AGROECOLOGY FOR WEEDS

Deliverable 5.4: Report on the efficiency of digital weed management solutions (version 2)

Grant Agreement number: 101083589
Start date of the project: 01/05/2023 **End date of the project**: 30/04/2027
Deliverable due date: 31/10/2024 **Date of delivery**: 30/10/2024
Classification: Public
Associated Work Package(s)

WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8
☐	☐	☐	☐	☑	☐	☐	☐

Version History

Version number	Implemented by	Notes
1.0	AUA	
2.0	AUA	

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Introduction

The GOOD project (aGroecOlOgy for weeDs) has established three special pilots corresponding to three Living Labs located in three European countries - Greece, France, and the Netherlands. Work package (WP) 5 of the GOOD project deals with digitalisation technologies of agroecological weed management systems. In the present document, we report on the progress on Task 5.2, “Weed management through the combination of digital tools and agroecological innovations” and on Task 5.3, “Development of Agroecological Weed Management (AWM) Toolbox”. Regarding Task 5.2, three innovative and technologically advanced weed control methods such as spot sprayers, mechanical weeders and autonomous robotic weeding platforms will be evaluated in special pilots concerning their effectiveness in combating weeds in three Living Labs in winter cereal (Greece), orchard (France) and onion (the Netherlands), with focus on improving weed management while reducing the use of herbicides and to test and gather valuable information regarding the effectiveness of each of the methods applied in the context of the Special Pilots.

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The weed control methods to be tested will be provided by leading robotic and hardware manufacturers. The results of the assessments and the experimentation will be made available publicly, further aiming at assisting in the improvement of the efficiency of weed management in the European cultivated fields and also at reducing chemical inputs and the overall environmental impact of weed management. Furthermore, the gathered information will be further exploited by Task 5.3, "Development of Agroecological Weed Management (AWM) Toolbox" to fine tune the Decision Support System (DSS) that will be developed in the context of the GOOD project. The AWM Toolbox is due in M36, but a first draft architecture is reported below, as several GOOD partners have started designing its features. Furthermore, in the following pages of the present document you will find the created templates that will be used for the Special Pilot periodic Reporting (SPR) in the second version of this deliverable in M18 and its subsequent updated versions in M30 and M48 of the GOOD project respectively.

Regarding Task 5.3, a digital tool, namely a Decision Support System (DSS), the AWM toolbox will be developed. The AWM Toolbox represents a digitally accessible DSS that will be integrated within the GOOD platform and made available upon user registration at no cost. Designed to streamline weed management decision-making for farmers, it will present a handy digital tool with a succinct questionnaire focused on pertinent aspects of crop cultivation and management practices. By soliciting input such as field location, main crop species, cover crops, cultivation methods, and desired outcomes, the toolbox will generate tailored recommendations aligned with agroecological weed management (AWM) practices. Drawing upon a comprehensive repository of AWM strategies developed within the framework of the GOOD project (D1.5), the toolbox will aim at automating data extraction based on predefined crop and practice parameters. Upon completion of user input, it will furnish a detailed DSS summary augmented with AWM-derived weed management recommendations. These recommendations will be complemented by insights into the anticipated environmental, economic, and social impact of each proposed strategy. Central to its functionality, the AWM Toolbox will encompass 32 AWM combinations curated for the crops under study within the context of the GOOD Living Labs. Furthermore, it will facilitate the identification of optimal temporal windows for AWM practice implementation (e.g. recommendations on the timing of cover crop sowing). In alignment with the overarching goals of the GOOD project, the AWM Toolbox will aim to serve as a pivotal tool in enhancing farmers' capacity to make informed decisions regarding weed management by giving different recommendations regarding weed management both for annual and perennial crops tested in the context of the GOOD project. Through its user-centric design and intuitive interface, it will aim to foster accessibility and comprehension among European farmers, while also contributing to the dissemination of knowledge and fostering adoption of sustainable agricultural practices by the European farmers. For the purpose of developing and fine tuning the AWM Toolbox, it will undergo several rounds of validation before being officially launched. Weed experts participating in the consortium will validate the final design and architecture of the Toolbox, while a group of experts will be responsible to provide data and knowledge from the Living Labs.

AWMToolbox mockups have been presented in the co-creation workshops conducted in WP1, as well as the annual project meeting in Pisa in May 2024. Precious feedback has been received from the LLs and the project partners. This feedback can be generalised in the following points:

- Stakeholders are so far highly satisfied with what was presented, especially because they had a chance to get a first glance and more detailed insights to the AWMToolbox specifications. They proposed delivering the AWMToolbox in different languages as it would greatly assist in overcoming the language barriers, a problem often overlooked by the experts but existing in the farmers community. Moreover, the stakeholders suggested keeping the architecture of the tool to be developed simple to also be attractive to the end users. Last but not least, they were interested in learning more about the training opportunities related to the AWMToolbox and the GOOD platform in general.

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- Project partners are enthusiastic to having received the AWMToolbox mockups this early in the project and they got the chance to provide early feedback which will be utilized to better streamline the fine-tuning of the AWMToolbox functionalities and outlook. They prioritized the simplicity of the tool to attract farmers and the coverage of different scenarios.

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Updates of D5.2

Deliverable	Version	Due month	Reporting
D5.2	1	M12 (April 2024)	Pilot plans
D5.4	2	M18 (October 2024)	Pilot plans updates + SPR1
D5.6	3	M30 (October 2025)	Pilot plans updates + SPR2
D5.9	4	M42 (October 2026)	Pilot plans results + SPR3

Description of the special pilot – WHEAT (GREECE)

Organization	AUA
Location	Domokos, Greece (GPS: 39°03'48.8"N 22°15'26.2"E)
Crop	Wheat
Aim	To test the efficiency of precision spraying systems backed by AI technology and compare it with similar conventional spraying systems.
Description of activities	This year, work will focus on advancing the precision spraying robotic platform based on the HUSKY GV system, building on the progress made last year. The specific hardware components, including the HUSKY GV robotic platform, spraying system comprised of a metalic skeleton and the anti-drift spraying nozzles placed and oriented in a specified manner and the weed detection system featuring a Basler RGB camera, were selected during the previous experimental year of the project. The system will utilize a JETSON AGX XAVIER CARRIER BOARD - DSBOARD-XV2 as its processing unit, providing enhanced computing power for the YOLO-based AI model implementation for weed detection. Additionally, a robust protocol for data collection to train the weed detection AI model was developed. To ensure accurate AI model training, Basler cameras will be mounted directly on the HUSKY GV robotic platform for field data collection. This implementation maintains the exact perspective and conditions that will be used during actual weed control operations. The camera system, integrated into the Husky's structure, will continuously collect field image data as the robot navigates through the experimental fields. Following data collection, a comprehensive image annotation process will be conducted to label the various weed species present in the captured images. This annotated, real-world dynamic data will then be used to train and fine-tune the YOLO-based AI model, enabling it to effectively differentiate weeds from wheat plants under authentic operational conditions and precisely apply herbicides in the field. By February, the first version of the system is expected to be operational and ready for post-emergence herbicide applications in the Greek Special Pilot. The results of this digital weed control practice will be compared to conventional methods either used by farmers or observed in the Living Lab's conventional sites (as referenced in WP2). The ongoing work builds on previous R&D Horizon projects like OPTIMA, ROBS4CROPS, and SmartDroplets, leveraging AUA and UG's experience to retrofit and optimise the boom sprayer for precision spot spraying at the plant level.
Timing of activities	February- March (Based on the weather conditions we will choose the period coinciding with weed rapid growth stage)
Measurements	Weed density and weed biomass at species level before application and a few weeks after to evaluate the efficacy of the practice. Distinguish between weed species and their characteristics. LCA monitoring. Weed control efficacy on species level using sensor-based technologies (NDVI) Crop density and crop growth monitoring. Grain yield and its components.

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Training activities	Demo events (if possible, in combination with the demo farm events of WP2, WP3) Video content to be stored in the e-learning module. Pdf files with the results. The files will be used as guides for farmers and stakeholders.

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Description of the special pilot – ONION (NETHERLANDS)

Organization	Delphy B.V.
Location	Colijnsplaat, Zeeland, The Netherlands (501°35.3650'N 3°51.1148'E)
Crop	Onions
Aim	Investigate alternative methods to deal with the reduction in the available, chemical herbicides
Description of activities	In the special pilot alternative (non-chemical) weed control methods will be used to compare with the conventional weed control method. The objects mainly consist of mechanical control, possibly in combination with chemicals, applied to the sowing row. In addition, in the organic part, weeds will only be mechanical controlled. In autumn 2024 the green manure Phacelia has been sown in the trial field prior to the onions. The special pilot for 2025 is divided in 4 objects. One object will be monitored by University of Gent with a drone. The drone will be exploited to capture photos of the Special Pilot field with an aim to determine the populations of weeds in it. The captured images will be further analyzed in order to produce spraying recommendation maps to combat the weeds present in the field. The onions will be seeded in spring 2025 on ridges with drip irrigation instead of conventional sprinkler on the field. Other methods aiming at reducing and combating weeds such as cultivation techniques (e.g. precise application of irrigation water through innovative techniques) and mechanical weeding techniques will also be investigated in the context of the Dutch Special Pilot.
Timing of activities	As soon as the onions are seeded, the first chemical apply will happen. Moving forward from that while keeping the Good Agricultural Practices (GAP) in mind, mechanical weeding will be applied while weeds are still in the seedling growth phase.
Measurements	Weed density, counting 3 times per plot and determination and amount per weed. Amount of plants, counting 2 times in 1m x 1,5m per plot
Training activities	Event in 2025: International Onion Day, Colijnsplaat. Around 1500 persons will attend this event and will be divided in different groups which contains around 20 persons in 5 different rounds to view the trail field. During this day someone will tell about the trial and the aim of the trial. PDF file with the results of the trial which can be used as information for farmers.

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Description of the special pilot – APPLE/PLUM (FRANCE)

Organization	CTIFL
Location	Prigonrieux, France
Crop	Apple
Aim	Different automated equipment will be tested for weeding
Description of activities	For the 1st year of the trials, a small mowing robot (Vitirover) was tested in orchards and compared to conventional weeding. For the Vitirover, two trajectory management scenarios were tested: • The first scenario consisted of carrying out a random trajectory, along and through the orchard rows. • The second scenario consisted of setting a trajectory only along the plantation row in order to weed only around the plants, the most complex areas to weed, posing a high risk of damaging the cultivated plants. These tests made it possible to identify certain limits of the solution and to propose improvements to the agricultural equipment manufacturer. In particular, for the second scenario, the robot was unable to maintain its trajectory along the row. Adapting the solution with an RTK GPS could help solve this problem (in discussion to test it next year). The first tests showed similar performance in weed management by the robot and in conventional weeding. Moreover, weeding with this robot made it possible to avoid 2 to 3 chemical weeding applications and 5 to 9 mechanical weeding applications with a tractor.
Timing of activities	From April up to November: main weeding activities in spring and autumn, harvest in October Whole data analysis by the end of the year
Measurements	Trajectory management and capacity to move into the orchard (a complex environment) Work rates, maximum surface area that can be managed by the robot User feedback and ease of use Yield and fruits quality Economic impact
Training activities	Demonstration in events No specific training proposed

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Annex 1: Template for periodic Special Pilot Reporting (SPR)

SPECIAL PILOT REPORTING (SPR) SHEET

Version history table

Version	Date	Author(s)	Notes
SPR1	30/10/2024	AUA	

Special Pilot

Tick the box of your Special Pilot

Special pilots for Task 5.2		
Country	Code number	
Greece	GR_wheat/16	☐
Netherlands	NL_onion/12	☐
France	FR_apple-plum/21	☐

Special Pilot reporting – WHEAT (GREECE)

Special Pilot Reporting Period	☒ SPR1: M18 (October 2024) ☐ SPR2: M30 (October 2025) ☐ SPR3: M42 (October 2026) *Tick the box of the SPR*
Communication activities of the LL	On February 2nd, the GOOD project was presented through a banner at the Agrotica exhibition, the largest agricultural event in the Balkans, drawing over 200,000 participants from a wide range of stakeholders, including farmers, advisors, researchers, and consumers. During the exhibition, we had the opportunity to discuss the goals of the GOOD project with various attendees and exchange views on weed management practices. This interaction helped to raise awareness about the project and its objectives among key stakeholders.

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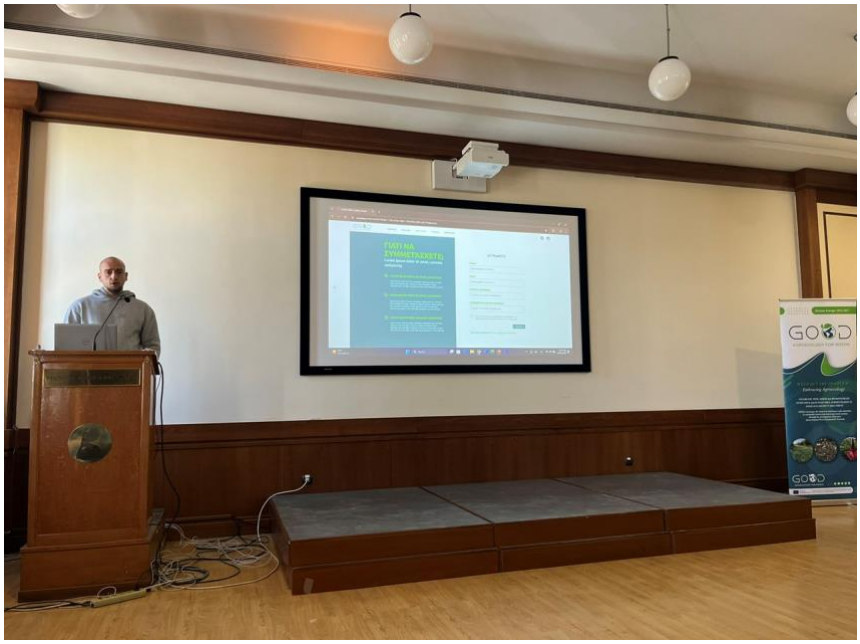
Dissemination activities of the LL	The first co-creation workshop for the Greek Living Lab on wheat was held on Tuesday, October 22, 2024, at the Agricultural University of Athens, attracting strong participation with 57 attendees, including farmers, advisors, researchers, policymakers, and consumers. During the workshop, we assessed the effectiveness of agroecological weed management practices tested across both conventional and organic farming systems, and shared key insights from the first year of experiments in the project. Additionally, the robotic precision spraying platform design was presented and discussed with the participants, providing us with precious feedback and insights for the next steps and the technical implementation. Additionally, we had a session where we presented the first version of AWMToolbox mockups and discussed them with the participants, gathering valuable feedback that will help refine the tool and better meet the needs of the agricultural community. Last but not least, a field day event has been scheduled to take place on June 2025. 

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Demonstration activities of the LL	"Not applicable for this SPR"
Publications	We have published two articles one online and one in print (on 01/08/2024 and on 01/09/2024, respectively) in one of the most popular Greek agricultural journals, in which we presented our project and its objectives and showed and discussed our results on the performance of cover crops and the Agroecological Weed management practices which tested in our Living Lab the first growing season. https://www.agrotypos.gr/paragogi/fytoprostasia/nees-proseggiseis-stin-agroikologiki-diacheirisi-zizanion https://issuu.com/agrotypos/docs/gk-7-24-hd?fr=sN2MxZTcwMjI4NjU

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Participations in regional/national events	On November 6th, the GOOD project was presented at a workshop on weed management methods in the Peloponnese region. The event, which drew 40 participants, was specifically aimed at farmers, researchers, and advisors. During the workshop, we highlighted the project's objectives and explored innovative agroecological approaches to weed management.
Cross-visits	Not applicable for this SPR
Ethical and Data Protection	Not applicable for this SPR
Major field operation problems & Risks identified	Not applicable for this SPR
Social media	Not applicable for this SPR
Other	Not applicable for this SPR

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Special Pilot reporting – ONION (NETHERLANDS)

Special Pilot Reporting Period	☒ SPR1: M18 (October 2024) ☐ SPR2: M30 (October 2025) ☐ SPR3: M42 (October 2026) *Tick the box of the SPR*
Communication activities of the LL	In total, the Good project was promoted at 4 events. At the Onion Day 2023 in Colijnsplaat on August 24, 2023, at the Agricultural Trade Days in Assen on November 9, 2023, at the Akkerbouw Snertdag on December 14, 2023, https://www.landbouwagenda.nl/evenement/6768-akkerbouw-snertdag/, and at the Potato Days on January 30, 2024.  

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Dissemination activities of the LL	The activities of season 2023 and 2024 and preliminary initial results were presented at a meeting on July 3, 2024 with consultants, researchers and water boards. 
Demonstration activities of the LL	During a meeting on July 3, 2024, the trial field with the tests was visited and the equipment used for mechanical weeding was viewed. The researchers involved explained the various tests to consultants, researchers and water boards. 

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Publications	Not applicable for this SPR
Participation in regional/ national events	International Onion Day, Colijnsplaat on 29th of August 2024 https://www.uinovatie.nl/p/183/183 Around 1100 persons(farmers, advisors, researchers and policy makers) attended this event. d will be divided in different groups which contains around 20 persons in 5 different rounds. During these rounds a Delphy advisor was telling about the trial and the aim of the trial at the trail field. 

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Cross-visits	Not applicable for this SPR
Ethical and Data Protection	Not applicable for this SPR
Major field operation problems & Risks identified	Not applicable for this SPR
Social media	On the 17th of April we posted a introduction of the LL Netherlands Union on Facebook LinkedIn en X. https://www.linkedin.com/posts/agroecology-is-good-aba946275_agroecologyisgood-agroecologyforweeds-goodhorizon-activity-7216780849151680515-84wE?utm_source=share&utm_medium=member_android On the 5th of July we shared a post about a meeting at the trail field with stakeholders, advisors and policy makers on Facebook LinkedIn en X. https://www.facebook.com/AgroecologyisGOOD/posts/pfbid0XV8EEjo2JsMZ1YikYXMXFkg2GSph4hHVgmsqz9fDBv3KjQJxBo557YTGAUawXWaol On the 10th of July and the 8th of October we posted a video of the LL Netherlands Union activities season 2023-2024 on Facebook LinkedIn en X. https://x.com/ProjectGood/status/1843575826425495823
Other	A video has been made of all the activities at the Living Lab Onion of the 2023 and 2024 season https://www.youtube.com/watch?v=y9zPtwb-jso

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Special Pilot reporting – APPLE/PLUM (FRANCE)

Special Pilot Reporting Period	☒ SPR1: M18 (October 2024) ☐ SPR2: M30 (October 2025) ☐ SPR3: M42 (October 2026)
Communication activities of the LL	Articles on our website about GOOD project or other events and activities around automation of weeding (in French): • (for LL presentation in WP1) EUROPEAN PROJECT GOOD: 36 weed management strategies - https://www.ctifl.fr/en/news-europeen-good • État des lieux : quelles solutions et perspectives pour la filière fruits et légumes ? (State of play: what solutions and prospects for the fruit and vegetable sector?) https://www.ctifl.fr/etat-des-lieux-quelles-solutions-et-perspectives-pour-la-filiere-fruits-et-legumes • Retour en Images MécaF&L 2024 : les acteurs robotique et mécanisation agricole au rendez-vous (MécaF&L 2024: robotics and agricultural mechanization players at the meeting) - https://www.ctifl.fr/retour-en-images-mecaf-l-2024-les-acteurs-robotique-et-mecanisation-agricole-au-rendez-vous Testimonial about using a mowing robot in orchard Article about the test in newspaper Mediafel: https://www.tema-agriculture-terroirs.fr/mediafel/techniques-culturales/quatre-innovations-reperees-au-mecafl-du-ctifl-907228.php Réussir Fruits et Légumes - Robots agricoles : que proposent les constructeurs en arboriculture ? (Agricultural robots: what do manufacturers offer in arboriculture?) - https://www.tema-agriculture-terroirs.fr/mediafel/techniques-culturales/robots-agricoles-que-proposent-les-constructeurs-en-arboriculture-952530.php
Dissemination activities of the LL	Ongoing development of a partnership with the “Grand Défi Robotique Agricole”, led by Robagri association, to test a larger number of robots and pool methodologies
Demonstration activities of the LL	1 demonstration during the event MecaF&L of the mowing robot Vitirover and autonomous tractor (programm: https://www.ctifl.fr/mecaf-l-2024-technologies-innovantes-de-surveillance-et-protection-des-cultures) 

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Publications	Not applicable for this SPR
Participation in regional/national events	CTIFL organized an event, MécaF&L, dedicated to innovations in agricultural equipment and new technologies for fruit and vegetable crops. This event aimed to bring together different actors on a national scale to attend dynamic demonstrations of innovative solutions, to exchange and debate around these subjects during conferences and meetings. This event highlighted innovative crop monitoring and protection technologies in the fruit and vegetable sector: sensors, innovative application techniques and alternative technologies to use of phytosanitary products, such as automation and robotics. The event attracted 232 participants, such as professionals from the fruit and vegetable sector, group technicians, teachers, researchers and producers.
Cross-visits	Not applicable for this SPR
Ethical and Data Protection	Not applicable for this SPR
Major field operation problems & Risks identified	The main problems associated with the use of robots are leaving the working perimeter. The cohabitation of the robot in the plot with other tools (tractors in order to avoid collisions). Theft of the robot despite a safety device. For these problems add security controls to the software. Add functions to the software so that the robot returns to its charging station if a tractor is present in its work area. Use signs to prohibit passers-by from entering the plot and inform them of the presence of a robot in the plot. In the event of an accident, both the robot designer and the user may be involved.
Social media	1 Publication on Linkedin on GOOD project: https://www.linkedin.com/posts/ctifl_agroecologyisgood-agroecologyforweeds-goodhorizon-activity-7196872009820106752-YJJY?utm_source=share&utm_medium=member_desktop
Other	Not applicable for this SPR

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