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INNOVATIVE GREENHOUSE SUPPORT SYSTEM IN THE MEDITERRANEAN REGION: EFFICIENT FERTIGATION AND PEST MANAGEMENT THROUGH IOT BASED CLIMATE CONTROL — IGUESSMED

Deliverable 4.2

Protocol for living labs creation.

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Dissemination Level

☒	**PU:**	Public
☐	**PP:**	Restricted to other programme participants (including the Commission Services)
☐	**RE:**	Restricted to a group specified by the consortium (including the Commission Services)
☐	**CO:**	Confidential, only for members of the consortium (including the Commission Services)

Abstract

The deliverable contains the guideline for living lab creation. In each country, a Living lab (LL) will be established following a common protocol. The LL in iGUESS-MED project will support the stakeholders' involvement, will provide sound evidence-based information about the socio-economic and environmental performance of the innovative solutions proposed in previous WPs, to support farmer investment decisions. The LLs will focus on emphasizing country-specific issues and will contribute to fostering dialogue on salient issues, e.g., gender equality and inclusion, equity along the value chain. The protocol is designed to provide an adequate understanding of the sustainable implication of the new technology installed in the new greenhouses. To this aim, the deliverable 4.2 will provide guidelines on all LL activities to ensure fruitful engagement and coherent data collection. The deliverable includes a series of annexes providing templates and examples to facilitate data collection and stakeholder engagement and reporting templates.

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Acronym list

DSS: decision support system

LCA: Life Cycle Assessment

LCC: Life Cycle Costing

LL: Living Labs

MCA: Multi-criteria analysis

NEI: Needs, Expectation and Impact

SDGs: Sustainable Development Goals

SWOT: Strengths, Weaknesses, Opportunities, and Threats

1. Introduction

The iGUESS-MED project aims to develop a Decision Support System (DSS) able to effectively manage fertigation and prevent plant diseases and pests in tomato crops grown in soil and soilless in commercial greenhouses of the Mediterranean region. This innovative greenhouse DSS will be developed to (i) help greenhouse farmers to improve the management of fertigation in areas with low (saline) quality waters, (ii) to reduce the use of chemicals by a sustainable and integrated pest and disease control and, (iii) to improve the climatic efficiency in the existent greenhouse by low-cost climate actions. The DSS will allow obtaining healthier and higher quality productions and higher yields while reducing the use of water and the loss of nutrients and chemicals to the environment. iGUESS-MED will be able to manage efficient fertigation, forecast diseases and pests, and improve the climatic efficiency in tomato greenhouses, using only climate data acquisition and basic information on cropping systems. The DSS will provide feedback and alerts about crop needs and real-time recommendations to the farmers through friendly portable real-time data visualisation tools such as PC, tablets, or smartphones. To achieve this objective, new models for calculating crop evapotranspiration will be performed by integrating sensor data from plant, soil and climate, and forecasting models for assessing disease and pest risks will be developed by using Integrated Pest Management.

The project consortium (research centres, SMEs and end-users of EU and non-EU countries belonging to the Mediterranean basin) will collaborate from the beginning to make the DSS marketable, involving end-users and stakeholders to validate the system in their own greenhouses, reducing gaps between research, application developers and farmers. The application of DSS will benefit the workers and the consumers, providing better working conditions, crop healthiness and reduction in environmental impact.

1.1 Summary of the deliverable

The overarching objective of WP4 is to create an enabling environment for the transition towards sustainable, resilient and inclusive greenhouse cropping systems.

Sub-objectives are as follows:

- To boost stakeholders' involvement, to empower a new generation of farmer and to overcome gender barriers;
- To provide sound evidence-based information about the socio-economic and environmental performance of the innovative solutions proposed in previous WPs, emphasising country-specific issues;
- To support farmer investment decisions while promoting social dialogue, gender equality and inclusion by removing knowledge barriers.

WP4 develops multidisciplinary and transdisciplinary research to enable reliable and comprehensive decision support towards more ecological greenhouse production in developed and developing countries of the Mediterranean basin. To that purpose, a responsible research approach (Owen, Macnaghten and Stilgoe, 2012) is adopted to assess how the adoption of the DSS can facilitate a transition towards an agricultural model that simultaneously supports more environmentally friendly production and consumption of fresh vegetables, the prosperity of rural areas and equity among all actors involved.

Task 4.2 supports these broad objectives by creating Living labs (LL). The LL represents a hot topic in the field of social science as it can strengthen the capacities of actors and regions by involving and mobilizing stakeholders' knowledge in a quadruple helix model (Carayannis, Campbel 2009). In addition, a continuous dialogue between stakeholders can ensure the acceptability of proposed technological solutions, innovation, and sustainability as the ultimate results (Compagnucci et al., 2021). However, as McCrory et al. (2020) pointed out, the LL needs often remains limited to qualitative analysis. The LL activity should include a salient quantitative exercise to provide a robust analysis. Therefore, the proposed guideline aims to integrate both a qualitative analysis of stakeholders' needs with a robust empirical assessment of innovation in the greenhouse and its impact on the territorial scale.

LL will be established across the iGUESS-Med consortium (4 LLs in total, one per partner country) by involving a variety of stakeholders with expertise in the greenhouse sector in a participatory process to support data collection and interpretation and enabling knowledge co-creation through the integration of formal knowledge and know-how in task 4.3.

Each LL will develop the following activities:

Subtask 4.2.1: Support sustainability assessment at the test site level, i.e. quantitative Life Cycle Assessment (LCA) and Life Cycle Costing (LCC), which serve to identify the main environmental and economic issues of the current production system (before adoption) and the potential contribution of the DSS to address them (after adoption);

Subtask 4.2.1: Supporting the careful consideration of social aspects (e.g., new jobs, improvement of working conditions, reduction of exploitation of immigrant labour and of the gender gap), by contributing to qualitative social impact assessment at the test site and territorial levels, which serve to frame the contribution of the DSS (after adoption) to improve the social performance of greenhouse farming;

Subtask 4.2.2: Engagement in a participatory process with the research team to deliver a qualitative assessment of Needs, Expectations and Impact (NEI) at the territorial level by: (i) pinpointing stakeholder needs for enabling the diffusion of the DSS technology, by means of a description of the context and the identification of the

strengths, weaknesses, opportunities and threats (SWOT analysis); (ii) participating to a participatory MCA exercise to prioritising the sustainability issues related to the diffusion of the DSS and enable the definition of societal expectations, through issue mapping to UN Sustainable Development Goals; (iii) creating a community of practice to encourage technology adoption and to provide guidance to newcomers, based on the co-created practice-validated knowledge in task 4.3.

Deliverable 4.2 has the objective of supporting iGUESS-Med partners in the implementation of LL activities is subtasks 4.2.1 and 4.2.2 by describing research methods, providing guidelines and templates for data collection and reporting, as well as by providing supporting materials for stakeholder engagement, including workflow of activities, proposed agendas and deadlines, invitation letters, templates, slides for presentations, evaluation questionnaires and consent forms for participants.

The main deliverable text has two more sections, as follows:

The next section (Section 2) describes research methods and data collection for the LCA and LCC (test site level), as well as for the social assessment (test site and territorial level);

The following section (Section 3) describes research methods and data collection for the NEI assessment.

The Annex section provides guidance and templates for data collection, including a pilot case study and materials for stakeholder engagement.

2. Research methods and data for Life cycle assessment and Life cycle costing

This section concentrates on Subtask 4.2.1. by providing guidance on LCA and LCC, which are strictly related to each other. Social impact assessment will be presented alongside Subtask 4.2.2, due to the close relationship with MCA development.

Life Cycle Assessment (LCA; ISO 14040:2006, 14044:2006) and Life Cycle Costing (ISO 15686-5:2008) are process-based tools to assess the environmental (LCA) and economic (LCC) impacts of products, from the production of raw materials to disposal. LCA and LCC are carried out through a stepwise approach with 4 phases, i.e. goal and scope definition, life cycle inventory analysis, life cycle impact assessment, and interpretation. This section describes the empirical application of the 4 LCA and LCC phases in iGUESS-MED, more details are available, e.g., from Brentrup et al., (2004); Curran, (2013); Pennington et al., (2004); Rebitzer et al., (2004).

2.1. Goal and scope definition

The goal of the study is to provide a comparative environmental and economic assessment of the life cycle of greenhouse tomatoes for fresh consumption before and after the adoption of the iGUESS-med technology at the test site level. An additional objective is to compare the findings across test sites.
The functional unit is the occupation of 1 hectare with a greenhouse that produces tomatoes for fresh consumption, over a 1-year period. Data refer to year 2022.
The system under study is the test site, i.e. the greenhouse where the DSS will be intalled and tested. The boundaries of the analyses are from input production to the farm gate and cover all the elements (i.e. life cycle stages) of the system (Figure 1).

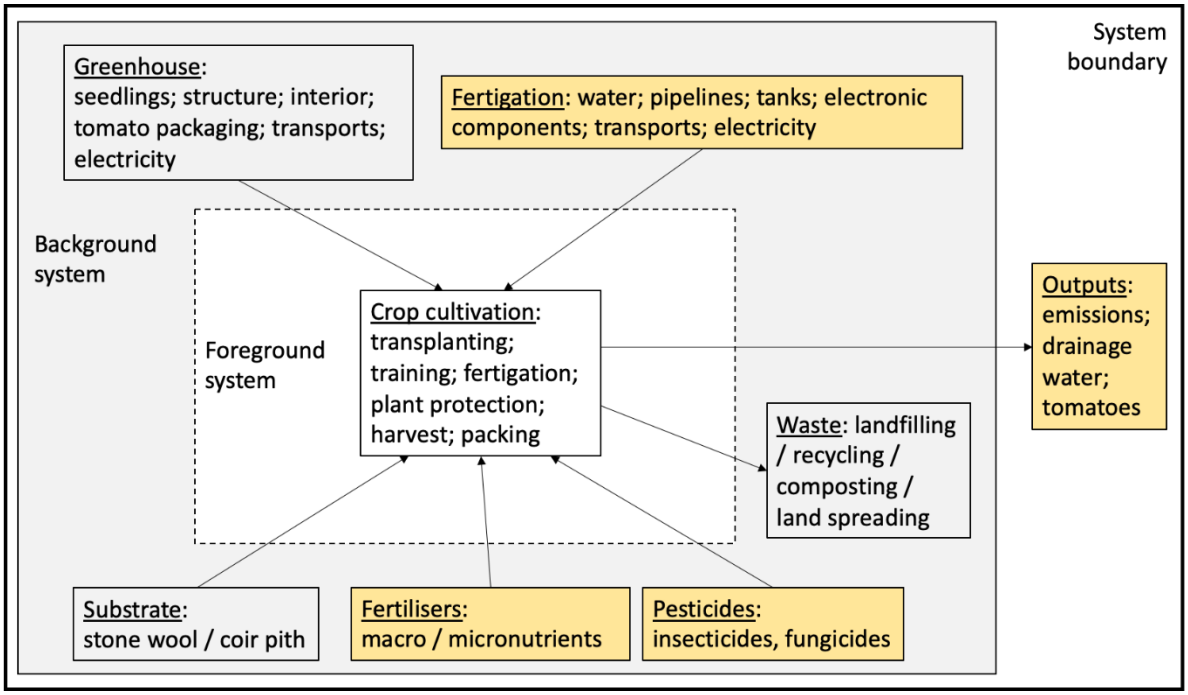

Figure 1 - System boundaries for LCA and LCC at the test site level.

In figure 1, each box displays a stage of the system. The background system includes all the stages that are needed to allow crop cultivation. Those stages are the greenhouse infrastructure, the fertigation infrastructure, the cultivation substrate (in case of soilless cultivation), fertilisers, pesticides and waste management. The foreground system includes crop cultivation (the "use" stage), i.e. the stage where background system stages are "used" to deliver system Outputs. Those Outputs are emissions to air, water and soil, drainage water (if present) and tomatoes for fresh consumption. Yellow boxes show the elements of the system that are subject to change after the adoption of the iGUESS-MED technology.

2.2. Life cycle inventory analysis

This phase includes data collection and the creation of the final dataset for analysis. Primary information is gathered by iGUESS-Med Partners on the field about the quantities and costs of all the inputs (materials and natural resources) and outputs (emissions, harvested product) within system boundaries.

The quantities and costs for the farmer of all the inputs and natural resources used during crop production are recorded.

Indirect emissions originate from background system processes (e.g., production of inputs) and are from the Ecoinvent 3.8. Direct emissions originate during the use phase (here farming) and are calculated using emission factors. The following emission factors are used:

Emissions	Formulas	Description	Source
Machinery (to air)			
CO, HC, NO_X	= $ER_{CO,HC,NOx}$ * ot	$ER_{CO,HC,NOx}$ = reference emissions from field operation (g/h); ot = operation hours	(Nemecek and Kägi 2007)
CO_2, CH_4, NH_3, SO_2	= DC * $EF_{CO2,CH4,NH3,SO2}$	DC = diesel consumption; EF = emission factor (g/kg_{diesel})	
$PM_{2.5}$	= $EF_{PM2.5}$ * 0.854 *MP * ot	$EF_{PM2.5}$ = emission factor for $PM_{2.5}$ (g/kg_{diesel}); MP = (mean power during fieldwork	
Fertilisers (to water)			
N_2O	= 1.25% of N_f	N_f = total N applied with fertilizers (kg/ha)	(Nemecek and Kägi 2007)
NH_3	= 2% of N_f		
No_x	= 0.21 * emissions of N_2O		
Fertilisers (to soil)			
NO_3	= 0.3 * N_f		(Erickson et al. 2001; Masoni 2010)
K_2O	= K_{pl} * (K_l/100)	K_{pl} = amount of potentially leachable potassium oxide (kg/ha); K_l = leaching coefficient	
Pesticides			
To air	= 5% active ingredient (g/ha)		(Audsley et al. 1997; Margni et al. 2002; Juraske et al., 2007)
To water	= 8.5% active ingredient (g/ha)		
To soil	= 76.5% active ingredient (g/ha)		

Table 1 - Details about emission calculation methods.

Costs are considered as prices for the relevant decision-making actor, here the farmer. Given system boundaries, information about costs includes building and maintenance (e.g. administrative costs, project design, advisory), labour (family and/or hired workers) and demolition (e.g. demolition company, disposal of construction waste). The monitored costs for the farmer are enough to build the LCC inventory, as they incorporate all the costs of upstream phases in the value chain.

2.3. Life cycle impact assessment

Impact indicators are calculated in the LCA only, as costs are already expressed in the relevant unit of measure for impact assessment, i.e. currency. Some indicators are calculated in the LCC as well, to derive insights about the profitability of the investment over time.

In the LCA, data about direct and indirect emissions and resource consumption from the LCI are classified to impact categories and characterised, based on the selected life cycle impact assessment model, ReCiPe 2016 Midpoint (H) (Huijbregts et al. 2017). This model is selected as it allows the comparison of European and non-European countries. The characterisation of impact categories is based on characterisation factors ($CF_{i,j}$) that represent the potential contribution of emissions (E_j) or resource consumption (R_j) to impact categories (IC_i) they are classified to, as follows:

$$IC_i = \sum_j (E_j \vee R_j) \times CF_{i,j}$$

The following characterised impacts are calculated:

- Climate change (kg CO2 eq)
- Fine particulate matter formation (kg PM2.5 eq)
- Terrestrial acidification (kg SO_2 eq)
- Freshwater eutrophication (kg P eq)
- Marine eutrophication (kg N eq)
- Terrestrial ecotoxicity (kg 1,4-DCB
- Freshwater ecotoxicity (kg 1,4-DCB
- Marine ecotoxicity (kg 1,4-DCB)
- Human carcinogenic toxicity (kg 1,4-DCB)
- Human non-carcinogenic toxicity (kg 1,4-DCB)
- Water consumption (m^3)

The indicators calculated from the LCC are as follows (Gava et al. 2023):

- Total Cost of Production: the sum of all costs beared by the farmer for 1 year production (based on the data collection year);

- Net Present Value: the actualised value of cash flows over the lifetime of the greenhouse (here 20 years);

- Profitability Index: the ratio between Net Present Value and the initial cost of the investment.

2.4. Interpretation

LCC and LCA findings are interpreted in a comparative way, i.e. before-after DSS adoption. The driving comparison is to show the effect of DSS adoption on all indicators, by highlighting differences and trade-offs among categories before and after technology adoption. Contribution analysis will support the identification of hotspots. Analytical findings are compared and discussed with the relevant literature, as well.

3. Assessment of Needs, Expectations and Impact and Social impacts

3.1. Needs, Expectations and Impact assessment

The Needs, Expectations, and Impact (NEI) assessment will generate co-created knowledge on the potential impact of the adoption of the DSS at the territorial level, through the engagement of a multiplicity of stakeholders, representing individual producers, institutions and the wider society, building on the theoretical framework (D4.1). The NEI assessment is a participatory tool for the assessment of digital technologies in agriculture, especially through LL (Metta *et al.*, 2009). The NEI assessment will consider the different socio-economic context of the project consortium and the overarching project objectives, including the different focal questions towards which the LL are built.

The territorial level of the LL is a NUTS2[1] area for EU (Italy, Spain) and EU candidate (Turkey) countries, and a comparable area for Tunisia.

The workflow for NEI assessment is as follows:

Identification of needs, through context analysis supported by SWOT analysis;

Multi-criteria assessment of sustainability issues;

Assessment of societal expectations.

The needs will be assessed at the stakeholder level. Needs are the conditions that should be met to enable the diffusion of the DSS at the territorial level. Needs will be pinpointed as the synthetic output of two complementary activities, i.e. context analysis and SWOT analysis.

MCA is a widely applied analytical tool to solve decision problems, by considering multiple evaluation criteria or dimensions, simultaneously. In iGUESS-MED, a series of specific sustainability issues (indicators) will be evaluated, covering the three broad dimensions of sustainability issues, i.e. economic, environmental and social (Figure 2).

[1] NUTS is the Nomenclature of Territorial Units for Statistics of the EU.

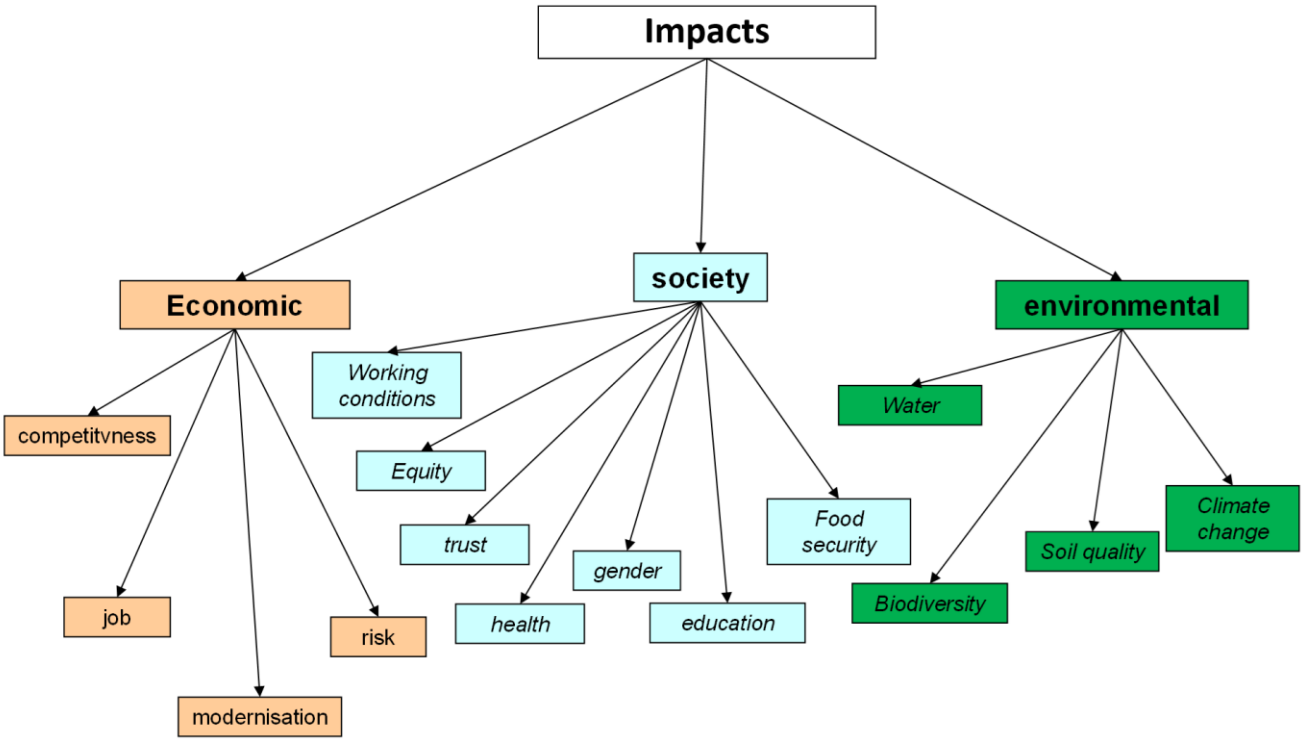

Figure 2 – Hierarchy of sustainability priorities.

The relative relevance (score) of the indicators will be evaluated by considering the extent to which the diffusion of the DSS can help solving the specific sustainability issue at the territorial level. Each indicator will be scored on a 0-7 scale, i.e. from the DSS does not solve the issue at all (0) to the DSS completely solves the issue (7). The relative importance (weight) of the DSS to contribute to mitigating the three broad sustainability issues will be evaluated on a 0—7 scale, as well, i.e. from the DSS does not solve the issue at all (0) to the DSS completely solves the issue (7). Weights will then be subject to internal normalisation (0-1), to highlight the trade-offs between the issues. A single score will then be calculated, representing an index for the aggregate performance of each indicator, according to stakeholder preferences, as follows:

$$Single\ score = \sum_{i=1}^{n} w_i S_{i,j}$$

where,

i = broad sustainability issues

j = indicators (specific sustainability issues)

w = importance weights, s.t. $\sum_{i=1}^{n} w_i = 1\ and\ w_i \geq 0\ for\ i = 1, \ldots, n$

S = sum of expert scores

The single score will enable indicator ranking considering the importance of the broad sustainability issue, as follows: the sustainability issue that will benefit more from the DSS is the one with the highest value for the single score(Munda, 2005). To calculate the single score, a simple linear additive function is used, coherently with the simplified questionnaire format adopted in the study. Additionally, linear additive models offer advantages for transparency to the user and parsimony of data collection, compared to more complex functions, which are important in participatory research (Stewart, 1995; De Vente *et al.*, 2016).

The MCA exercise will be conducted through a participatory approach, to ensure an inclusive approach to data collection. This activity will be combined by submission of questionnaire to local stakeholders in order to collect individual preference about impact domain and assess the relative importance of the proposed indicators. Ideally, each LL should collect about 10 questionnaires, covering the main stakeholder categories (see D4.1, Table 7). The rationale behind this exercise is to generate a broader understanding of the potential sustainability impacts of the diffusion of the DSS at the territorial level. Then, the exercise will build on a future perspective, by prospecting a "what if" situation (thought feasible), where the technology is adopted by all relevant greenhouse producers in the reference area.

Expectations define prospects of changes, through targets, formulated in qualitative or quantitative ways. In iGUESS-MED, UN Sustainable Development Goals (SDGs) will be used to identify societal expectations related to DSS diffusion at the territorial level (Incrocci *et al.*, 2008). To that purpose, the indicators used in the MCA will be mapped to SDGs.

3.2. Social impact assessment

The adoption of digital technologies for more ecological greenhouse cropping may have a variety of social implications and impacts. However, there is not wide quantitative knowledge about social impacts in the greenhouse sector, especially in non-European countries. Then, a qualitative approach based on a self-developed questionnaire is developed.

This approach is developed as an adaptation of the planned activities in technical annex. As LL activities were running, the research team agreed that it was not possible to quantify indicators for Social LCA or even to generate a qualitative understanding of social impacts at the test site level. This was probably due to the short time that has passed after DSS uptake, which did not enable changes in farm management or an understanding of the potential implications for farm management.

The improvement of social conditions related to greenhouse farming is central in the iGUESS-MED project. Then an alternative methodology will be used to enable social impact assessment of the DSS. Social impacts will be assessed through a set of indicators suitable for the evaluation of the social performance of digital technologies in agriculture. The indicators were selected by the research team to provide a broad overview of the social implications of the DSS and to enable comparisons or integrations with studies about other types of digital technologies. The set of indicators was developed as part of the MCA, which will be detailed in annex 3. Through the MCA exercise, the indicators will be prioritised.

For social impact assessment, a dedicated survey will be developed expanding the set of experts, compared to those involved in the MCA and in the LL in general. The aim is to gather knowledge from previous stakeholder experience about the potential social impacts of the DSS. To facilitate the exercise, the survey will include a description of the key elements of the iGUESS-MED project as well a summary of the key achievements (from LCA and LCC). In the survey, stakeholders will be asked to provide a description of the impact generated by each indicator both at the test site and at the territorial level (see Table 2 for an example of analysis).

Social aspect	Test site	Territorial level
Improvement of working conditions	Reduction of working hours, as DSS facilitates the control of nutrients and plant health	Greater attractiveness of greenhouse farming due to simplification of management
Greater equity in the distribution of value added among supply chain actors	No difference	In general, the reduced burden of agricultural work due to greater level of technology can attract more women
Greater affordability of food	Reduction of production costs might enable revenues even if market price decreases	The general reduction of production costs and the possibility to apply for incentives for sustainable farming may enable a decrease of consumer price
Increased trust among value chain actors	Buyers trust the greater sustainability of production due to greater efficiency of input use and IPM	Possibility to apply for sustainability certifications
Improvement of farmer health	Reduction of exposure to toxic pesticides	Reduction of toxicity impacts and general improvement of farmer health

Table 2 - Example of social impacts at the test site and territorial levels.

We will ask stakeholders to respond based on their personal knowledge and experience of the iGUESSmed project's research findings regarding the environmental and economic impacts of adopting the iGUESSmed DSS on demonstration sites. This exercise aims to generate a broader understanding of the potential sustainability impacts of diffusing iGUESSmed technology at the territorial level. We assume that stakeholders will describe potential impacts under a 'what if' scenario, with a hypothesis of diffusion of DSS at territorial levels.
Given the potential difficulty of this exercise, the questionnaire will be administered in the native languages of each partner country and kept simple to allow for ample flexibility in respondents' answers. The questionnaire is available from Annex 5.

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Annex 1 Workflow

What to do	Time	Who
Training	End of march	UNIFE All LL coordinators
LCA and LCC inventory (before adoption)	End of April	All LL coordinators
LCA and LCC inventory (after adoption)	End of May	All LL coordinators
Individual report section 1.1	End of May	All LL coordinator
MCA questionnaire	End of June	All LL coordinator
Individual report all section	End of September	All LL coordinator
Comparative Report	End of November	All LL coordinator

Table A 1 – Workflow

Annex 2 Reporting templates for living lab activities

Please use the following template to elaborate the report about the LL activities developed under subtask 4.2.1 and 4.2.2.

Focal question of the living lab
Please indicate the focal question of the LL; see the Italian example below:
"How to make effective use of the DSS to improve the environmental performance of soilless cropping, while supporting profitability and reduction of workload and health risk for farmers, as well as encouraging new entrants (especially young farmers and women)?"

Life cycle assessment and life cycle costing

This section is for reporting test site's description and the findings of LCA and LCC at the test site level (max 6 pages).

Description of the test site

Add here the Description of the test site. Please refer to the Italian pilot (Annex 3).

Data

Please carry out data collection using the excel file provided by UNIPI (Annex 3)
Add here the final inventory for LCA and LCC provided by UNIPI and provide an explanatory text.

Impact assessment

Add here the results of the LCA and LCC provided by UNIPI and provide an explanatory text.

Needs, Expectations and Impact assessment and social impact assessment

This section is for reporting the findings of the NEI assessment and of the social impact assessment.

Participatory data collection

Please add here information about the stakeholders involved in the NEI assessment (including social impact assessment).

Category	Number
Policy expert	
Researcher	
Advisor	
Farmer	
Value chain	

Table A 2 - List of interviewed stakeholders.

Analysis of needs

Context analysis (max 3 pages including table)

Add here the data for describing the protected horticulture sector at the territorial level and an explanatory text. If data are missing at the territorial level, please refer to country-level data.

Domain	Indicator	Description	Reference
Diffusion	Total area in hectares (ha)		
	Average extension		
	Distribution (concentrated or dispersed)		
	% entrepreneurs and foreign investments		
	Level technology		
	Structure: • type of prevailing structure (high tunnel, classic greenhouse, multi-span etc.) • Average eaves/ridge height • prevailing coverage type (plastic film, glass etc.) • type of opening • % heated greenhouses		
Performance	Main cultivated crops (up to five)		
	% tomato production		
	Average annual production (t)		
	Average annual profitability (€)		
	Annual waste production (plastic, substrates, etc.)		
Technology	% of soilless culture and main technique used (hydroponic, substrate, etc..)		
	The main substrate used		
	Irrigation: • main irrigation system in soil and in soilless crops • Irrigation scheduling in soil crops and in soilless crops • % closed or semi-closed cycle systems		
	Dominant pest control typology (organic, integrated etc.)		
	Climate control technique (manual, automatic, temperature sensors etc.)		
	Excess humidity control technique (fans, greenhouse opening etc.)		
	Low humidity control technique (mini-fog, foliar spraying, etc.)		
	Chemical inputs (Type and number of treatments)		
	Crop protection (chemical, biological, etc.)		
	% sustainable systems (e.g. rainwater storage, Use of renewable energy, etc.)		
Worker	Level of specialisation (roles and mansions)		
	Level of salary		
	Average working hours		
	Type of contract (fixed-term or open-ended)		
	Immigrant/national workers ratio		
	Top five country of origin of workers		
	Average age immigrant workers		
	Male/female ratio		

Domain	Indicator	Description	Reference
Economics	Estimated production costs		
	Higher production cost (labour, transportation, irrigation, etc.)		
	Incentives and facilities for technological and eco-sustainable investments		
Production chain	Main stakeholders (seed producer, fertiliser and defence systems, technical consultancy, transport, waste disposal, et.)		
	Distribution market (GDO, local market, direct sale, etc.)		
	Critical point		
	Public opinion on greenhouse products and environmental impact		
	Manufacturer's opinion/confidence in IoT		

Table A 3 - Context analysis at the territorial level.

SWOT analysis (max 2 pages including table)

Please fill in the SWOT analysis table, using the instructions (*italics*) and provide an explanatory text.

STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
• *Qualities that distinguish your context from others* • *Things that in your context are done well* • *Conditions that make your context unique*	• *Long term and persistent problems in your context* • *Things that your context lack* • *Things that other contexts do better* • *Resource limitations*	• *External trends and development which can offer new possibilities to solve problems* • *Social, market, technological, policy development in the last years*	• *External trends and development which can worsen specific problems* • *Etc.*

Table A 4 - SWOT analysis.

Needs

Please provide here the analysis of stakeholder needs as they emerge from context analysis and SWOT analysis.

Need	Description	Stakeholder
		Please refer to stakeholder categories

Table A 5 – Analysis of needs.

Multi-criteria analysis and social impacts

Please use the table below to report the results of the MCA assessment.

Broad issue	Average weight	Specific aspect	Average score
Economy		Economic	
		Increase of farmer competitiveness	
		Creation of rural jobs	
		Greater availability of sustainable technology for greenhouses	
		Risk of misuse of technology	
		MISSING ASPECTS added during the questionnaire (add lines when needed)	
Society		Improvement of working conditions	
		Greater equity in the distribution of value added along supply chain actors	
		Greater affordability of food	
		Increased trust among value chain actors	
		Improvement of farmer health	
		Greater food safety	
		Greater job opportunities for women	
		Increase of female entrepreneurship in agriculture	
		Improved farmer education	
		Improved women education (especially in farming)	
		Improved farmer livelihood	
		Condition for vulnerable groups (i.e. minority & migrants)	
		Any MISSING ASPECTS emerged from the questionnaire (add lines when needed)	
Environment		Increased protection of ecosystems	
		Cleaner surface water bodies	
		Cleaner underground water	

		Increased availability of water for agricultural uses	
		Increased biodiversity	
		Increased soil quality	
		Reduced climate vulnerability	
		Increased water security	
		Any MISSING ASPECTS emerged from the questionnaire (add lines when needed)	

Table A 6 - Stakeholder preferences.

Please use the table below to report the results of qualitative social impact assessment at the test site and territorial level.

Social aspect	**Test site level**	**Territorial level**
Improvement of working conditions		
Greater equity in the distribution of value added along supply chain actors		
Greater affordability of food		
Increased trust among value chain actors		
Improvement of farmer health		
Greater food safety		
Greater job opportunities for women		
Increase of female entrepreneurship in agriculture		
Improved farmer education		
Improved women education (especially in farming)		
Improved farmer livelihood		
Condition for vulnerable groups (i.e. minority & migrants)		
Any MISSING ASPECTS added during the questionnaire (add lines when needed)		

Table A 7 - Social impact at the test site and territorial level.

Annex 3 Data collection templates

This annex includes a series of materials for supporting data collection and stakeholder engagement for LCA, LCC and NEI assessment. The annex is provided as a compressed folder.

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Annex 4 Questionnaire for multi-criteria analysis

Questionnaire for prioritizing sustainability issues at the territorial level

This brief questionnaire aims to identify and value the most relevant sustainability aspects related to adopting the iGUESS-MED technology at the territorial level.

You are asked to fill in the questionnaire based on your personal knowledge and experience and on the research findings of the iGUESS-MED project about the environmental and economic impacts of adopting the iGUESS-MED DSS on demonstration sites.

Any personal information about the participants in this activity is confidential and will be used for research purposes only after anonymisation.

Section 1: General information

Q1.1 In which country do you operate?

- ○ Italy (1)
- ○ Spain (2)
- ○ Tunisia (3)
- ○ Turkey (4)

Q1.2 In which region do you operate?

_____

Q1.3 How would you describe your category?

- ☐ Policy-makers (1)
- ☐ Scientists (2)
- ☐ Local community representatives (3)
- ☐ Producers (4)
- ☐ Processors (5)
- ☐ Retailers (6)
- ☐ Consumers (7)
- ☐ Advisory services (8)
- ☐ NGOs (9)
- ☐ Business sector (10)
- ☐ Prefer not to say (11)

Q1.4 Which sector do you work in?

- ○ Private (1)
- ○ Public (2)
- ○ Public-private (3)
- ○ Civil society (4)
- ○ OTHER (5) _____

Q1.5 Please indicate your age

- ○ Younger than 30 (1)
- ○ 30-40 (2)
- ○ 41-50 (3)
- ○ 51-65 (4)
- ○ Older than 65 (5)
- ○ Prefer not to say (6)

Q1.6 Please indicate your gender

- ○ Male (1)
- ○ Female (2)
- ○ Prefer not to say (3)

Q1.7 What is your highest level of education?

- ○ Primary school (1)
- ○ Secondary school (2)
- ○ University degree (Bachelor, Master, PhD) (3)
- ○ Other (4) _____

Q1.8 Do you have a formal agricultural or food education?

- ○ yes (1)
- ○ no (2)
- ○ prefer not to say (3)

Section 2: Identifying and prioritising sustainability issues and potential project achievements at the territorial level

In this section, you are asked to evaluate the relevance of the sustainability criterion and aspects each in the related potential improvements that are achievable through the diffusion of the iGUESSmed technology at the territorial level (what if situation).

The evaluation is on a 0 to 9 scale, where 0 means “no relevance” and 9 means “extremely high relevance.

Q2.1 Please evaluate the relevance of each BROAD SUSTAINABILITY ISSUES in your region

0 no relevance - 9 extremely relevance

0 1 2 3 4 5 6 7 8 9

Economy	
Society	
Environment	

Q2.2 Please evaluate the relevance of each ASPECT of the ECONOMIC ISSUE

0 no relevance - 9 extremely relevance

	0 1 2 3 4 5 6 7 8 9
Increase of farmer competitiveness	
Creation of rural jobs	
Greater availability of sustainable technology for greenhouses	
Risk of misuse of technology	
Please add any MISSING SPECIFIC ECONOMIC ISSUE	

Q2.3 Please evaluate the relevance of each ASPECT of the SOCIAL ISSUE

0 no relevance - 9 extremely relevance

Q2.4 Please evaluate the relevance of each ASPECT of the ENVIRONMENTAL ISSUE

0 no relevance - 9 extremely relevance

	0 1 2 3 4 5 6 7 8 9
Increased protection of ecosystems	
Cleaner surface water bodies	
Cleaner underground water	
Increased availability of water for agricultural uses	
Increased biodiversity	
Increased soil quality	
Reduced climate vulnerability	
Increased water security	
Please add any MISSING SPECIFIC ENVIRONMENTAL ISSUE	

Section 3: Concluding questions

Q3.1 Please list up to 3 policy improvements that might encourage the diffusion of the iGUESSmed DSS.

_____

Q3.2 Please list up to 3 improvements of the governance of the greenhouse section that might encourage the diffusion of the iGUESSmed DSS.

_____

Q3.3 Comments on the exercise and/or on the iGUESSmed project

_____

Annex 5 Questionnaire for social impact assessment

Questionnaire for social impact assessment at the test site and territorial level

This brief questionnaire aims to collect the perspective of multiple stakeholders about the social impacts of DSS adoption at the test site and territorial level.

Any personal information about the participants in this activity is confidential and will be used for research purposes only after anonymisation.

Section 1: General information

Q1.1 In which country do you operate?

- ○ Italy (1)
- ○ Spain (2)
- ○ Tunisia (3)
- ○ Turkey (4)

Q1.2 In which region do you operate?

_____

Q1.3 How would you describe your category?

- ☐ Policy-makers (1)
- ☐ Scientists (2)
- ☐ Local community representatives (3)
- ☐ Producers (4)
- ☐ Processors (5)
- ☐ Retailers (6)
- ☐ Consumers (7)
- ☐ Advisory services (8)
- ☐ NGOs (9)
- ☐ Business sector (10)
- ☐ Prefer not to say (11)

Q1.4 Which sector do you work in?

- ○ Private (1)
- ○ Public (2)
- ○ Public-private (3)
- ○ Civil society (4)
- ○ OTHER (5) _____

Q1.5 Please indicate your age

- ○ Younger than 30 (1)
- ○ 30-40 (2)
- ○ 41-50 (3)
- ○ 51-65 (4)
- ○ Older than 65 (5)
- ○ Prefer not to say (6)

Q1.6 Please indicate your gender

- ○ Male (1)
- ○ Female (2)
- ○ Prefer not to say (3)

Q1.7 What is your highest level of education?

- ○ Primary school (1)
- ○ Secondary school (2)
- ○ University degree (Bachelor, Master, PhD) (3)
- ○ Other (4) _____

Q1.8 Do you have a formal agricultural or food education?

- ○ yes (1)
- ○ no (2)
- ○ prefer not to say (3)

Section 2 Social impact assessment

What is the potential impact of the iGUESS-MED DSS on SOCIAL ASPECTS? Please fill in the boxes with concise qualitative and/or quantitative information based on your experience. For your convenience we have provided an example here.

Social aspect	Test site	Region where you operate
Improvement of working conditions	Reduction of working hours, as DSS facilitates the control of nutrients and plant health	Greater attractiveness of greenhouse farming due to simplification of management
Greater equity in the distribution of value added among supply chain actors	No difference	In general, the reduced burden of agricultural work due to greater level of technology can attract more women
Greater affordability of food	Reduction of production costs might enable revenues even if market price decreases	The general reduction of production costs and the possibility to apply for incentives for sustainable farming may enable a decrease of consumer price
Increased trust among value chain actors	Buyers trust the greater sustainability of production due to greater efficiency of input use and IPM	Possibility to apply for sustainability certifications
Improvement of farmer health	Reduction of exposure to toxic pesticides	Reduction of toxicity impacts and general improvement of farmer health

	Test site (1)	Region where you operate (2)
Increase of farmer competitiveness (22)		
Creation of rural jobs (23)		
Improvement of working conditions (1)		
Greater equity in the distribution of value added among supply chain actors (10)		
Greater affordability of food (11)		
Increased trust among value chain actors (12)		
Improvement of farmer health (13)		
Greater food safety (14)		

Greater job opportunities for women (25)		
Increase of female entrepreneurship in agriculture (26)		
Improved farmer education (27)		
Improved women education (especially in farming) (28)		
Improved farmer livelihood (29)		
Condition for vulnerable groups (i.e. minority & migrants) (30)		
other (9)		
other (5)		
other (7)		

Section 3: Concluding question

Comments on the exercise and/or on the iGUESS-MED Project

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