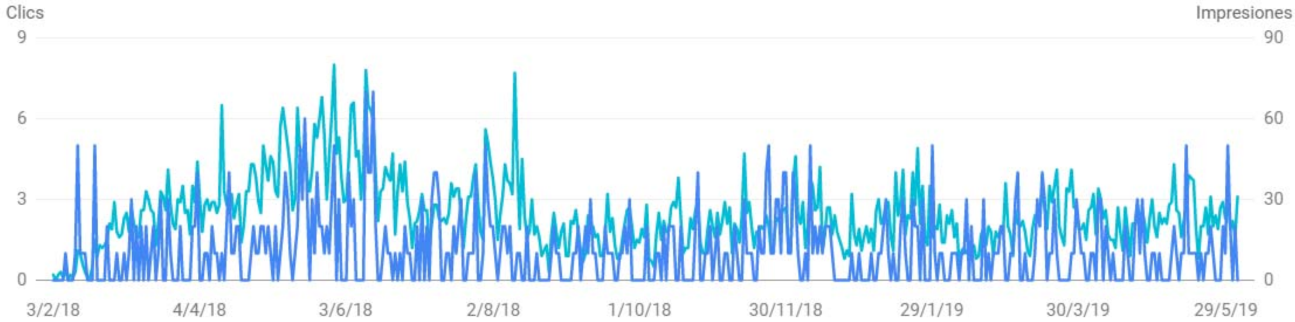


Figura 1: Website's clics and impressions from last year.

Table 10. Website's statistic

Website's statistic	End of the project	In 5 years
Average visit duration (minutes)	5	5
Nº downloads	188	250
Nº individuals	150	300
Nº of unique visits	5587	8000

7.10. Other tools for reaching/raising awareness of the general public (indicator 11.2)

Several communication activities were carried out during the Project in order to increase its visibility and disseminate its results to end users and groups of interest.
The following table shows the activities done in Murcia to disseminate LIFE-DRAINUSE Project.
The After LIFE Communication Plan aims to ensure the dissemination of the project results after the end of the project. Based on the technical and economic viability results, a pool of actions is planned with three leading objectives: Dissemination of results, Commercial promotion, Governance. Actions include all the steps leading to the registration of the Intellectual Property Rights (IPR), the commercial promotion of the DRAINUSE System, the inclusion of DRAINUSE in the regional training programs of the Rural Development Plan, the initiative to participate in more projects for further technological and scientific progress of the system. The activities are foreseen within 3-5 years after the completion of the project and is targeted to the stakeholders: farmers, companies and associations, technicians, students, public advisors and decision makers.
The final number corresponds to the number of people estimated to have been influenced by LIFE-DRAINUSE project in the different media.

The values of the indicators of this section 11.2 in the KPIs webpage are not correct. The correct ones are those that appear in "Deliverable E4 Final Indicators Table" included in "*Annex IV Deliverables*".
The values that appear in the website are those that were defined during the Midterm Report, but due to a misinterpretation of the units, the data are overestimated. We tried to correct these values

during the Final Report, but the page gave us the following error and we have not been able to correct them.

Table 11. Dissemination activities in Region de Murcia

Activities	Murcia	In 5 years
Publications/reports	4	4
Print media	21	35
Other media	1	1
Hotline/information centre	0	0
Displayed information	5	5
Events/Exibitions	39	60

7.11. Networking (indicator 12.1)

Great effort has been invested in networking in the Región of Murcia. Dissemination in symposiums, congresses and meetings, workgroup conferences and local media. The main objective of these activities was to present the progress and final results of the LIFE-DRAINUSE project. These events facilitated the exchange of knowledge and experience among the participants, debates, and identification of new lines of investigation. Many of the workgroup conferences were held to raise awareness of the LIFE program as a funding alternative for research and innovation studies that have a favourable impact on the environment.

At the end of the LIFE-DRAINUSE project, we will continue to hold meetings in order to study the reuse of drainages in soilless culture through other projects. The following table shows the number of people who participated in these meetings.

Table 12. Networking in Murcia at the end of the Project and beyond 5 year

Networking	Murcia	In 5 years
Numbers of interesting groups	150	200
Students	90	140
Professionals	120	150

7.12. Jobs (indicator 13)

LIFE-DRAINUSE project applies technology in rural agriculture, converting farm crops into more autonomous and specialized farms more sustainable with the environment. Therefore, the implantation of the system in the local exploitations, could have a direct impact and improve he following category of jobs:

• Installation companies: The implementation of the LIFE-DRAINUSE system will need an increase in the technical team of RITEC.
• Software maintenance companies: the software that has been developed by UMU. Software should be constantly improved, and need a continuous review to offer better versions to the end-user. UMU throught new software development project, will need to hire new employees.

• Production companies: The increase of incomes, due to the improvement of fruit quality and the saving by reduce input (water and fertilizers) could increase the production area lead to increase the number of unskilled employees. On the other hand, more specialized jobs are required in the production companies (graduates in agronomic engineering or similar) in order to manage all the information available with this system.
The following table shows specific jobs that could be create by implementing the DRAINUSE project.
At the end of the project, the number of jobs needed for the maintenance of a 1Ha pilot plant under optimum working conditions is the one listed below. After 5 years, it is assumed that in an favorable scenario the pilot plant could be installed in 30% of the surfaces of the tomato crops without soil, which supposes some 300ha in the region. This means an improvement in the jobs´s creation.

Table 13. Jobs generated by LIFE-DRAINUSE project

Jobs	End of the project	Beyond 5 years
Instalation companies	3	5
Software maintance companies	1	2
Production companies	2	30

7.13. Running cost/operating cost during the Project and expected in case of continuation/replication/transfer after the Project period (indicator 14.1)

At the end of the project, an economical study about implementation of the pilot plant was made by the partnes in both, national and international scenario.
The following table shows the estimated budget for the implementation and start-up of a recirculation plant. The operating costs of the system are also estimated during the first year in Murcia and Mediterranean area.
The following table shows the costs that have been taken into account for this operation study.
The international scenario is 6% more expensive than national scenario due to costs derived from transport, maintenance, lodging and issuance of visas by the company's assembler technician.

Table 14. Implementation, set up an running during the fist year of crop

		Cost category	Costs incurred within the reporting period in €
1.		Personnel	709.894,36
2.		Travel and subsistence	10.700,35
3.		External assistance	32.629,93

4.		Durables goods: total non-depreciated cost	110.313,26
		- Infrastructure sub-tot.	3185,66
		- Equipment sub-tot.	
		- Prototype sub-tot.	107.127,60
5.		Consumables	67.204,86
6.		Other costs	6.153,66
7.		Overheads	65.580,00
8		Infraestructure	9557
		TOTAL	1.012.033,41

7.14. Future funding (indicator 14.3)

In order to continue investigating the optimization of the closed system proposed in LIFE-DRAINUSE, and the development of the new technology and its applications, CBAS CSIC will continue collaborating with RITEC and UMU in the following Projects (all financed with regional, national and European Commission funds).

- HIDROLEAF Project (New cultivation systems for vegetables production. RTC-2016-4827-2)
- BERRIES 4.0 (Greenhouses 4.0 for superfoods production 2I18SAE00060)
- Development of commercial software for the reuse of drainages in soilless culture (20528/PDC/18).
- Prima WATERMED 4.0 (Efficient use and management of conventional and non-conventional water resources through Smart technologies applied to improve the quality and safety of Mediterranean agriculture in semi-arid areas) and
- PRIMA Precimed (Precision irrigation management to improve water use efficiency in the Mediterranean region).

7.15. Entry into new entities/projects (indicator 14.4)

The modular and scalable nature of the system makes it easy to adapt to multiple scenarios depending on the starting point. The 4 units that compose the systems, fertirrigation unit, control unit, purification unit and desinfection unit, are functional and configurable independently, which makes it a very adaptable working system.

None of the four units that compose the system require any special permission for installation, and comply with current legislation both in Spain and in the rest of the countries of the European Union.

7.16. Entry in new sectors (indicator 14.4)

In order to transfer the system to other greenhouses or other crops, it will be necessary to take into account: irrigation water quality, weather conditions, type of substrate, type of crop, previous installation and the size of the installation.

Selected countries: Spain, Italy, Greece, Turkey

8. Comments on the financial report

8.1 Summary of Costs Incurred

Total summary of costs incurred

PROJECT COSTS INCURRED				
	Cost category	Budget according to the grant agreement in €	Costs incurred within the reporting period in €	%
1.	Personnel	656.125	709.894,36	108,19%
2.	Travel and subsistence	17.085	10.700,35	62,63%
3.	External assistance	42.503	32.629,93	76,77%
4.	Durables goods: total non-depreciated cost	115.460	110.313,26	95,54%
	- Infrastructure sub-tot.		3185,66	
	- Equipment sub-tot.			
	- Prototype sub-tot.	115.460	107.127,60	92,78%
5.	Consumables	83.050	67.204,86	80,92%
6.	Other costs	14.373	6.153,66	42,81%
7.	Overheads	65.000	65.580,00	100,89%
	TOTAL	**993.596**	**1.002.476,41**	**100,89%**

In general terms, costs incurred by type of category are in line with project budget and timetable actions. There are no significant deviations from planned budget except from Travel and Subsistance Costs and Other Costs that have been below Budget. Nevertheless, the following minor incidences should be noticed by cost category where main deviations can be seen:

Travel: Concerning the "Travel and subsistence" category, the incurred costs have been minimal despite the beneficiaries held several Technical meetings with regards the Actions B. The main reason for this saving is that most of the meetings took place in Murcia where are the headquarters of all the beneficiaries. It was not always easy to coordinate the agendas of the beneficiaries which made very difficult to arrange face-to-face meetings. Therefore the Consortium decided to set up videoconferences and/or phone meetings. As a consequence, travel and subsistence´s budget wasn´t consumed.

External Assistance: A great part of the external assistance budget is associated to dissemination and communication activities effectively incurred during the Project duration. There are two main reasons why the total budget was not used in this category. The first one is that the cost of the Project video was less than expected. The total cost of the Project Video was 3790 Euros and the budget foreseen in the Grant Agreement for this Demo Video was 8.000 Euros. The second reason is that the organisation and expenses of the Infoday in Brussels were less than initially expected due to the fact that it was organised at the premises of CBAS-CSIC Brussels, therefore there were not venue´s expenses. The cost of the catering of the Infoday was 510 Euros and the total budget foreseen for the Infoday was 5250 Euros.

Infraestructure: There was not Budget foreseen in Infraestructure in the proposal. But during the Project´s execution the Consortium realised that CEBAS-CSIC's greenhouse (where it was foreseen to house the pilot plant) wasn't big enough according to the design and dimensioning needed for the system. Therefore a house of 60 m^2 to shelter the pilot plant had to be built next to the greenhouse. CEBAS-CSIC could assume the unforeseen cost without any increase in the final Budget.The reason is that the budget for the initial greenhouse conditioning foreseen in the proposal was not needed and could be used to build the new house extension. The cost of the new house was 12.742,66€ € and the Budget foreseen for the greenhouse conditioning was 12.750€. The detailed breakdown of the cost comparison is shown below:

- Cost foreseen in the budget for the greenhouse conditioning and that has not been needed: The ceiling of the greenhouse, new mesh plastic of shade, frequency variators and a propagation chamber

Prototype

Beneficiary	Action number	Description	Cost (€)
CSIC	B3	Greenhouse condition: 1 unit Propagation Chamber	2400
CSIC	B3	Electric components: 3 frequency variator	3500

Consumable

Beneficiary	Action number	Description	Cost (€)
CSIC	B3	Shade cloth 500m2	3500
CSIC	B3	Plastic films 600m2	3350

Total 12.750€

- Cost needed for the additional facility construction: Concrete floor and Iron structure (electroweded lath), an aluminium window and a door.

Prototype:

Beneficiary	Action number	Description	Cost (€)
CSIC	B3	24524/16 Additional facility construction: concrete slabs	2805,82
CSIC	B3	24518/16 Additional facility construction: joist, door, glass window and blind	8788,04
CSIC	B3	25463/16 Additional facility construction: slab, electrowelded lath.	1148,80

Total 12.742,66€

The EC in its letter from December 8th, 2017 in point nº17 requested to declare all costs associated to this new facility/ extension of the greenhouse in the category "infrastructure" instead of "prototype".

Prototype: Assemble and set up of the prototype has been implemented successfully and almost all the budget initially foreseen has been used. The cost of the extensión of the greenshouse has been included in the category "Infraestructure", following the instrucions of the EC.

Consumables: As numbers show, almost all the Budget foreseen for the tomato crop demonstration activities has been consumed.

Other cost: This category is directly related with dissemination and communication activities. Great effort was dedicated to the dissemination all along the Project. The reasons for not having consumed the whole budget foreseen in the Grant Agreement are the following:

In Other Cost was foreseen the Audit of the Project with a budget of 6.252 Euros. Due to the Amendment nº1 signed on 6 December 2016, the external auditor have to certify the financial statmeents only for beneficiaries for which the expected contribution of the European Union exceeds 325.000 Euros which is not the case for any of the beneficiaries of this Project. Therefore only the firsts months of the Project were audited until the enter into force of this Amendment nº1 and the total budget foreseen in the Grant Agreement was not used. The amount paid to AUDIPUBLIC AUDITORES, S.A. was 1.984 Euros.

The 2.605 Euros foreseen in the budget of CSIC for "Open Access publication fees" were not spent since all the technical and scientific publications were able to be published free of charge. The 416 Euros foreseen as well in the budget of CBAS for "Fees 1 national and 1 EU events" were not used neither. All the events were able te be attended without any cost.

<u>Comparison of total summary costs budgeted and incurred per partner</u>

COSTS PER BENEFICIARY (TOTAL Contractual Budget)													
Short Name	Days	Personnel	Travel	External Assistance	Infrastructure	Equipment	Prototype	Consumables	Other	Overheads	EU Contrib.	Total Elegible Costs	% of Total elegible costs
CEBAS-CSIC	1.635,00	328.755,00	8.760,00	22.403,00	0,00	0,00	38.069,00	74.050,00	9.273,00	33.691,00	309.001,00	**515.001,00**	**51,83%**
FECOAM	255,00	45.380,00	3.070,00	20.100,00	0,00	0,00	0,00	4.000,00	4.700,00	5.407,00	49.594,00	**82.657,00**	**8,32%**
RITEC	545,00	158.500,00	3.775,00	0,00	0,00	0,00	60.111,00	5.000,00	400,00	15.945,00	146.238,00	**243.731,00**	**24,53%**
UMU	580,00	123.490,00	1.480,00	0,00	0,00	0,00	17.280,00	0,00	0,00	9.957,00	91.324,00	**152.207,00**	**15,32%**
Total	3.015,00	656.125,00	17.085,00	42.503,00	0,00	0,00	115.460,00	83.050,00	14.373,00	65.000,00	596.157,00	**993.596,00**	**100,00%**
Share of total eligible costs		**66,04%**	**1,72%**	**4,28%**	**0,00%**	**0,00%**	**11,62%**	**8,36%**	**1,45%**	**6,54%**	**60,00%**	**100,00%**	

COSTS PER BENEFICIARY (TOTAL Declared Costs)													
Short Name	Days	Personnel	Travel	External Assistance	Infrastructure	Equipment	Prototype	Consumables	Other	Overheads	EU Contrib.	Total Elegible Costs	% of Total elegible costs
CEBAS-CSIC	1.682,77	353.131,72	4.313,46	11.974,93	3.185,66	0,00	29.391,98	67.204,86	2.100,66	32.991,00	302.576,56	**504.294,27**	**50,30%**
FECOAM	287,77	54.235,19	4.073,81	15.080,00	0,00	0,00	0,00	0,00	4.053,00	5.420,00	49.717,20	**82.862,00**	**8,27%**
RITEC	969,38	178.820,39	1.168,83	5.575,00	0,00	0,00	60.589,72	0,00	0,00	17.230,00	158.030,36	**263.383,94**	**26,27%**
UMU	583,75	123.707,06	1.144,25	0,00	0,00	0,00	17.145,90	0,00	0,00	9.939,00	91.161,72	**151.936,21**	**15,16%**
Total	3.523,66	709.894,36	10.700,35	32.629,93	3.185,66	0,00	107.127,60	67.204,86	6.153,66	65.580,00	601.485,85	**1.002.476,41**	**100,00%**
Share of total eligible costs		**70,81%**	**1,07%**	**3,25%**	**0,32%**	**0,00%**	**10,69%**	**6,70%**	**0,61%**	**6,54%**	**60,00%**	**100,00%**	

8.2 Accounting system

How it is ensured that invoices contain a clear reference to the LIFE project showing how invoices are marked in order to show the link to the LIFE project.

As stated and communicated in the project on the one hand in the Management Guidelines (DE1), and on the other hand in the Partnership Agreement signed just at the beginning of the project, the entire consortium was informed and confirmed to be aware that there should be a clear reference to the Project on all the invoices using the format: LIFE14 ENV/ES/000538.

Besides, when purchasing goods, suppliers are given the project reference and informed that its inclusion in the invoice is compulsory. When this is not possible, beneficiaries have a mark stamp with the projects reference and internally they always check that all invoices are correctly marked.

CEBAS-CSIC:

Accounting System: All Centers and Institutes belonging to CSIC work under a Standardised Management System of Internal Accounts (SANCI from its Spanish name Sistema de Administración Normalizada de Cuentas Internas), as established in the Instruction of 10th February 2016 of the General Secretary of CSIC.

Internal Accounts (Cuentas Internas) are created in order to register all costs incurred under one specific scientific activity or project and constitute the basic unit for the financial management of this specific activity.

Therefore LIFE DRAINUSE is identified with the following reference Account: 403140 MARTINEZ LOPEZ, VICENTE - LIFE14 ENV/ES/000538 - 403140-LIFE14 ENV/ES/000538 OPE01240 DRAINUSE

CSIC

Fecha: 31/03/2017
Hora: 10:04
Página: 1 de 3

Extracto de cuenta Interna

090202 CTRO. EDAF. Y BIOL. APLICADA DEL SEGURA

Fecha Desde: 01/01/2016 **Fecha Hasta:** 31/12/2016 **Tipo:** Todos los tipos

Cuenta 403140 MARTINEZ LOPEZ, VICENTE - LIFE14 ENV/ES/000538 - 403140-LIFE14 ENV/ES/000538 OPE01240 DRAINUSE

Tipo: PROYECTOS

Approval of cost, purchase procedures: The researcher responsible for the project in CEBAS-CSIC is the competent person to propose the register of an invoice to the corresponding Internal Account.

The procedure for costs' approval is determined on the LGP 47/2003, *Ley General de Subvenciones 38/2003RD 3/2011, del 14 de noviembre,* la *Ley de Contratos del Sector Público* updated with *la Ley 9/2017 de 8 noviembre de Contratos del Sector Público and RD 1730/2007 de creación de la Agencia Estatal CSIC* and its Estatuto.

Time registration: The official LIFE model time sheet is used for all personnel participating in the implementation of the project. As required by the LIFE Program, Timesheets are double signed by the supervisor and the person participating in the project.

There is no a physical/electronical registration system. At the end of each month, the filled-in Timesheets are printed and signed.

VAT deduction: CSIC carries out activities subject to VAT that cause a legal right for tax deduction, according to the national legislation and particularly to Regla de la Prorrata of the Ley 37/1992 de 28 de diciembre, del Impuesto sobre el Valor Añadido (where Impuesto sobre el Valor Añadido - IVA - corresponds to VAT).

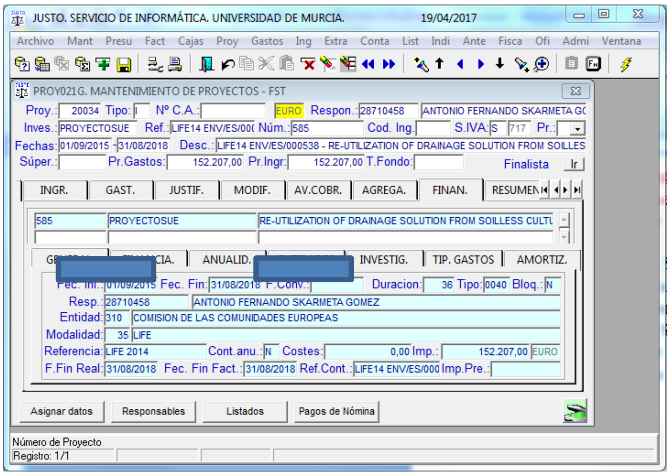
Every year, CSIC is meant to calculate the percentage of the supported IVA (VAT) in the previous fiscal year that can be deducted as it is established in the aforementioned law. In 2015 and 2016, the percentage of IVA deductible (recoverable) was 72%, meaning CSIC assumed 28% of this tax (non-recoverable). In 2017 the porcentaje of IVA deductible was 84% and in 2018 of 85%.

Please find attached the yearly VAT declaration submitted to the national tax authority (Agencia Tributaria belonging to Ministerio de Hacienda y Administraciones Públicas) for the fiscal years 2015, 2016, 2017 and 2018.

UMU: University of Murcia

Accounting System: The Accounting System established at the University of Murcia is a Public Accounting System that uses a computer application called "Justo" implemented since 1996. The basis of accounting lays on the accrual and the currency used is the Euro.

The Accounting System is the same one for the whole University of Murcia. Therefore, in order to carry out the accounting of a project, income and expenditure are identified through the allocation of a "Justo" project number. Project DRAINUSE has been assigned number 20034.



<u>Approval of cost, purchase procedures:</u> The Principal Researcher of the project is responsible for authorizing the necessary expenses for the execution of the project. Once this person authorises (signs) the invoices, these invoices have to be sent to the Department of Economic Management to be charged to the project.

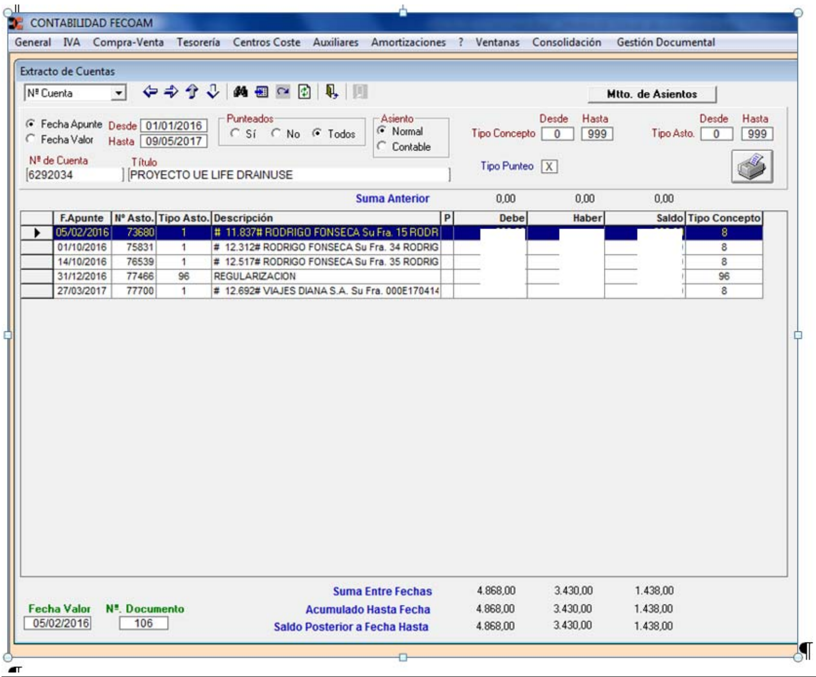
The pocedure followed by UMU for approval of cost and purchase procedure is described in articles 48 to 59 of the economic regime that can be found in the web page of UMU in the following link : https://sede.um.es/sede/normativa/instrucciones-de-regimen-economico-presupuestario-modificacion-2018/pdf/68.pdf

<u>Time registration:</u>. The University of Murcia uses the model timesheet made available on the LIFE website, an “Excel” spreadsheet which is manually completed.

Each employee registers the time worked for the project in a timely manner, on a daily basis or as soon as possible. The fulfilled timesheet printout for a given month is signed and dated by the employee and passed to the supervisor, who checks the timesheet before signing and dating it, within the first two weeks after the month the timesheet relates to, being the supervision role for the Principal Researcher developed by the Secretary of Department of Information Engineering and Communications.

FECOAM:

<u>Accounting System:</u> FECOAM counts on an analytical accounting system that distributes the costs amongst department, projects and activities. In this sense, the costs charged to LIFE DRAINUSE project expenses are distinguished from others as they use a clear accounting reference “6292034” and named: PROYECTO UE LIFE DRAINUSE.



<u>Approval of cost, purchase procedures:</u>

The approval of expenses: In accordance with Law 38/2003, of November 17, General of Subsidies. *Article 31. Eligible expenditure*, where it is stated that when the amount of eligible expenditure exceeds EUR 30 000 in the case of a cost for the execution of a work, or EUR 12 000 in the case of supply of capital goods or provision of services by consulting or technical assistance companies, the beneficiary shall request at least three offers from different suppliers, prior to contracting the commitment for the provision of the service or delivery of the good, unless the number of entities that provide it with the special characteristics of the eligible expenses does not exist in the market Or provide, or unless the expense has been incurred prior to the grant application.

The choice between the bids submitted, which must be provided in the justification, or, where applicable, in the application for the subsidy, shall be made according to efficiency and economy criteria, and the choice must be expressly justified in a report when it does not fall within the Most advantageous economic proposal.

Travel costs Employees travelling are asked to fill a “Travel Note” to register all the expenses that have to be reported by providing all supporting tickets and invoices. There is a travel agency that manage and book the flights and accommodation, and after the administration Department validates the expenses and includes the costs on the corresponding sub-account. Travel expenses are generally reimbursed on real cost basis with supporting documents. Travel tickets are issued on economy class basis.

<u>Time registration:</u>

FECOAM uses the model of Timesheet proposed by LIFE Program as template for time registration. The timesheet, which includes not only DRAINUSE but other European projects being funded as well, is filled in a daily manner by the worker; printed out, dated and signed every month by the staff during the first week of the following month. This timesheet signed by the worker is also sent to the supervisor who validates that the information is correct and signs and dates the timesheet during the first week of the following month.

RITEC: Riegos y Tecnología S.L.

Accounting System: RITEC has an analytical accounting system that distributes the costs amongst department, projects and activities. In this sense, the costs charged to LIFE DRAINUSE project expenses are distinguished from others as they use a clear accounting reference: LIFE14 ENV/ES/000538

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24-04-2017 Desde : 01-01-2016 Hasta : 31-12-2016 * EN EUROS *

CUENTA:20000005 GASTOS I + D LIFEI4 ENV/ES/000538

Time registration: RITEC uses the model of Timesheet proposed by LIFE Program as template for time registration. The timesheet, which includes not only DRAINUSE but other European projects being funded as well, is filled in a daily manner by the worker; printed out, dated and signed every month by the staff during the first week of the following month. This timesheet signed by the worker is also sent to the supervisor who validates that the information is correct and signs and dates the timesheet during the first week of the following month.

All the beneficiaries of this Consortium guarantee the implementation of the procedures defined by LIFE during their approval of costs and the purchase procedure .

8.3 Partnership arrangements

Financial transactions between the coordinating beneficiary and the associated beneficiaries

There is a partnership agreement that was signed on November 2015 by the entire consortium (It can be found in Annex VI). Key content of the document is: Definition and duration; Consortium management and structure; Technical and financial management of the project; Payment conditions; Intellectual Property Rights; Access rights; Results publication and dissemination; Responsibilities; Confidentiality and payment schedule.

Financial reporting implemented by each beneficiary and consolidated cost statement prepared

For the financial reporting, the Coordinator prepared a Management Guide (Delivered in the First Progress Report, DE1), which explains the procedure to be performed. Besides, the coordinator has the support of an external assistance company (Euro-Funding) subcontracted to deal with any financial project issues and assist with the procedure of requesting, reviewing and compiling the different Reports (Progress, Mid-Term and Final).

All in all, the Periods of justification will be communicated in advance by the Coordinator in order to plan the timings to request the information.

- A template for each report with instructions to be completed will be sent to each partner two weeks before the end of each period of justification.
- At the end of the period of justification, a reminder will be done to all partners.
- The template will be sent back completed maximum 2 weeks after the end of justification period to review and consolidate the information received and request any change if required before sending the final version to the Commission and the External Monitoring Team.

In addition, the coordinating beneficiary will require from the associated beneficiaries copies of the supporting documents (e.g. pay slips, timesheets, invoices, proof of payment, etc.) with the production of every report in order to monitor the development of the financial implementation of the project.

The financial information will be reviewed and if any incongruences or errors are detected during this process, the corresponding beneficiary will be informed and modifications requested if needed.

8.4 Certificate on the financial statement

In accordance with Annex Art. II.24.2, an independent auditor, nominated by CEBAS-CSIC, has verified the statement of expenditure and income submitted to the Commission. The coordinating beneficiary has selected **AUDIPÚBLIC AUDITORES, S.A.**, ROAC No S1700, Nº3 Plaza de los Apóstoles 30001 Murcia.

The Period audited comprehends from September 1st 2015 until May 31st 2016. Taking into account that in December 2016 the EC launched an amendment limiting the need to present the Certificate on the financial statement to those beneficiaries for which the total contribution in the form of reimbursement of actual costs was at least of EUR 325.0000.

8.5 Estimation of person-days used per action

Action type	Budgeted person-days	Estimated % of person-days spent
Action A: Preparatory actions	85	**78 %** (66,21)
Action B: Implementation actions	2095	**127,2%** (2665,2)
Action C: Monitoring of the impact of the project action	60	**94.2%** (56,5)
Action D: Public awareness/communication and dissemination of results	205	**106,7 %** (218,76)
Action E: Project management	570	**90,7%** (516,99)
TOTAL	**3015**	**116,9%** (3523,66)

ACTION A: Preparatory Actions

Action	A.1	
	BUDGETED PERSON-DAYS	REAL PERSON DAYS
Days Worked	55	41,38

Action	A.2	
	BUDGETED PERSON-DAYS	REAL PERSON DAYS
Days Worked	30	24,83

The amount charged corresponds to 41,38 days-worked in Action A1 and 24,86 days-worked in Action A2. The effort has been less than budgeted due to the fact that more senior staff was involved. CEBAS-CSIC had some internal procedures for hiring personnel that delay the beginning of Action A1, resulting in a delay of Action A2 as well. To overcome this situation, CEBAS-CSIC involved more senior staff than expected that helped saving working days.

Action B: Implementation actions

Below is described the effort deviation per action:

Action	B.1	
	BUDGETED PERSON-DAYS	REAL PERSON DAYS
Days Worked	45	19,33

Action	B.5	
	BUDGETED PERSON-DAYS	REAL PERSON DAYS
Days Worked	710	797,07

Action	B.2	
	BUDGETED PERSON-DAYS	REAL PERSON DAYS
Days Worked	140	165,43

Action	B.6	
	BUDGETED PERSON-DAYS	REAL PERSON DAYS
Days Worked	50	59,00

Action	B.3	
	BUDGETED PERSON-DAYS	REAL PERSON DAYS
Days Worked	555	871,77

Action	B.7	
	BUDGETED PERSON-DAYS	REAL PERSON DAYS
Days Worked	50	54,70

Action	B.4	
	BUDGETED PERSON-DAYS	REAL PERSON DAYS
Days Worked	495	643,71

Action	B.8	
	BUDGETED PERSON-DAYS	REAL PERSON DAYS
Days Worked	50	54,20

In Action B1: The amount charged corresponds to 19,33 days-work by CEBAS-CSIC, being the effort in person-days dedicated by CEBAS-CSIC lower than the foreseen in this action (budget = 45 days). As consequence of the hiring difficulties experienced at the beginning of the project because of CEBAS-CSIC's internal lengthy procedures, Action A1 was delayed, resulting on a delay and overlap of Action A2 and B1. To catch up with the work progress, fewer technicians were involved and more senior staff took part. As a result of the experienced profiles and efforts made by CEBAS-CSIC, they managed to maximize results of its dedication and optimize the efforts.

Action B.2 "Pilot plant design of the integrated system for water reuse and recycling" started on time but some extra days were needed to complete the design of the system planned in this action.

In total 25,43 days more than expected were necessary. During the preparation of the proposal we estimated very tight the time needed for the design of the Pilot Plant. CBAS CSIC and RITEC, specially, needed a few more days than initially planned to plan properly the design of the integrated system.

The total amount of days worked was 165,43 days: 27,33 days-work by CEBAS-CSIC, 77,63 days-worked by RITEC and 60,47 days-worked by UMU.

In Action B3 CEBAS-CSIC had to involve more professors, technician and bachelors efforts than initially planned due to the magnitude of the Project.

During the construction phase, several changes had to be implemented into the initial design. Among them:

- The greenhouse of CEBAS-CSIC was not big enough to build the prototype and a few additional days were needed to study the new lay out. An extension of 60sqm was decided and constructed.
- The second change was the number of irrigation sectors. Initially, we considered one irrigation sector (one treatment tank). But for operational reason it was decided to change and work with three irrigation sectors. Three tanks to be used to irrigate with different treatment (different water quality). This changed implied more pumps, valves, sensors, and a considerable modification in the hydraulic installation. And as consequence several addition days to implement.
- Problems with the electrical installation: there were a lot of signals coming from different PLCs and we had to separate them in different blocks.
- We had to change some flow meters and a pump that did not worked properly.
- The increase in the number of automata devices and electric panels (more sensor/actuator signals to monitor the system) that required additional time.
- Management of the process by the automata. Initially, we defined the management of the whole process with two master automates, but afterwards, once the system was implemented, we decided to control the management only with one master automata.

In total, all these changes required 316,77 additional days in Action B3 than initially expected in the Grant Agreement. CEBAS-CSIC worked 119,40, RITEC worked 577,63 days and UMU worked 174,74 days.

During **Action B4,** *"set up and follow up of the Pilot Plant"*, the following problems rose:

- Disinfection with the UV lamp was not effective, some microorganisms mainly fungi, yeast and bacterium were detected in the drain water after the disinfection. To solve these problems, more personnel that initially expected had to be involved in the next cycles and find a solution for the disinfection.
- Greater effort than initially expected was needed with the flow meters that had to be replaced with signals. And the replacement of the pump that feeds the Osmosis Plant because was not supplying enough water pressure.

As a consequence, a total of 148,71 days more than initially expected were needed for this Action, to solve these problems and properly set the pilot plant. CEBAS-CSIC worked 103,13 days, RITEC worked 227,38 days and UMU worked 313,2 days.

In Action B5 *"Demonstration of water closed cycle in soilless tomato production"* The amount charged corresponds to 797,07 days worked by CEBAS-CSIC. 87,07 days more than initially expected had to be invested in this action by CBAS CSIC. The main reasons for this additional effort are the problems faced during the first cycle (tomato crop was affected by plague and plant density didn´t have optimal values) and the additional effort needed for carrying out the third cycle (spring-summer) not foreseen initially in the Proposal and that was concluded with great results.

Bachelor, technicians, scientist, and professors as it is core action for the project and experts were involved in order to supervise and guide the successul implementation. Main tasks performed in all the cycles have been: preparing the seeding transplanting, transplanting, water and nutrients application and control, analysis of nutrient solutions and drainages, fruit harvest and analysis of production, yield and quality.

In Action B6 Economic Feasibility analisis 9 days more than initially foreseen were needed.

The amount charged corresponds to 10 days worked by RITEC and 49 days worked by CEBAS-CSIC.The additional effort (9 days)invested in the preparation of these Deliverables are due to the need to include all the details that the EC requested in its letter from September 7th , 2018.

In Action B7, the amount charged corresponds to 38,20 days worked by CEBAS-CSIC and 16,5 days worked by FECOAM.

The additional effort 4,70 days invested in the preparation of this Deliverable is due to the need to include all the details that the EC requested in its letter from September 7th , 2018

In Action B8, additional effort of 6.20 days worked by CEBAS CSIC were needed in the preparation of Deliverable "Transferability of LIFE DRAINUSE results" due to the need to include all the details that the EC requested in its letter from September 7th , 2018.

The amount charged corresponds to 36,20 days worked by CEBAS-CSIC and 18 days worked by FECOAM.

The reason for the extra effort of 27, 2% in Actions B has been the additional effort needed as consequence of all the unexpected circumstances that raised all along the Project and that have implied a change in the initial design of the Pilot Plant.

Action C: Monitoring of the impact of the project action

Action	C.1	
	BUDGETED PERSON-DAYS	REAL PERSON DAYS
Days Worked	30	28,33

Action	C.2	
	BUDGETED PERSON-DAYS	REAL PERSON DAYS
Days Worked	30	28,17

In Action C1 and Action C2, CEBAS CSIC had 30 days foreseen each one for the monitoring of the "Efectiveness of LIFE DRAINUSE actions as compared to the initial situation" and for the "Monitoring of the socio-economic impact of the Project on the local economy and population".

Days invested in both of the Actions were in line with the Budget. No major deviation has occurred.

Action D: Public awareness/communication and dissemination of results

Action	D.1	
	BUDGETED PERSON-DAYS	REAL PERSON DAYS
Days Worked	155	162,31

Action	D.2	
	BUDGETED PERSON-DAYS	REAL PERSON DAYS
Days Worked	10	12,57

Consumables	D.3	
	BUDGETED PERSON-DAYS	REAL PERSON DAYS
Days Worked	35	31,25

Action	D.4	
	BUDGETED PERSON-DAYS	REAL PERSON DAYS
Days Worked	5	12,63

In Action D1 *"Dissemination of the project results"* Effort per partner has been:

CEBAS CSIC worked 21,7 days; FECOAM 107,32 days; RITEC 24,75 days and UMU, 8,54 days

In Action D2 *"Elaboration of Project Website"* Effort per partner has been:

The Consortium agreed on transferring the budget of the external assistance from CEBAS-CSIC to RITEC so that the website would be launched as early as possible. In any case CEBAS-CSIC remained the leader of this Action.

That is the reason why RITEC had to invest 2,5 days not initially planned in this Action. CEBAS CSIC worked 10,07 days and RITEC worked 2,5 days

In Action D3 *"Elaboration of the Layman´s Report"* FECOAM worked 31,25 days;

In Action D4 "*Elaboration and maintenance of Notice Boards*" FECOAM worked 12.63 days . Additional days were necessary to agree on the design and location of the Notice Boards.

Total Budget for Actions D was 205 days and were needed 218,76 days to complete successfully the dissemination of the Project. Time worked was in line with the time budgeted in the proposal

Action E: Project management

Action	E.1	
	BUDGETED PERSON-DAYS	REAL PERSON DAYS
Days Worked	500	457,27

Action	E.2	
	BUDGETED PERSON-DAYS	REAL PERSON DAYS
Days Worked	30	18,33

Action	E.3	
	BUDGETED PERSON-DAYS	REAL PERSON DAYS
Days Worked	30	30,72

Action	E.4	
	BUDGETED PERSON-DAYS	REAL PERSON DAYS
Days Worked	10	10,67

In Action E1 “*Project Management*” all the partners have contributed:

CEBAS CSIC worked 318,53 days; FECOAM 62,44 days; RITEC 49,5 days and UMU, 26,8 days. There have been three visits from the External Monitoring Team and two progress Reports, one mid term report and this final report that have been prepared during the Project duration, in addition to the day to day management.

In Action E2 “*Networking activities with other Projects*” mainly CEBAS CSIC centralise all the efforts of the networking activities, having worked 18,33 days.

In Action E3, “*After Life Plan*” CEBAS -CSIC worked 12,47 days, and FECOAM 18,25 days. A plan for the future dissemination ofm the Project has been gathered in the “After Life Plan”.

In Action E4, “*Compilation of information for indicator tables*” was monitored by CEBAS CSIC

that worked a total of 10,67 days.

Budget foreseen in ACTION E1 has been of 570 days and the days effectively worked by all parnters have been, 517 days.

Deviations in Personnel Costs:

1) CBAS-CSIC

In general the daily rate of the Sicentists from CBAS-CSIC involved in the Project has been in line with the budget foreseen in the proposal except from Francisco Rubio Muñoz which daily rate was approximate 20% higher than the numbers foreseen in the proposal. At the time of writting the proposal was taken into account the average cost of a Scientist in CBAS-CSIC. Being the daily rate of this employee higher in average than the rest due to his specific knowledge and experience.

The contribution of Bachelors and Technicians from CBAS-CSIC had a lower cost than initially foreseen in the proposal. The profiles selected reunited all the specific knowledge required for the Project but the market Price at the time of execution of the Project was lower than expected.

2) FECOAM

The daily rate reported by the workers of FECOAM has been in line with the budget foreseen in the proposal except from Mª Dolores Mondejar Acosta that has a slight higher daily rate than the rest of employees. The reason for this higher daily rate is that: Mª Dolores is a worker of FECOAM since 07/05/1985 and in application of the the Labor Agreement, she has a recognition for her seniority in the company. The right to retain the supplement is of three years at 7% and always respecting the maximum limit of 60% at 25 years or more of seniority, at a rate in the amount of the percentage that they had perfected for that concept on December 31, 1997 always applied to the current salary, as a right acquired "ad personam".

We include below the article from the Labor Agreement that applies to her.

“ Artículo 16.- Antigüedad.

Los trabajadores incorporados a las plantillas de las Empresas afectadas por este Convenio a partir de 1.º de enero de 1995, no devengarán el complemento salarial de Antigüedad.

Los ya pertenecientes a las plantillas con anterioridad a dicha fecha, mantendrán el derecho a percibir dicho complemento, a razón de trienios al 7% y respetándose siempre el tope máximo del 60% a los 25 años o más de antigüedad, en la cuantía del porcentaje que tuvieran perfeccionado por tal concepto el 31 de diciembre de 1997 aplicándose siempre sobre el salario vigente, en concepto de derecho adquirido “ad personam”.

3) UMU

There was not deviation from the budget foreseen in the Grant Agreement. Personnel costs have been in line with the budget foreseen.

4) RITEC

There was not major deviation from the budget foreseen in the Grant Agreement. Personnel costs have been mostly in line with the budget foreseen. Except from the daily rate of Jose Antonio Marin and Francisco Millán that have been lower than initially foreseen. The reason is that salary increases foreseen for employees of RITEC at the time of writting the proposal have not been materialised due to the difficutlies that the spanish economy has been facing in the last years. The employees have only benefited from moderate salary increases.

The rol Montador/ assemblers not foreseen originally in the Grant Agreement were necessary to build the pilot plant, since the position of Engineer was needed for the design. This role was not foreseen in the Grant Agreement, but during the execution of the Project we realised it was necessary this role for assemblies and adjustments throughout the entire Project.