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SQAT
SOIL QUALITY ANALYSIS TOOL

Deliverable D3.3

Smart Farming Applications performance reports

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Executive Summary

Farms are at the forefront of the data economy, propelled by digitalisation, robotics, and smart algorithms. However, these advancements exacerbate societal pressures on soil health, demanding cleaner water, healthier soils, increased carbon storage and biodiversity. Current solutions are costly and unsuitable for farmers. With this in mind, the EU-funded SQAT project will develop a smart soil mapping service. Combining multi-level, multi-technology approaches, SQAT offers high-resolution soil property maps and tailored solutions for farmers. Using autonomous robot-mounted sensors and innovative in situ analysis tools, the SQAT system enhances productivity while reducing costs. Co-developing with SMEs, SQAT aims to commercialise its solutions, empowering farmers with variable-rate applications for liming, fertilisation, seeding, tillage, and carbon farming.

By investing in the usability of its soil data products through the development of Smart Farming Applications (SFAs), farmers are able to utilize the soil data produced through the SQAT system by making variable-rate applications for liming, fertilisation, seeding, tillage, and carbon farming possible. SQAT doesn't just develop precision farming technologies, it aims to aims to make its solutions available to users in a manner that (a) takes requirements from a variety of users into account, (b) is interoperable with existing smart-farming software and (c) packages system output with automated and tested SFAs.

Enabling these features requires a set of activities which run parallel to the development of the SQAT system and the implementation of the use cases. The activities range from automating the workflows for use case implementation to setting up user feedback sessions and visualizing SQAT results in a user-friendly dashboard. These activities often overlap with tasks and depend on developments in other parts of the SQAT project. For management purposes an overview and time planning of activities was added to this report. Initial results include an overview of feedback on a smart farming technologies questionnaire and the first steps in the development of automated workflows, which will be required for use case implementation starting in early 2026.

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Abbreviations

ABE	Association of Balkan Eco-Innovations
AGRILAB	Agrilab limited liability company
ATB	Leibniz Institute of Agricultural Engineering and Bioeconomy e.V.
EV ILVO	Eigen vermogen van het instituut voor landbouw-en visserijonderzoek
HSG-IMIT	Hahn-schickard-gesellschaft fur angewandte forschung ev
ILT-OST	Institute for Lab Automation and Mechatronics
KER	Key Exploitable Results
MRV	Monitoring, Reporting and Verification
OFI	Officine innovazione s.r.l.
SFA	Smart Farming Application
SOC	Soil Organic Carbon
SOM	Soil Organic Matter
TERRATMD	Terra Controlling TMD d.o.o
VDBORNE	Van den borne projecten bv
WP	Work Package

1 Introduction

Precision farming aims to increase productivity and sustainability of agricultural systems by implementing management techniques that take local variability in crops and soil into account. By applying innovative technology to investigate and monitor intra- and inter-field variation, precise soil management and application of resources such as seed, fertilizers and lime is made possible. Unfortunately, many of the current solutions are both too costly and unsuitable for farmers. The Soil Quality Analysis Tool (SQAT) project, funded through HORIZON Europe, started in 2024 in order to address these concerns.

The first innovation of the SQAT project is the usage of multi-level and multi-technology workflows to create a smart soil mapping service. By combining earth observation (EO) data, soil sensors, automated robotics and on-the-field in-situ analysis tools, the production of high-resolution soil maps is optimized with regards to quality, workload and price. The second innovation of SQAT is its focus on usability of its soil data products through the development of Smart Farming Applications (SFAs), which empower farmers by making variable-rate applications for liming, fertilisation, seeding, tillage, and carbon farming possible. Where other projects might focus solely on the development of new precision farming technologies, SQAT continues past this point and aims to make its solutions available to users in a manner that (a) takes requirements from a variety of users into account, (b) is interoperable with existing smart-farming software and (c) packages system output with automated and tested SFAs.

Work package (WP) 3 **Enable** includes developments on the second of these two innovations. The objective is to utilize the novel data from the SQAT system through the SFA's to deliver valuable and actionable information to end-users. This report, the first of two, will provide an overview of the work done in **task 3.4 Smart farming applications & information delivery** after ca. three months since its start (August 2025), a setup for the *what*, *when, why* and *how* of this workload and an overview of expected results at the finalization of the task (April 2027).

This deliverable is an early version of the final report and should be regarded as a plan and methodology document. It presents the setup and an overview of the planned activities rather than results of completed work. The related tasks have only recently started, and the focus so far has been on setting up the required hardware, workflows, and basic components that will be used in the next stages.

2 Task description and activities

2.1 Task description

Task 3.4 of WP3 is an assembly task which partly aims to glue together the developments done in other sections of the project and partly to develop SFA's in parallel with the implementation of the use cases. The overall focus is on the utilization of the SQAT system output, namely the high- resolution soil data. Table 1 contains an overview of the subtasks, taken from the SQAT proposal.

Table 1: Overview of subtasks for task 3.4 from WP3 Enable.

Sub-task	Description *(Citations from page 35 of SQAT proposal)*	Related to
1	Identify interoperability aspects to use SQAT's data in the different Applications.	**WP4**
2	Automate the workflow for each Application (aligned with T6.1), and tackle relevant quality assurance issues. We explore/favour the use of Copernicus DIAS's, where relevant, for data storage, processing, and delivery.	**T6.1**
3	Test and validate Applications, with SQAT's outputs, and assess the quality (e.g., completeness, precision (random errors), accuracy (systematic biases)). Validate against reference data from soil samples. Depending on the data structure and availability, appropriate validation methods will be selected and applied. These include conventional methods such as bias-, correlation-, and root-mean-square-difference analysis and, where possible, advanced statistical methods such as triple collocation.	**T2.1**
4	API development and integration. A RESTful API will be developed to interface with: interactive front-end solutions, dashboard for soil carbon MRV, reports, or existing platforms used by users. The API will be used throughout the project to retrieve and store information;	**WP4**
5	Evaluate information delivery to intended users together with the users through workshops, continuous trials in the season, etc. – as relevant and in close collaboration with use cases in T2.1 – and use user feedback to improve the methodology and workflows for information delivery developed in II) and III). This is an iterative process that will take place at least 3 times in the 3 seasons in which the use cases are implemented, and will depend on the specific nature and target users of each Application, as presented in *section 1.2.2.5*. For example, the carbon farming MRV will involve workshops with industry to ensure that data generated and presented in a dashboard aligned with data needs of corporate/industry actors buying the carbon credit offsets.	**T2.1**, **T5.3** and **T6.3**

The task description in Table 1 leaves room for a number of follow-up points and questions. These have been divided into a set of themes, sometimes with additional commentary.

2.1.1 Setting up Smart Farming Applications

- **What are smart farming applications?**
  The SFA are the methods or tools used to implement output from the SQAT system to tackle real-world use-cases and deliver valuable and actionable information to users. The exact infrastructure of

these applications, whether they consist of software or outline standardized 'cookbook' with methodologies, is worked on and finalized during the course of this task.

- **Who is the owner of the smart farming applications?**
  The SFA's developed during the course of this task are one of three Key Exploitable Results (KER) outlined in section *Exploitation* in the SQAT proposal (p. 26). These applications will consist of intellectual property which has to be maintained in order to stay functional. After the project is done, who in the consortium will be responsible for the ownership and long term upkeep of these applications?
- **How flexible are smart farming applications?**
  The subject of precision farming is approached from the user's perspective, making sure that soil data produced through the SQAT system is capable of tackling relevant challenges of end-users. However, since every end-user is unique, how flexible do the developed solutions have to be? The (automated) workflows need to be operational for the stated use-cases, but how adaptable do they have to be to new cases?
- **What are the interoperability aspect of smart farming applications?**
  Interoperability aspects are the components that ensure that different systems can exchange, understand, and use information effectively. What are these aspects in the case of the SFA's?

2.1.2 Testing of Smart Farming Applications

- **How are Smart Farming Applications tested?**

The testing and validation of SQAT output will focus on two main outcomes:

1) How accurate are the SQAT products?
2) How useful are the SQAT products in the variable-rate applications?

The validation will not focus on testing the effect of the implementation of the use cases. This means that there will be no validation of precision farming practices, such as the effectiveness of variable rate seeding on increasing farm productivity. This is beyond the scope of the project and was investigated in a variety of past research studies. Rather, the accuracy of the soil data products from the SQAT system will be assessed and the ability of the SFA's to tackle real-world use cases is assessed.

- **What are relevant quality assurance issues of the smart farming applications?**

2.1.3 Existing precision farming tools and software

- **What are common precision farming tools which are currently in use?**

Rather than re-inventing the wheel, the SQAT project aims to utilize existing software and smart farming tools where possible. This helps to promote user convenience through the usage of software which users are already familiar with, for instance to create task maps. It also enables the SQAT consortium to focus on novel solutions. An overview of current results on this question is provided in chapter 3.

- **Which existing tools and/or applications should be able to utilize the SQAT output?**

We should focus on a set of common existing precision farming tools which we'll take into account when working on our own solutions.

2.1.4 Human interaction

- **What are the demands on the interactive front-end solution?**
- **How much of the final workflow will be automated and where do we expect input from the end-user or interference from a human operator?**

- **Which service can be used for dashboarding?**
  SQAT consortium partner SENUS already possesses a dashboard for soil carbon Monitoring, Reporting and Verification (MRV) with automated reporting. To what extend can we make use of this platform?

2.1.5 User feedback

- **Who are the end users in the use-cases?**
  Information delivery to (intended) users has to be organized. Some use-cases, e.g. ILVO, will take place on test plots owned by the respective institution or organisation. In that case, who will stand in for an (intended) end user when organizing user feedback sessions?
- **What will workshops for user information delivery evaluation look like?**
  Evaluation of information delivery will happen in parallel with the implementation of the use-cases. Will these events be held in one location, one per use-case location or online? Furthermore, T5.3 and T6.3 also ask to organize meetings with stakeholders and groups of farmers for activating engagement and quality assurance. Perhaps these different meetings and workshops can be combined to some extent.

2.2 Planning

Table 2 presents an overview of activities for this task, based on the stated subtasks and questions in the previous section. Each activity contains a description and an expected number of meetings needed to handle this topic with the relevant SQAT partners and the expected duration. Month 23 aligns with November 2025 and month 40 with April 2027. A Gantt chart outlining the time planning for the different activities is visible in Figure 2.

Table 2: Activities overview.

ID	Activity	Description	Meetings	Duration	Dependencies
A1	Define SFA concept and scope	Define the structure, purpose, ownership model, and flexibility requirements for SFAs.	4-5	M23–M38	–
A2	Review existing tools	Catalogue and assess compatible smart farming software and platforms.	1-2	M23–M24	-
A3	Identify interoperability requirements	Specify data formats, APIs, and standards for SQAT output integration with external systems.	1-2	M24–M25	A2
A4	Develop workflow automation	Design automated workflows for SQAT data delivery (aligned with T6.1).	2-3	M26–M28	A3

A5	Integrate data storage and processing	Implement connection with existing infrastructures for data storage and handling.	1	M27–M29	A4
A6	Connect with existing dashboards	Design or adapt dashboards (e.g., soil carbon MRV) for user interaction and visualization.	2-3	M29–M32	A4
A7	Develop interactive front end	Develop a front-end solution for user interaction.	3-5	M30–M34	A6
A8	Define validation & QA framework	Establish validation metrics and statistical methods, as well as a quality assurance framework for use case implementation.	1	M25–M26	-
A9	Conduct validation of SQAT outputs	Test accuracy, precision, and bias of SQAT data using field samples and statistical analysis.	1	M28–M36	A8
A10	User engagement workshops (Cycle 1)	Gather user requirements and expectations; initial validation of information delivery methods. Organised around the first use case implementation.	2-3	M25–M26	A1
A11	Feedback & refinement (Cycles 2 & 3)	Conduct iterative improvements to workflows and dashboards based on continuing user feedback after subsequent use case implementations.	2-3	M29–M36	A7, A10
A12	Documentation & reporting	Finalize documentation of workflows, QA results, and user evaluation findings.	2	M38–M40	A9, A11

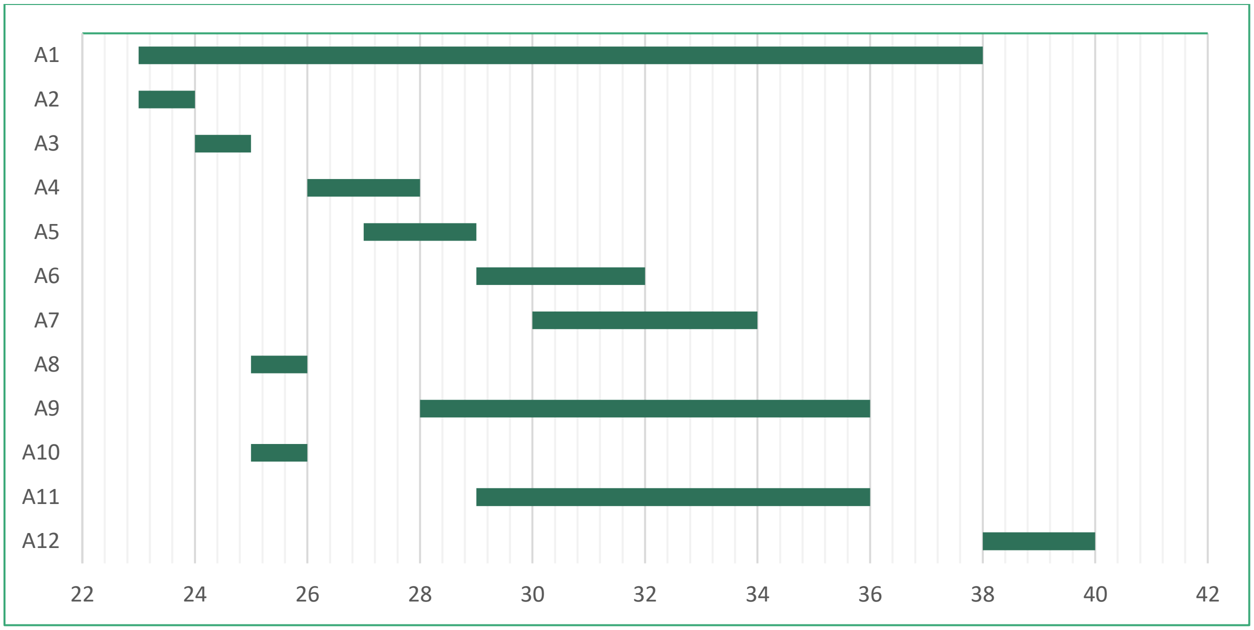


Figure 1: Gantt chart outlining the time planning for the different activities.

Since multiple partners in the SQAT consortium have a substantial number of work hours delegated for task 3.4 (see Table 3), the task can be split into multiple sections and the workload has to be spread over several partners. This is something that still needs to be discussed among the relevant partners. For now, it can be stated that since many of the activities require bringing multiple viewpoints together, a large part of the work will consist in organizing internal meetings.

Table 3: Division of working hours over task 3.4.

SQAT partner	Number of PM's	Percentage of PM's	Role
AeroVision	8	17 %	Leader
ATB	7	15 %	Participant
SENUS	7.5	16 %	Participant
OST-ILT	0.5	1 %	Participant
Exobotic	5	10 %	Participant
vdBorne	5	10 %	Participant
Terra	7	15 %	Participant
AgriLab	8	17 %	Participant
Total	48		

3 Existing precision farming software and applications

The main goal of task 3.4 is to ensure that high quality data-products created through the integrated SQAT solution are guided into existing smart farming platforms for ease of use by the user/client (farmer). Existing smart farming platforms refers to currently in-use applications for creating task maps and entering these task maps in the data platform(s) used by farmers, so that they can use the data produced through the SQAT solution in their farm management. Examples of available farm management applications are Trimble, DACOM and BBLEAP.

As a first investigation into existing smart farming platforms and tools, a questionnaire was send out to SQAT partners. This information will help guide us in the right direction for designing interoperability, automating workflows, and supporting API development and integration. It will also provide clarity on how to apply the outputs of the integrated SQAT solution in smart farming practices in different contexts (use-cases, EU countries, etc.).

The questionnaire consisted of four questions:

1. What platforms or tools do you currently use? (Task map creation, farm management systems, map-making software, etc.)
2. What data formats do you usually work with when converting soil maps into smart farming practices? (e.g., SHP, GeoJSON, CSV) Any preferences or requirements?
3. Are there any problems or gaps in the tools you currently use?
4. For use-case holders/farmers – Which features or capabilities of precision farming tools and platforms are most useful to you?

Table 4: Results from questionnaire on smart farming platforms and software.

Partner	Platforms / Tools in Use	Data Formats	Problems / Gaps	Most Useful Features for Farmers
ILVO	CropX (Dacom) FMS, Farmworks, John Deere Ops Center, QGIS, Python, ARTOF framework, Exatrek telemetry	SHP, ISOXML, CSV; CRS: WGS84 (EPSG:4326), UTM31N (EPSG:32631)	UAV data too large for FMS, need to switch platforms for VRA, hard to combine parameters (NDVI + yield)	Data integration (API/upload), visualization (clear soil maps), combining layers with rules, taskmap export to machine formats, advisor sharing
SENSUS	Own web GIS platform, QGIS, AgreCalc/FarmCarbonToolkit, Google Suite, Hubspot CRM, Canva, GitHub/Jira/Slack, IntelliJ, Eclipse, VSCode, Python (NumPy, Matplotlib, PyTorch, Jupyter)	GeoJSON (preferred), JSON, CSV, SHP; CRS: WGS84 (EPSG:4326), converts to national grids if needed	Emission calculators inconsistent, large maps render slowly	Visualization with farm maps (color-coded), nutrient distribution, nature leavers quantification, upload of timestamped/geotagged imagery

TERRA CONTR OLLING	Google Earth Engine (GEE), QGIS	SHP, CSV, GeoJSON, KML/KMZ	Lack of integration across GEE, QGIS, devices, client platforms; manual transformations; planning integrated app	Prescription maps for VR fertilization/seeding, visualization of soil/crop variability, zonal analysis for localized decisions
ATB	Own Python/R algorithms, Shiny-based Desktop Apps for VR liming & fertilization, NextFarming (FMS)	SHP, GeoTIFF, CSV; ISOXML, SHP (for machinery)	Farmers need user-friendly DSS (currently too technical); fragmented workflow	DSS for full workflow, national algorithms for lime demand, easy VR liming & fertilization

The results (see Table 4) of the questionnaire on smart farming platforms and software reveal several commonalities and challenges across partners. ILVO uses CropX, Farmworks, John Deere Ops Center, QGIS, Python, the ARTOF framework, and Exatrek telemetry, working with SHP, ISOXML, and CSV formats in WGS84 or UTM31N projections. Their main challenges include managing large UAV datasets, switching platforms for variable rate applications, and combining multiple parameters such as NDVI and yield. Farmers find data integration, clear soil map visualization, layer combination, task map exports, and sharing with advisors particularly valuable.

Senus relies on its own web GIS platform alongside QGIS, AgreCalc, FarmCarbonToolkit, and various productivity tools like Google Suite, Hubspot, GitHub, and Python libraries. They prefer GeoJSON but also use JSON, CSV, and SHP, converting to local projections when needed. Their main issues are inconsistent emission calculators and slow rendering of large maps, while farmers value visual farm maps, nutrient distribution, nature layers quantification, and uploading geotagged imagery.

Terra Controlling works with Google Earth Engine and QGIS, handling SHP, CSV, GeoJSON, and KML/KMZ files. The lack of integration between platforms, devices, and client applications, along with the need for manual transformations, are key problems. Farmers prioritize prescription maps for variable rate fertilization and seeding, visualization of soil and crop variability, and zonal analysis for localized decision-making.

ATB uses Python and R with Shiny-based desktop apps for variable rate liming and fertilization, alongside the NextFarming FMS. Their datasets include SHP, GeoTIFF, CSV, and ISOXML for machinery. The main gap is usability, as the tools are currently too technical and workflows are fragmented. Farmers find user-friendly decision support systems, national algorithms for lime demand, and easy variable rate application tools most useful.

Across all partners, QGIS is universally used, either as a primary GIS tool or as a backup, while Python is widely employed for data processing, and some partners also use R. Farm Management Systems are common, either in use or under development. SHP and CSV are standard formats, GeoJSON is widely used, and ISOXML is important for machinery compatibility. WGS84 is the standard coordinate system, with local conversions as needed.

Integration issues, handling large datasets, and tool complexity for farmers are recurring challenges. Farmers consistently value clear, color-coded maps, ready-to-use decision support, variable rate application task maps, and the ability to export maps in different machine-compatible formats. Overall, QGIS with SHP/CSV forms the backbone of most workflows, integration and usability remain key challenges, and the ultimate goal across partners is to provide farmers with simple, actionable insights to enable efficient variable rate applications.

4 Use-case workflows

Within the SQAT project a total of seven use-cases in seven different European countries are tackled (see Figure 2). In most of these use cases multiple VRA applications are utilized. To make it possible to implement the use cases, , narratives from deliverable 6.1 were utilized. The aim is to create parallel technological workflows/storylines. Explain the need of the user, and the step-by-step workflow of how our SQAT products will be used to solve the issue of the user. The information we want to present is exactly how and with what technology (software and hardware) the requirements of the user are met.

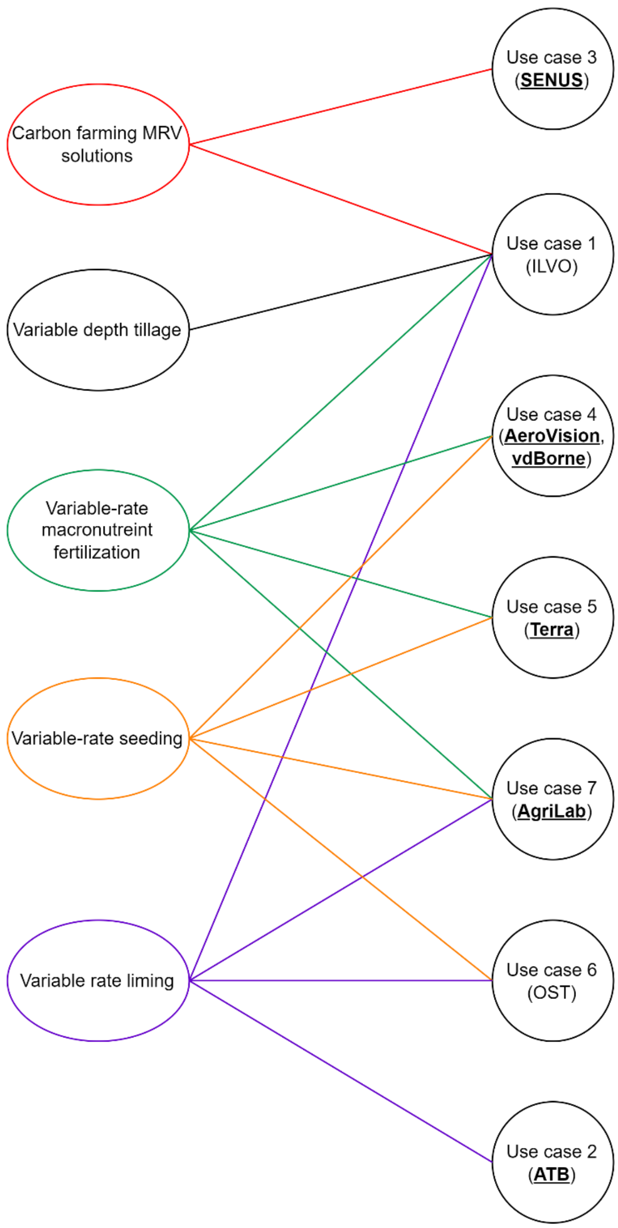


Figure 2: Variable rate applications (VRA) and use-cases.

4.1 Workflow variable-rate seeding

4.1.1 Use Case Storyline

Hans manages an 80-hectare arable farm on sandy soils, growing potatoes, sugar beets, wheat, and onions. He has observed a gradual decline in soil quality and wants to maintain soil health while keeping his business profitable. At present, soil information is mainly used for general fertilisation planning, and variable rate applications (VRA) are only occasionally applied by contractors.

4.1.2 Objectives and Challenges

Hans aims to optimise crop yields and input efficiency while maintaining and improving soil health and fertility. He also wants to adopt sustainable practices that are economically viable. Achieving these goals is complicated by the high spatial variability of soils across his fields, increasing weather fluctuations and drought risk, and limited labour availability during peak operations, which makes precise and timely management more challenging.

4.1.3 SQAT Workflow

The workflow begins with data acquisition. Satellite data, sensor readings and soil samples are collected and integrated according through the multi-actor workflow of the SQAT system. Results of the SQAT system are standardised and analysed, calculating key soil indicators such as organic matter, nutrient status, structure, and moisture capacity. Results are visualised as high-resolution soil quality maps, showing within-field variability and management zones. Using the soil indicators and crop requirements, SQAT provides site-specific recommendations and generates compatible VRA task maps for seeding. To this end, existing precision farming applications are utilized, as well as the developed SFA's. Contractors can upload the task maps directly into GPS-guided machinery for precise field operations and input application. Feedback sessions and stakeholder workshops are organised to aid in further improving the quality and usability of SQAT system output.

The SQAT workflow transforms detailed soil data into practical management outcomes. This enables farmers like Hans to respond to soil variability, use resources more efficiently, and move towards more sustainable and profitable production.

4.2 Workflow carbon farming MRV

4.2.1 Background

Agrifood companies, carbon project developers, and offset buyers require an affordable, science-based MRV system to accurately quantify soil carbon sequestration, report emission reductions to auditors, and generate verified carbon credits. Traditional MRV approaches rely on sparse sampling and heavy modelling, making them costly and imprecise.

4.2.2 Use Case Storyline

A dairy processor in Ireland wants to demonstrate measurable emission reductions across its supply chain. Using SQAT-enabled robots, sensors, and Earth Observation data, Senus (formerly FarmEye) establishes soil organic carbon (SOC) baselines for supplier farms. Changes in SOC from regenerative practices are tracked over time and integrated in the MRV dashboard (aligned with VERRA standards). Verified carbon credits are issued and applied to offset or in-set the company's product footprint.

4.2.3 Objectives and Challenges

Farmers receive financial incentives and recognition, while corporations achieve climate commitments through a transparent, scalable MRV solution. Carbon farming MRV is challenging due to the relatively high associated costs with gathering accurate soil data, while relative increases in the total carbon stock are often low and therefore challenging to assess.

4.2.1 SQAT Workflow

The workflow begins with baseline assessment, where GNSS-guided soil sampling through the Senus app, SQAT robots equipped with NIR sensors for topsoil mapping, and lab-based SOC analysis from collected soil profiles are used to create high-resolution SOC maps (expressed in tonnes of carbon per ha) across all fields. Reporting and verification are handled through the Senus MRV Dashboard, aligned with VERRA, Gold Standard, and ISO methodologies, with auditor access ensuring independent validation of carbon storage and emission reductions. The Senus platform issues certified carbon credits based on the validated data, which can be monetized or applied in-setting to reduce Scope 3 emissions across corporate supply chains.

4.3 Workflow Variable Rate Liming

4.3.1 Mapping the soil

Requests of this step: This SQAT storyline starts with a farmer having a suspicion that his parcels have soil that is acidic and needs the appliance of lime to improve soil-health, to improve his yield. The SQAT workflow results in three soil maps of the parcel in question: a map depicting SOM content, a map with the soil texture over the parcel, and a map with the pH levels.

Results of this step: SQAT workflow resulting in SOM, Texture & PH map

4.3.2 Crop pH requirements

Requests of this step: The farmer should provide the type of crop(s) he is aiming to grow on this parcel. The type of crop influences the target pH level; this is a singular fixed level (or range of levels). For example, a root crop like potatoes prefers slightly more acidic soil (5.2 – 5.8). This range also differs between potato types (seed vs. table) and should therefore be well documented by the farmer. Meanwhile, a legume like soybean prefers a higher pH (6.5 – 7.0) to stimulate nitrogen-fixing bacteria. This fixed pH target should be overlaid with the current pH map to create a map showing the difference between the current and target pH within the field.

Results of this step: A fixed target pH value, a map showing in-field differences between target and current pH, as well as SOM, soil texture, and pH maps.

4.3.3 Converting pH difference to lime requirement map

Requests of this step: The SOM and soil texture map should now be used to calculate the buffering factor, which together with the difference in pH determines the amount of lime per area. SOM and texture affect this buffering factor, as it influences how much calcium a soil needs to increase pH levels. Standard rule is that sandy and low SOM are indicators for a lower buffering factor, while clayey high SOM areas require a higher application of lime to increase pH. This combination will result in a buffering factor map, which than can be used in the lime calculation, resulting in the amount of lime needed in tons/ha per area of the field. At this moment the map still has a high resolution.

Results of this step: A buffering factor map based on soil texture and SOM, and a map of lime requirements in ton/hectare

4.3.4 Choosing type of lime and creating final prescription map

Requests of this step: The type of lime chosen by the farmer directly affects the final prescription map. An important factor to consider is the Calcium Carbonate Equivalent (CCE), which measures how effective lime is at neutralizing soil acidity. The required lime rate in t/ha must be adjusted for this value. For example, if the lime used has a CCE of 80% and the calculated requirement is 2 t/ha (pure $CaCO_3$ equivalent), then the adjusted application rate becomes 2 ÷ 0.8 = 2.5 t/ha of the chosen lime product.

Another critical property is the granularity or fineness of the lime, often expressed as the Effective Neutralizing Value (ENV). Fine particles react quickly, while coarse particles may take years to fully dissolve. A lime with low fineness will therefore be less effective in the short term, and the prescription rate should be corrected accordingly. For instance, if the product has a CCE of 80% and an ENV of 70%, its effective neutralizing capacity is 0.8 × 0.7 = 0.56. In this case, 2 t/ha pure $CaCO_3$ equivalent translates to 2 ÷ 0.56 ≈ 3.6 t/ha of actual product.

Finally, lime choice is often linked to magnesium requirements. If soil tests show Mg deficiency, dolomitic lime (calcium + magnesium carbonate) is preferred, whereas if Mg levels are sufficient, calcitic lime is usually more suitable. A magnesium map can therefore be valuable for deciding whether to apply lime that supplies both calcium and magnesium, or only calcium.

Results of this step: A detailed map with the amount of (total) lime needed to improve pH, as well if additional magnesium would be beneficial.

4.3.5 Creating a task map based on machinery to be used

Requests of this step: Most machines require a zone-based format, as they cannot handle very detailed grids. For example, if you are working with a lime spreader that has a width of 32 meters and the option to close one side, your zones should be designed 16 meters in width.

Each zone should include the following information:

- Application rate (t/ha, as defined in the prescription map). This value can be set to either the maximum rate within the zone or the average rate, depending on the farmer’s strategy.

- Rate limits: the application rate must be clipped within the minimum and maximum operating limits of the spreader to ensure proper execution.

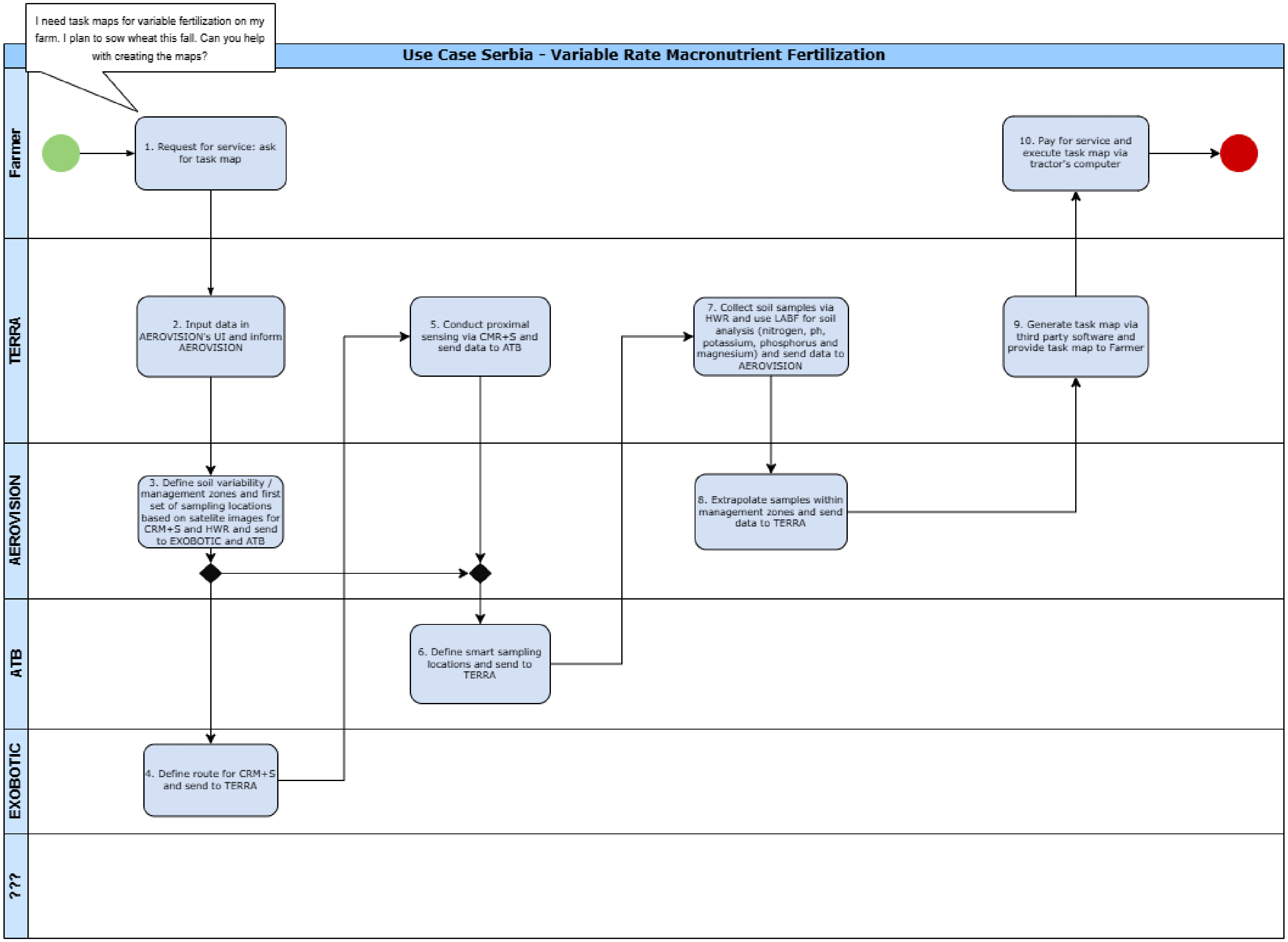
This step is typically handled by task map generators such as Trimble AgStudio, John Deere Operations Center, or similar software (many options exist depending on equipment). The output will usually be an ISOXML task file, although the exact format depends on the spreader and tractor system in use.

4.4 Serbian Use Case - application fertilization - business process model

The business model in Figure 4 illustrates how Terra provides precision agriculture services to farmers through data-driven and automated processes. When a farmer requests task maps for variable-rate fertilization, Terra evaluates the request and gathers the necessary information before deploying advanced field technologies. Using robots for mapping and soil sampling, along with on-field and external laboratory analyses, Terra collects and interprets detailed data about soil conditions.

In the Terra use case, two main sampling approaches are applied. For crops such as wheat, oilseed rape, and sunflower, N-min analysis is conducted at three depths (0–30 cm, 30–60 cm, and 60–90 cm). For all other crops and perennial plantations, BSP (Basic Soil Properties) analysis is performed at a single depth of 0–30 cm. The analytical results are expressed in the primary nutrients N (nitrogen), P_2O_5 (phosphorus pentoxide), and K_2O (potassium oxide), which form the basis for generating fertilization recommendations.

Based on this analysis, optimized task maps are generated through specialized software to guide efficient seeding and nutrient application. It should also be noted that zonal differences are sometimes adjusted according to the available fertilizer formulations, highlighting the practical usability of the data in real farming operations. This approach enables farmers to make smarter decisions, reduce input costs, and maximize crop yields while promoting sustainable and efficient farming practices.



CMR+S - Continuos Mapping Robot + Sensor (near infra red spetroscopy)
HWR - Heavy-weight Robot (soil profile sampling, penitrometer)
LWR - Light-weight Robot (top soil sampling)
LABF - Lab on the Field (ph and macronutrient analysis)

Figure 3:Terra business model

5 Final remarks

This report has been used to create an overview of the work to be done in task 3.4 of the SQAT project, as well as some initial results. For the remainder of this year we will be working towards the implementation of use cases, which is set to start in early 2026. For some of the VRA schematic workflows were outlines, but these have to be complemented with more detailed information to make implementation possible. After the first use case, which is planned to be variable rate seeding at the van der Borne potato farm in the Netherlands, the first opportunity for evaluation and refinement of workflows is possible. Later in the year more use-case implementations are planned. These implementations are great opportunities to organize stakeholder workshops and user feedback sessions, so further improvements to the SQAT services can be implemented. This leaves 2027 for finalization. In April of that year, all the tasks and activities outlines in chapter 2 should be finished.

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