University of Dundee

Report on first Mission Insights workshops

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DELIVERABLE 1.2

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Report

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PROJECT ACRONYM	GRANT AGREEMENT #	PROJECT TITLE
GROW	690199	The GROW Observatory

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v1-03	01/10/2018	Deborah Long	UNIVDUN	Final review

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Introduction

The GROW Observatory (GROW) is a Citizens' Observatory (CO), defined as a community platform for citizens to generate, share and utilise information to address community, science, policy and innovation challenges. The concept for GROW is to support the emergence of a movement of participatory citizens generating, sharing, utilising data and knowledge on growing and the land, leading to more sustainable land use practices, smart soil and land governance and policy, and a unique data repository for science. The project aims to demonstrate a CO, and that the concept itself and system can deliver widespread uptake, robust science, societal impact, and be sustained beyond the grant. To realise this goal, GROW will generate data and insights, for benefit of policy, science and citizens, and for evaluation and further development of GROW and the CO ecosystem.

In GROW, activity is organised into Missions, understood as periods of coordinated citizen science activity, which can involve sampling and sense making. Each Mission brings together a community of citizens to collaborate on research for environmental monitoring, whose issues have impacts related to land cover and land use. GROW Mission deeply engage citizens, scientists, policy makers and other bodies to collaborate. As such, Missions are the primary vehicle in GROW for creation of data, insights and value. Year one Missions had a focus on validation of GROW science, technology, data and engagement.

Each public mission in GROW aims to include a Mission Scoping exercise and end with Mission Insights workshops, bringing together representative stakeholders with citizens. Insights from these activities validate and inform the further development of Missions (WP1) and the underpinning science, data, technology and engagement (WP2,4,5,6). These insights are a jumping off point to further use and exploitation of data in WP3. This approach helps validate and evaluate results and Impact for D1.4 (Report on adoption of practices, land use change, and validation of techniques), and are communicated through to specialist communities in policy, science and industry, linking to T3.1 (Innovation Lab for specialist users in science, policy, business).

This deliverable reports the methods used to support insight gathering with a summary of identified GROW issues underpinned by the perceived gap, potential impact and suggested pathways for development (Task 1.2). The Deliverable presents an overview of key insights from year 1 for knowledge exchange, campaign design and citizen science experiments. It details first the methods and tools used, and then key insights generated in year one, relating to Mission outcomes and expected impacts, and to the development, delivery and evaluation of the Observatory. This includes discussion of the online and face to face events GROW participants (growers and expert users) have taken part in during the first year of the project. The Deliverable concludes with an account of pathways for development, describing the activities and outcomes under development in order to deliver the insights and value so described.

Section 1 gives an overview of methods and tools for insight gathering used within the GROW framework

Section 2 details the technology and scientific validation activities and insights gathered during the first full year of the project

Section 3 discusses stakeholder knowledge exchange activities and insights gathered during the first full year of the project

Section 4 presents the GROW platform and service development with insights to date

DEFINITION OF TERMS

Citizens' Observatory (CO) is a concept that has developed at EU level. It is a community of stakeholders which include citizens, scientists, policy makers and others collaborating on research for environmental monitoring, whose issues have impacts related to land cover and land use.

Collaboration Hub (CH) is a place to be part of the GROW community and to connect and discuss with other stakeholders. It is where people connect their soil sensor to the GROW database and where participants submit and can view data from experiment results and data from their land and soil survey, it refers to online infrastructure.

GROW Places (GP) are geographic focus areas where a high quantity of Flower Power sensors are deployed to record soil moisture and associated data at a high density of observations. They are in specific areas in Europe with strong stakeholder buy in.

Mission an approach a period of coordinated citizen science activity that can involve sampling and sense making. Missions engage citizens, scientists, policy makers and other bodies to collaborate; through contributing to experiments and goals they will amplify innovation and enable better environmental decision making. Missions are designed to achieve social, policy and innovation outcomes and be sustainable.

MOOC as it is commonly known stands for Massive Open Online Course, aimed at a learning journey featuring traditional educational materials, and community interactions. MOOC's have unlimited participation and are open access via the web.

Protocol An established procedure within a Mission for accomplishing a purpose

1. GROW Framework and methods for Insight gathering

A range of methods are being used to generate insights in GROW, and are applied throughout the GROW framework described in D1.1 and exemplified in Figure 1. Central to our methodology are our approaches to Scoping and Insights; these take place throughout key stages in the preparation, validation, delivery, reflection and evaluation of Missions. When insights are gathered they are applied in an iterative way to the development of mission design and citizen science experiments.
Methods to support insights are selected according to the user-context and the corresponding stage of the GROW Framework (D1.1), the activity, and the need or gap to be addressed. A list of approaches with an indication of which phase in the GROW framework they have been adopted are outlined below.

GROW PHASES	DESCRIPTION	ACTIVITIES
SCOPING	MAP IDENTIFY ISSUES, POSITIONING MISSIONS, INFRASTRUCTURE, PARTICIPANTS, DATA, SERVICES, CRITERIA	Research Citizens, Experts, Policy // Mapping Issues and Concerns // Platform and Product Dev // Gap analysis // Citizen Science // Best practices for CO's
COMMUNITY BUILDING	RECRUITMENT, ONBOARDING CITIZENS, EXPERTS, POLICY MAKERS	Engagement and Communications with Kindred Networks // Community // Storytelling // Thematics // Media Partnerships // Community Champions
DISCOVERY	EDUCATION and BUILDING UNDERSTANDING, CONTEXT, SCIENCE, PROTOCOLS, MISSION AIMS AND OBJECTIVES	Learning and Training // Data Literacy // Peer and Social Knowledge Exchange
SENSING	DATA GATHERING AND OBSERVATIONS USING TECHNOLOGY AND WITH CITIZENS, SHARING DATA	Sensor Distribution // Deployment // Data Upload and Access //
AWARENESS	DATA LITERACY, ANALYSIS, APPLICATION and ACTION	Webinar // Workshops // Celebration // Data Access, Aggregation // Sharing Insights// Scientific or Expert Interpretation // Critical Reflection with citizens
INNOVATION	NEW DATASETS, PROTOTYPING AND TESTING SERVICES WITH USERS, VALIDATING CO PLATFORM AND INFRASTRUCTURE	Design for New Services // Business proposals // New resources and assets for communities // Robust protocols and datasets
ADVOCACY	POLICY, SOIL, SERVICES, TECHNOLOGY, ROBUST DATA, CO APPROACH	Championing // Bi-laterals // Change: In practices, policy, uptake // External appropriation // Sustainability of the project and tools, outputs // Interventions

Fig. 1 GROW framework phases and description

Desk research

Encompassing official reports, academic papers, online and local news published with the objective of finding articles referring to local and global land management, soil, and related environmental issues. **GROW phase SCOPING.**

User research with citizens

The project has committed to a user-centric approach, this involves understanding user behaviors, needs, and motivations through feedback methodologies. In year one we have gathered insights using workshops, observation, personas, questionnaires, focus groups, surveys and individual interviews. **GROW phase SCOPING and AWARENESS.**

User research with specialist users in science and policy

Specialist users are also part of a user-centric approach to building an Observatory, being an important end-user of data and services. In the first year specialist users have consulted on the critical questions about data and service innovation in workshops, surveys and one to one interviews. **GROW phase SCOPING and AWARENESS**

Feedback Dashboards

To gather distributed feedback on a diverse set of items, such as user engagement, technical issues, protocols and ideas, WP1 developed Mission Proformas with Feedback dashboards to capture, reflect on and evaluate issues. **GROW phase AWARENESS**

Experimental design

To formulate and test hypothesis or questions, GROW researchers create a blueprint of procedures or protocols that enables piloting and validation by reaching valid conclusions about relationships between independent and dependent variables. It refers to the conceptual framework within which an experiment is conducted. **GROW full cycle**

Pilots and trials

Much of the first year of the GROW Observatory was spent piloting and validating approaches, tools, methods and technologies. **GROW full cycle**

Missions Workshops

Communities and stakeholders gather face to face during a Mission for a variety of reasons, including the scoping of issues, meeting experts or other stakeholders, training with sensors, planning of protocols, gathering of data, and sharing insights from data. Each Mission has at least three workshops, kick off, training and insights gathering, with other meetups designed to support the community. **GROW phase DISCOVERY, SENSING, AWARENESS, INNOVATION**

Monthly themes on the GROW Collaboration Hub

In order to engage participants and build community, monthly themes amplify and curate storylines that have a resonance in the world as well as align with GROW workflow. Themes to date have been: Your Soil, Your Data (Jul 2017), Living Soils (August 2017), GROWers (September 2017), Harvest (October - November 2017), Celebration The Year End (December 2017), Bedding down (January 2017), Your Soil, Your Data (February 2018). **GROW phase DISCOVERY**

Toolkits and expert interaction

The awareness stage of the GROW Framework is vital if stakeholders are to collectively realise the potential of data for innovation and new services. GROW is developing toolkits to support social, technical, business and societal innovation outcomes. Toolkits support stakeholders to together collaboratively understand data insights. In year 1 individuals who took part in the first MOOC ‘Soil to Sky’ were able participate remotely via a Webinar and connect with educators on the FutureLearn and GROW Fora. **GROW phase AWARENESS AND INNOVATION**

Web analytics and feedback on GROW website, social media and MOOCs

GROW is developing a range of methods for gathering feedback and insight sharing, with GROW participants and other stakeholders on a range of platforms. **GROW phase AWARENESS AND INNOVATION**

2. GROW technology and scientific validation activities and insights

2.1 Seasonal Testing and Validation of Sensors

One of the key innovations for GROW is to use the Flower Power sensor in outdoor conditions, thus aiming to extend the use of the sensor and validate new opportunities for citizen science projects using low cost soil sensors.

The validation of Flower Power sensors in the field was critical in understanding the perceived gap and potential impact on data quality, data gathering and the Observatory as a whole. The parameters and physical performance of the Flower Power sensors was tested in the ‘Over Winter Mission’, from

January 2017. In this, 200 sensors were deployed in winter conditions in different climatic and environmental zones, and their performance monitored and evaluated. The variables tested included temperature measurement, scientific protocol, useabilty, technical specifications, calibration and access to undisturbed land.

Scientific and technical sensor tests had two main parts. 1) One was to test its outdoor survival, battery life and housing in low temperatures, and 2) test the data transmission and measurement uncertainty. A scientific document was produced to validate the measurements, interpret the values in different kind of soil conditions and develop an integration toolset for interpreting and correlating the different measurements.

A User-Research strand sought to understand users' experience/interaction with the sensors and the Flower Power app, to help define the protocol for positioning and registering sensors as well as time commitment for participants. This was all with the aim of producing GROW manuals and toolkits. A feedback dashboard gathered observations, problems, and suggestions for improvements.

There were several successes, including:

1. Effective coordination amongst GROW partners as a test for future missions.
2. Positive results in regards to the outdoor performance of Flower Power sensors in a wide range of climatic and geographical conditions
3. A collated a comprehensive list of FAQ and troubleshooting information that will be invaluable in future missions
4. A list of potential issues that might arise was identified, allowing the consortium to prepare in advance and consider solutions
5. The objectives of the mission were successful and resolved some issues with Flower Power sensor
6. The mission was a successful first test of the logistics model to request and send out sensors.
7. Partners who took part now feel more confident and familiar with the sensor, which will be key in the future when the team starts training citizen scientists to use them.
8. The GROW platform was set up successfully and is now able to collect data from Flower Power sensors.

Issues:

Issues and Observations: Battery life is extremely good in comparison with other sensors, however there was a failure rate of 1 (of 5) sensors by month 5. This insight only became apparent as the sensor was connected to another 4. If a user has a single sensor that has this problem, then diagnosis of the issue would have been difficult (it simply fails to connect). Comments: No other battery issues have been reported. Data doesn't get lost if battery fails, and we advise batteries are changed as a first solution.

Recommendation: Give users a list of approx. 3 steps they should check before replacing a sensor. Let users know that batteries may fail within the lifetime of the project (approx. 6 months), and that they will need to replace them (and how to do it).

Summary of Insights:

1. Sensor orders must be placed well in advance
2. Ideally orders should be sent in bulk to reduce postage

3. Participants should be sent additional information to the instructions included in the Flower Power sensor box to ensure they connect the sensor with the GROW platform correctly and are clear about steps to resolve FAQ's
4. Issues about users registering more than one sensor or changing the sensor to a new location were noticed and a solution identified
5. We need to be clear about compatible operating systems to avoid disappointment from potential participants and errors when planning recruitment numbers.

Sustainability:
The Changing Climate Mission in year 2 is the next step to continue and scale up the successes of this first mission.

Policy relevance:
This mission has proved the value of Flower Power sensors for outdoor citizen science missions. This factor has big implications for the potential of citizen science projects as evidence-producing and awareness-raising in relation to agriculture and soil policy.

Outputs:
1. FAQ document
2. Troubleshooting guide
3. Training manual for using sensor
4. Map of sensor distribution.

2.2 Sensor Testing and validation, Soil Texture and Soil Moisture

A lab exercise was conducted to characterize the sensor performance in four different kinds of soils. A programme of activity in the Lab was conducted to assess quality and validity of the Soil Moisture data produced by Flower Power sensor. It is important to validate and characterize the Citizen Observatory estimations. In citizen contributed data, several random or trended error sources can be anticipated.

The end point of the testing and validation is a robust network of pilots representing the potentials and limitations of the CO systems.

Sensor testing and validation methodology:
Testing use in environmental monitoring, a two phase approach,
1. Optimal conditions – The sensors are first tested in control conditions using a CO approach. This is through the sensing pilots, where citizen contributors are supported by science teams, with continuous quality and participant control and support.
2. Real life conditions – citizens themselves record the measurements, supported by GROW training, guidelines, tools and quality assurance measures detailed below.

Quality assurance strategy:
1. Repeat citizen observations on site
2. Take samples and analyse them to see the reliability of the estimations.

Learnings from validation and quality assurance can be projected to the unchecked, non-visited sites, and guidelines developed on handling the limitations. GROW Places can then be compared with the optimal situation, the limitations identified, the provided data classified accordingly and integrated to the final monitoring network, in a way that maintains the limitation information.

Summary of Insights:
Sentinel 1 Validation:
All points, representative of an area - with the size of at least three times larger than of a sentinel based soil moisture data pixel resolution - are useful, depending on the sensor data reliability.
For Sensor Validation

- there is a clear correlation in the uncertainty.
- Flower Power measurements on dryer soils have larger positive divergence form the actual measured value, which is changing direction around 40% moisture content.
- Flower Power overestimating the moisture below 40% actual value, while starts underestimating it above 40%.
- The cross validation among the sensors is more or less constant, except the very dry conditions.

2.3 Pilot Sensing Mission requirements for soil moisture survey

A Pilot Sensing Mission served to test the implementation of GROW Places and their usability for science. One prior insight from the Functional Specification of the Sensor Network (D3.1) was the introduction of focus areas where a high quantity of Flower Power sensors are deployed to record soil moisture and associated data at a high density of observations in specific areas in Europe.

Fig. 2 GROW Site selection Hungary

Insights on science requirements for a Soil Moisture Survey were generated through a pilot Sensing Mission. The objectives of this Mission were as follows:

1. Validate scientific usefulness of the data through satellite validation activities and preliminary gridded products production
2. Validate the material (see Fig. 2), protocols and instructions to provide to the citizens to deploy and maintain the sensing network from a scientific point of view
3. Test GROW's back end system and its capacity to collect and provide the data to users

The pilot Sensing Mission also validated citizen scientists' data by observing how participants use the training materials and with what level of accuracy they carry out the metadata measurements and the selection of a suitable place for the sensor.
This entailed:

1. The local GROW team carry out metadata measurements in each of the participating growing sites.
2. Participants' workshops, including a Kickoff workshop mid-October and an Insights and celebratory workshop at the end of Nov.
3. Participants carried out metadata measurements and a selection of a suitable spot for the sensor, then submitted data to the GROW platform.
4. GROW compared the two data sets (see point 1 and 3): 1) from GROW Hungary team and 2) Participant-generated data to identify any errors and potential sections of the protocols that require clarification.
5. The local GROW team to identify potential community champions in the area for next year and kindred organisations.
6. The local GROW team to record workshops and measuring activities: photographs, short videos/interviews, etc.

Summary of Insights

Characterising GROW Places

- Diverse –> an even geographic distribution to cover different climates and environmental conditions, different cultures, engagement approaches, communities and land uses.

Table: Requirements for Gridded Product and Sensor Validation

Variables	Gridded Product	Sensor Validation
Depth for sensor location	yes	yes
Urban/periurban/rural area	yes	yes
Undisturbed / cultivated land	yes	yes
Irrigation (also irregularly) / no irrigation	yes	yes
soil texture	yes	yes
vegetation / canopy height	yes	yes
sensor location (lat/lon)	yes	yes
fertilization	yes	yes

Applications of the GROW soil moisture data

1. Agricultural assistance – local, for citizens
2. Monitoring and validation – characterizing a larger area
   a. Validation of Sentinel data
   b. Integration of the sensor measurements into the existing environmental monitoring networks.

Data needs (for environmental monitoring):

- Soil, terrain and landuse data.
  - Terrain and landuse are available.
  - Soil data is the gap – addressed in GROW.

Insights from workshops and plans for implementing participants' feedback:
The workshops carried out in Hungary, Greece and Ireland have provided us with very useful insights to incorporate into the timeline and structure of future Missions in 2018 and how they fit with the timeline for the GROW app, the revised version of the training materials and the planned MOOCs.
Training materials for the Changing Climate Mission (the roll out of the pilot Sensing Mission that took place in 2017) include:

1. Written training materials translated into the languages of the selected GROW Places (i.e. the Sensing Manual and field handbook).
2. The GROW app, also translated, that will serve as the main mechanism for GP participants to upload the land and soil survey data of the specific spot where they place the sensor/s.
3. An alternative data submission mechanism to complement the above has been suggested (the GROW website) in case the app fails or is delayed or participants refuse to use it.
4. MOOCs will be available as additional training for GP participants who will be strongly encouraged to take part in the courses, especially in the Soil to Sky MOOC and Sensing MOOC. They are also welcome to join the Living Soils Mission that will have 2 associated MOOCs (in April and Oct - Nov 2018 respectively).

The written materials were updated based on the insights from the pilot Sensing Mission to incorporate:

1. feedback from participants
2. changes for the soil texture protocol and
3. a guide to the GROW app

The materials will be made available on the GROW website in different languages.

The workshops in GROW Places will be scheduled to take place at the same time as the start dates/weeks of the MOOCs: Citizen Science: from soil to sky (19th Feb), Citizen Science: sensing your soil, sensing your climate (19th March) and Citizen Science: from soil to food (9th April) in order to encourage engagement and where possible, collective participation.

2.4 Gridded Product

The GROW projects aims to demonstrate the potential use of soil sensor measurements and the added value that can be achieved by post processing activities of the data. The project will develop raster maps – gridded products – for the GROW places for all quantitative variables, static and dynamic soil parameters that will be collected by the participants or the measured by the sensors.
Scoping and insights activity in year one has characterised the intended Gridded Product to be developed in GROW.

Summary of Insights

There will be several soil and landscape information collected within the citizen science and landscape/soil description activities for each of the sensor locations. These properties, like soil texture, clay percentage or stoniness have a spatial distribution over the landscape. These distributions are driven by several soil forming factors, including terrain, geology or vegetation/land use. There will be more variables collected by the sensors used: like soil moisture, temperature, electric conductivity. All of these properties, variables will be available as point information.

There are several different approaches to interpolate the point information and estimate the properties for any non-visited site, create a continuous surface from the point observations. These layers, the so called *gridded products*, represent the final products of the monitoring system. The performance, or accuracy of the estimations – dependent variables - are mainly the function of the availability of accurate, high resolution independent/explanatory variables, the so called *environmental covariates*, such as digital elevation model and its derivatives: slope, aspects, hydrological functions explaining the surface water flow, etc.. Digital elevation data and satellite information – optical and radar (Sentinel-1) – are the most common sources for environmental modelling, geostatistical estimation, mapping approaches.

3. Stakeholder Engagement, knowledge exchange activities and insights

Exploitation of GROW data and services by communities and stakeholders in science, policy and industry has been facilitated by user research and through workshops. GROW has to identified prospective users, use cases, and gathered initial requirements. The stakeholders are defined as potential users of both the raw data and derived insight and services.

3.1 Stakeholder Engagement in Pilot Mission 'Citizen Science: Soil to Sky'

The first GROW Mission had the aim to test the GROW pedagogical framework and social learning approach as well as the migration (both social and technical aspects) to the GROW Collaboration Hub (CH) of a first cohort of GROW participants.

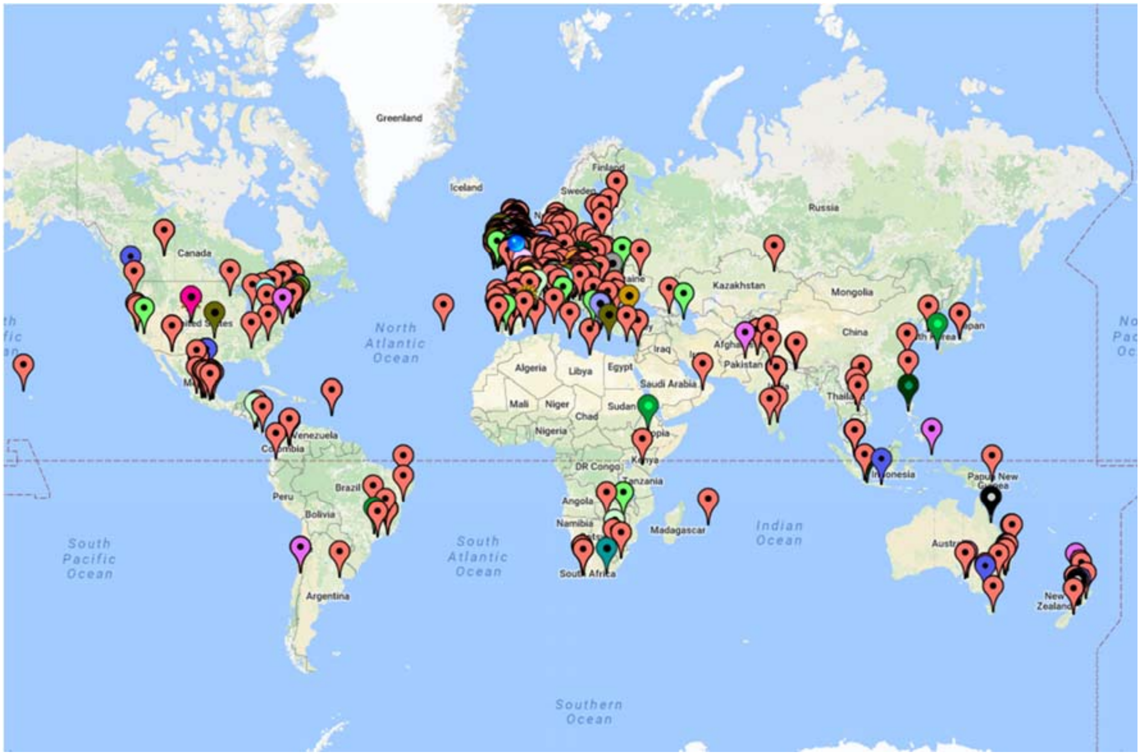


Fig. 3 MOOC ZeeMap showing locations of participants in 'Soil to Sky'

Description:
The Mission involved the creation and run of GROW's first MOOC: "Citizen Science: From Soil to Sky, participation was concentrated across the EU (Fig. 3) but there was worldwide interest as shown in the same figure. The course ran for three weeks, from 8-26th May 2017 and covered the following topics:

Introduction to the GROW Observatory
Citizen Science and Fieldwork
Soils, Growing Sites and Plant Health
Climate, Temperature and Moisture
Landscape Representivity and Cover
Soil Components
Global Challenges for Soil
Regenerative Techniques
Landscape Ecosystems

MOOC Data collection and analysis
Participants of the MOOC were asked to input information about their GROWing space, and the growing practices they used. The selected datasets are essential for annotating sensor data in subsequent missions. The data collection is detailed in Appendix 1, and was split into:

- the land cover of their growing space sub grouped into size, planting and cover
- the slope and aspect of their space, slope and description of slope
- how they maintain their growing space and soil type.

Summary of Insights:

- Post MOOC migration of participants to other platforms, such as the GROW Collaboration Hub is needed to maintain the momentum after the course end.
- Feedback from participants reported that content was of a good quality, but very dense for the majority to complete the course in 3 weeks; the course will run over 4 weeks in 2018 to allow participants the time to complete all the observations.
- Using google hangouts on air for the webinar was complex despite having several test runs.
- MOOC participants demonstrated a fantastic level of interest in citizen science, soil and regenerative practice.

A follow-up webinar was held after the end of the course to offer participants the opportunity to learn how to make sense of the data they collected and offer ongoing participation and learning opportunities in between MOOCs, this is the awareness stage of the GROW Framework. The details of the webinar are discussed in the next section.

3.2 Stakeholder Engagement the GROW Webinar Knowledge Exchange

The GROW team held its first webinar to relate insights from data collection with participants who have taken part on the MOOC ‘Citizen Science from Soil to Sky’.

Fig. 4 Illustration of invitation to participants for the Webinar

The webinar focused on key topics of relevance to MOOC participants. The topics were selected after reviewing and analysing the hundreds of comments by participants in the online course. Key interests for learners were centred around the connection between soils and growing, factors and techniques that can help their growing, and also that relate to global environmental challenges. The webinar presenters discussed the importance of soil, how to understand soil texture and structure, and soil properties and cultivation.

An important aim of the webinar was to look at the data participants had contributed from observations in growing spaces during the online course discussed in section 2.1.

The webinar was a fantastic opportunity for participants to come together and join a live session with an international network of growers as well as accessing different sources of expert knowledge. The

webinar offered a space for discussing how individual actions and observations in growing spaces can help individual growers improve their own growing while also answering major challenges for science. Offering a joint space for MOOC participants and lead educators to interact live is also part of GROW's objective to facilitate the collaboration of citizens with professional scientists.
The webinar details were as follows:

Date: 29th June 2017

Speakers:

A. Drew Hemment, GROW's Coordinator and Academic Lead.
B. Naomi van der Velden (NvDV), Researcher at the Permaculture Association and plant ecologist.
C. Blair McKenzie (BMc), Agricultural Scientist at the James Hutton Institute
D. Pavlos Georgiadis, GROW's Community Champion coordinator, ethnobotanist, biodiversity researcher and organic olive grower.

Channel:
The webinar was live-streamed using Google hangouts on air. The recording of the video can be accessed here: https://www.youtube.com/watch?v=okgKoHUUvdQ

Webinar engagement

- 42 comments / questions in the YouTube live chat - https://docs.google.com/spreadsheets/d/1zpAVqj52aepf7skCTUfYk76Q4OTi1kBgYOIT-BHS-Y4/edit?usp=sharing
- The webinar twitter feed #GROWWebinar generated: 27 tweets during activity.

Summary of Insights:
Making sense of data and observations

The session discussed the trends from the collective data set from the MOOC. The data analysis showed that more people on the online course had sandy soil than any other. NvDV showed the different techniques used to determine soil texture and how they compare. NvDV also shared some of the important aspects that need to be taken into account when planning citizen science projects, including a well-designed method, clearly communicated, which everyone follows, so the data are comparable and meaningful. The method and tools need to be accessible to people, and combining different approaches can allow one method to be validated by another. This discussion provided participants with an introduction to the Living Soils Mission that will run in 2018 and will include citizen science experiments to assess the suitability and effectiveness of polycultures as well as training on how to designing robust citizen science projects.

People's questions and comments on the live chat and social media delved deeper into these themes. For example, one of the participants asked on how the observations in individual growing spaces can lead to better growing, and how they can link to and inform wider science challenges. The team explained how one key goal in GROW is to create an unprecedented survey of soil moisture, to validate the European Space Agency's Sentinel 1 satellites, and to help improve climate models for predicting floods and droughts.

There was also interest in finding out more about how to change the type of soil in a growing space to suit specific crops. BMc spoke of the lengths a grower can go to to change the structure of any given soil, followed by a discussion of dig and no-dig approaches, and the consequences for weeds and waterlogging.

Participants also had the opportunity to share issues that link their growing with the wider local and global climate and access to water. For example, there was a discussion of the problems of having a short growing season in Scotland, and how that compares to conditions facing growers in France who were experiencing a very hot dry June with water restrictions in force.

The GROW team provided advice and explained how it is usually better to fit the crop to the soil than the soil to the crop, and discussed the best soil for different crops. This is another topic that will develop further next year, with crop recommendations for specific soil and local climate to be introduced in GROW during 2018.

Over the summer the citizen science activity introduced in the online course continued, and participants were able to take part in more learning opportunities and experiments to observe key soil properties in their growing space. Observations on soil moisture, soil stability and biological activity levels were and continue to be designed by the GROW to enable growers to compare the effects of different management approaches.

3.3 Stakeholder Engagement for Scoping Soil Moisture Data and Application

Insights on need, demand and requirements for soil moisture data among science users were determined through one-on-one interviews. The purpose of the interviews was to find out the current activities in the MET Office that involve soil moisture data, what appetite and market for GROW's soil moisture data there might be, and what formats would be most useful for the data to be provided in.

Scientists with an interest in soil moisture data from across the MET Office were identified and invited to participate. A series of interviews with these scientists, all of whom have an interest in soil moisture, took place in summer 2017.

Talking to these scientists in an one-on-one interview context had the objective to give the project a deeper understanding of their use of soil moisture data and their future requirements. This method was adopted because it kept to a minimum the time input required from individuals at this stage, making their engagement more likely.

Date: The interviews were conducted with Met Office staff in June/July 2017.

Number and Job titles of attendees:
The interviewees were drawn from a range of areas which were selected to give a broad overview of the ways in which soil moisture data is used within the Met Office. The interviewees selected were:

- Account Manager (Business Group)
- Account Manager (Government Services)
- Scientist in Land Surface Processes (Science)
- Weather Analytics Manager (Applied Science)
- Climate Impacts Scientist (Climate Science)
- Programme Manager (Technology and IT Services)

Summary of Insights

There was a broad range of reported current applications of soil moisture data in the Met Office, including:

1. Landslide prediction for railway embankments
2. Water companies who use the data for helping to determine water table levels and planning demand
3. Agricultural customers who use the data to help predict when is best to spread slurry (to avoid runoff) or plant crops, and to better manage irrigation
4. Broadcast media customers (some of their audiences have reportedly requested soil moisture data from broadcasters)
5. A main finding of the initial interviews was the need for more detailed information about the performance of the sensors and validation of the sensors before the scientists would commit to judging the worth of the data.

When asked whether the interviewees had any questions for GROW, the main concern was around how the sensors are validated and what they actually measure. These would need to be thoroughly understood before the data could be used.

Plans for future workshops with expert users:

GROW will conduct more interviews with the science community outside the Met Office and follow up with those scientists we have already spoken to once we provide them with more information outlining in more detail the data that are being collected as part of the project (see section above).

3.4 Stakeholder Engagement approach in GROW Places

We tested the implementation of the GROW places approach and its usability for science. This Mission is a "Soft launch of GROW places" with the aim of expanding their number in 2018 and 2019. Insights are just emerging after the mission concluded in Dec 2017.

Description:

The GROW places are focus areas where GROW will deploy a high quantity of Flower Power sensors to record soil moisture and associated data at a quite high density of observations.

The 5 main objectives of a GROW place are:

1. Validate scientific usefulness of the data through satellite validation activities and preliminary gridded products production
2. Validate the material (see Fig 2), protocols and instructions for citizens to deploy and maintain the sensing network from a scientific point of view
3. Test local aspects of the engagement protocol (participant pathway, community champions) for engaging participants within the project
4. Validating that the growers are able to take benefits of the sensors and additional activities
5. Test GROW’s back end system and its capacity to collect and provide the data to users

The 3 GROW Places in this Sensing Mission were:

- Alexandroupolis (Greece)
- Cloughjordan (Ireland)
- Miskolc (Hungary)

The training programme for participants taking part in this Mission included printed materials (Sensing Manual and Field Handbook), as well as 2 to 3 face to face workshops in the local areas. Participants used Typeform to submit their land and soil survey measurements electronically while the sensor data will automatically be transferred from the Flower Power app to the back end of the GROW platform.

This pilot Mission started on 16th October 2017 with a feedback strategy in place to ensure feedback is consistently collected from participants and from GROW local coordinators.

3.4.1 GROW Place Mission Workshops, Hungary

The team based in Hungary is providing personal assistance in the registration of sensors and metadata collection. In parallel the team is also carrying out the soil and land survey data in order to validate data collected by citizen scientists. Thus the training materials were presented personally at the growing sites, along with offering help placing and registering sensors. In the Miskolc region there were 3 sites selected for pilot sensing and recruitment. The strategy of the local team was to have measurements on spots where they have knowledge and environmental (soil, profile, land use, etc.) data of the site for validation purposes.

Workshop 1. Onboarding: 2017-10-19 Tard, Hungary

Fig. 5 Participants at onboarding workshop in Hungary

Summary: A workshop was held in Tard, Hungary to which 18 participants attended near the pilot sites where sensors are being installed, see Fig 5. The sensors were set around a test site in household gardens. Workshop 1 was concerned with ‘Onboarding’ an approach to bring participants into GROW and articulate the objectives through the following methods:

- *Introduction to GROW and objectives of the mission:* This was covered in the presentation and during the Q&A session.
- *Introduction to remote sensing and soil moisture:* This was covered in the presentation.
- *Participants handled the sensors for the first time. Then* sensors were distributed to participants afterwards, personally.
- *Check together the protocols for metadata from the manual:* This was explained by facilitators in the presentation when talking about remote sensing namely what remotely sensed data means, and what explanatory information is needed for interpretation.
- *Demo run of metadata measurements (land cover, soil texture, etc.):* The group was taken outdoors where the team installed a sensor and collected all metadata. An insight from in this session came during the process it was identified that the soil texture method needs refinement. The experiment works with certain soil textures but extreme clay texture gives no results. The revisions are being incorporated in the revised version of the training manuals. The soil texture measurements and metadata collection is guided by our team and goes in parallel with validation data collection.

Workshop 2: Sensor Registration, 2017-11-15 Baktakék, Hungary

Fig. 6 Participants in Hungary at the sensor registration workshop

The team is provided personal assistance at the registration and metadata collection. In parallel we repeated the collection of validation data.

The workshop was held in a small village, Baktakék, Hungary. 13 Participants, see Fig 6, were gathered from the local area and Facebook contact, the event was announced in Facebook events (https://www.facebook.com/events/306984276473230/) and in posters placed in bus stops, the village store and the health centre.

Facilitators provided:

- an i*ntroduction to GROW and objectives of the mission to newcomers*
- *an introduction to remote sensing and soil moisture*
- *Participants were* shown in the presentation the measurements from sensors already installed.

Results:
Within two weeks we organized 2 more of these events in different areas.

To increase interest we are organizing scientifically based garden research. For this we set up composting research and introduce the Flower Power sensor and lab data. In addition we provide a soil-scanner which provides images of what happens within a compost setup. This will be blogged through Hungarian GROW Facebook.

The workshop did not result in an increase in number of growers involved, but did raise interest from some professional growers who had interest in sensing, so as result the team managed to place 12 sensors on highly representative land use areas

Summary of Insights:

- The application (Flower Power) in Hungarian would be more suitable for Hungarian users. Translation would help increase the number of participants.
- Making the measurement data available for download to Flower Power users would increase their interest and could give more ideas for data interpretation and visualisation.
- The application (Flower Power) is not compatible with phones having prior version than Android 6.0, and on Windows Phone devices, which restricts the number of users.

Workshop 3: Celebration and presentation of sensing results (Tard, 2017-12-08)

Fig. 7 Participants at the final workshop in Hungary

This workshop was attended by 12 participants, see Fig. 7. The purpose of the workshop was to visualise and explain the data already measured. We used data from a local garden to demonstrate differences between covered and bare soil properties. Another comparison discussed was in relation to different manure and compost effects on the measured soil conductivity data.

Afterwards in informal conversation, facilitators requested feedback on how the data visualisation and explanation could help growers. Some of the audience volunteered to investigate the downloaded data, compare it with personal observations to help build data interpretation. One of the results of the workshop was to make the raw data available for download to participants: this process was a good way to generate good ideas and questions.

The third part of the workshop focused on getting feedback from participants on GROW activity. Facilitators went through a survey with the audience. The summary of the feedback will be generalised in one single report from the Miskolc sensing area.

3.4.2 GROW place Mission Workshops in Ireland

Workshop 1: Launch workshop for GROW Place Cloughjordan (CJN)

The Cloughjordan GROW place was launched during Convergence (Sustainable Living Festival). A special GROW Place session was designed to disseminate information about the Observatory and to seek interested participants for the sensing mission.

Date held: 20th September 2017
35 attendees

Location: WeCreate Workspace, Cloughjordan, Ireland

Summary

The session comprised of the following.

1. Presentation on the GROW Citizen Observatory
2. Overview of the pilot sensing mission and GROW Places
3. Specifics on the science of using sensors for soil moisture
4. Overview of the Flower Power Sensor and discussion about the use of the Flower Power app
5. Overview of DIY sensor options and some examples
6. Hands on experience with the sensor
7. Sensors handed out to local growers
8. Discussion about the role and importance of Citizen Observatories

The event gave us the opportunity to make contact with interested and engaged participants who will support GROW over the course of the project. Five potential future GROW community champions left with sensors after this meeting.

Agreement was also reached with three commercial farms and one agricultural college that they would support the mission and engage students and interns associated with their farms. This suited the Cloughjordan GROW place as it offered a solution to the low population density of the area and thus the difficulty of engaging many individual while also being a suitable distribution method to meet the scientific requirements of the mission.

Training materials and sensors were delivered to the participants in October, following this launch event.

Workshop 2: Students and Lecturers from Gurteen Agricultural College
Cultivate (CUL) held a workshop with students and lecturers from Gurteen Agricultural College. The workshop took place in the field at the designated sensor location.

Date Held: 8th November 2017
18 attendees

Location: Gurteen agricultural College, Tipperary, Ireland
The workshop comprised of the following:
1. Overview of the GROW Observatory project
2. Relevance of the sensing mission to those involved in agriculture
3. Discussion about the impact of climate on agriculture
4. Practical session on the use of the Flower Power app.
5. Placement and syncing of sensors with the app

Interest was expressed in the GROW project from growers specialising in non-vegetable growing. In Ireland some cereal crops are not successful due to increased atmospheric humidity and soil moisture levels, a MET Office monitoring station is situated at the college and participants were aware of the need to be able to predict moisture levels to help in ensuring crop yields.

Workshop 3: Review of Sensing Mission Pilot
When working with professional/ semiprofessional growers it is difficult to find a time and place for a workshop with representative attendance. It was decided that a more personalised review should take place via face to face meetings and phone calls.

Date Held: 4th-8th December 2017
Met with 29 people to review the mission activities and future potential for a longer term GROW place in Cloughjordan.

Location: WeCreate Workspace, Cloughjordan and Sensor site locations

The Review consisted of:

1. Feedback on the Sensing Pilot mission
2. Relevance of the Observatory to participants work
3. Potential for longer term Observatory at the selected sites.

The feedback from this session will be included in the review of the initial GROW places and will inform the next phase of development of the Sensing Mission.

Summary of Insights:
When locating a cluster of sensors at scale it is important to reflect on the most suitable land use for locating the sensors. In the Cloughjordan GROW place two sites were used for pasture which, while set aside currently, are probably not suitable for a longer term mission as the fields could be used by tractors and cattle. A third site was for vegetable production, the difficulty here is finding a location that will not be disturbed through soil preparation. To maintain such a site would require more effort to protect the sensor. The fourth location was a number of fields comprising of an apple orchard and areas set aside for encouraging biodiversity. This location is the most suitable for longer term use as the land has very little traffic.

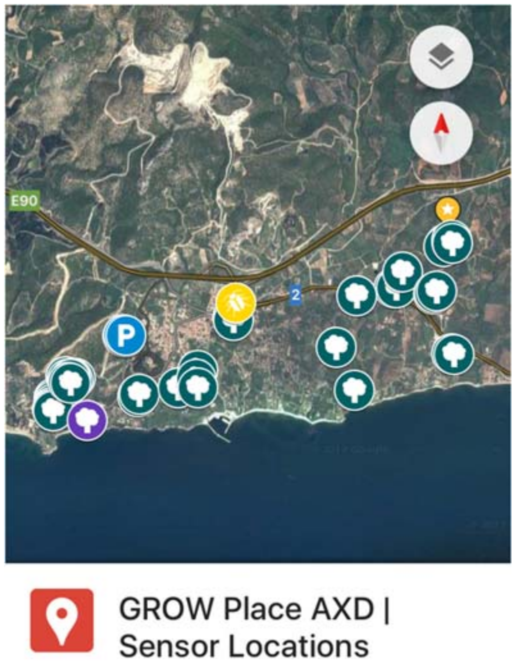
3.4.3 GROW Place Mission Workshops in Greece

Workshop 1: Introduction to GROW Place AXD

The workshop took place on 25th October 2017 in the premises of the Municipal Public Library of Alexandroupolis. Thirteen participants attended the workshop. The session started with the participants sitting on a circle, introducing themselves, their motivations to join GROW and their expectations from the Sensing Mission. This has allowed for the creation an open discussion framework, which allowed participants to feel welcome.

Following this introduction, the GROW Community Manager described the scope, vision and mission of the GROW Observatory as well as the specific targets for the mission in the GROW Place. Besides explaining the value of Citizen Science, the presentation consisted of an outline of the development and design of the project, introducing the consortium partners and describing the various activities launched so far (i.e. MOOC, Monthly Themes, Webinars). This was complemented with screening of two videos: “GROW Observatory” (https://vimeo.com/210444233) and “GROW at the Open Science Fair” (https://vimeo.com/238898068).

An online Google Map was projected on a screen in order to visualise the positions of suitable sites for the installation of sensors within the priority area. This provided an initial impression of the number of sensors to be received by each participant.



The Community Manager presented the Flower Power sensor and thoroughly described each step of the Sensing Manual and Field Handbook, inviting questions and queries regarding the identification of suitable sites, taking field notes and uploading the data online. A Greek translation of the Sensing Manual was distributed to each participant, with the request to read the instructions and take notes of any questions to be addressed in the next meeting.

Fig. 8 Greek version of the Sensing Field Notebook for Participants

A field demonstration was arranged for 29th October 2017 inside the organic olive grove of Calypso (www.calypsotree.com), during which participants had an opportunity to have a hands-on experience with the full procedure on locating the appropriate sites for installing the sensor, connecting the sensor to the Flower Power App, taking field notes and soil samples for the soil and land surveys.

Workshop 2: Deployment of Soil Sensors

The workshop took place on 1st November 2017 in the premises of the Municipal Public Library of Alexandroupolis. Eleven participants attended the workshop. The purpose of the workshop was to get feedback on the level of understanding derived from the printed Sensing Manual, see Fig. 8, distributed in the previous meeting, as well as the hands-on demonstration that took place a few days ago in the organic olive grove of Calypso (www.calypsotree.com).

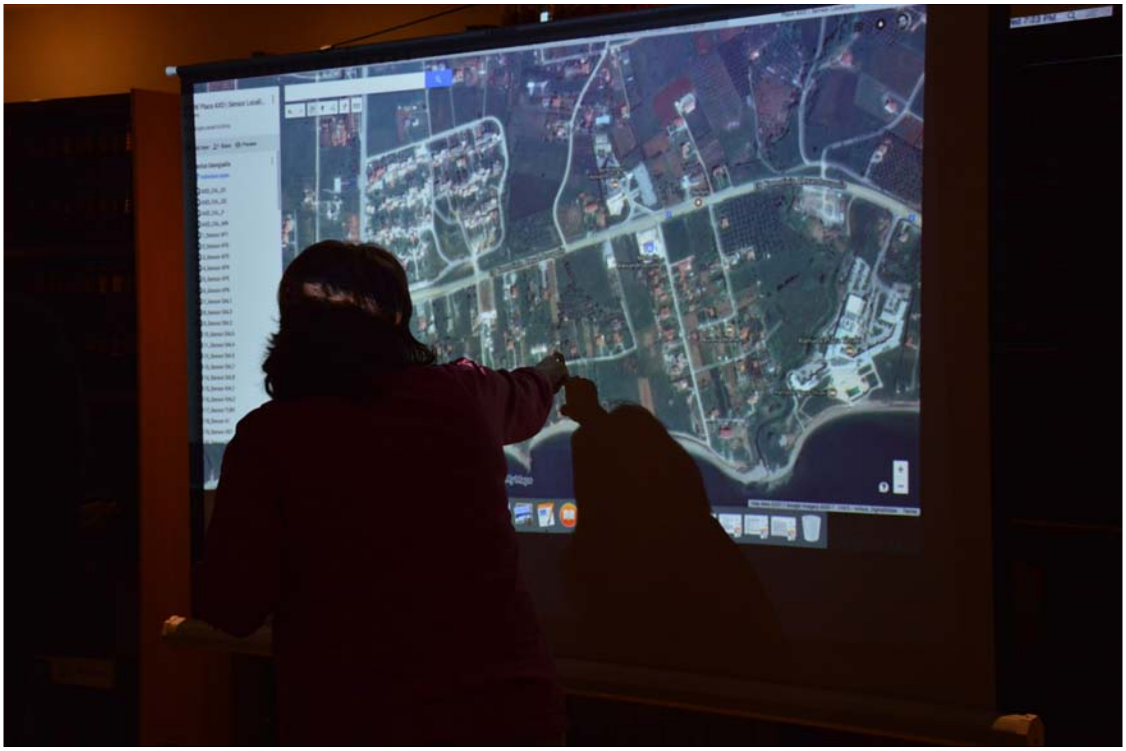


Fig. 9 Presentation of a map showing appropriate locations for sensor placement

The session started with the participants sitting on a circle, introducing themselves and sharing impressions from their introduction the project. Most of the discussion focused on the different aspects of the Sensing Mission, as was described in the Sensing Manual that the participants received in the first workshop.

The format of the discussion allowed for an open exchange of questions and answers from the community itself, covering all different queries about the sensor deployment in the appropriate locations, taking field notes and soil samples for the soil and land surveys. One of the participants with a research background on Earth observation took the floor to describe the wider benefits of GROW and how a community of citizen scientists can improve the capacity of science to deliver accurate forecasts for climate adaptation. This has demonstrated a multiplier effect, when trained members of the community took the initiative to further explain the project, even assisting in the recruitment of new participants.

The participants received the sensors that have been assigned to them according to the availability of appropriate locations in their growing spaces, already defined in the first workshop and during the previous days. The GROW Community Manager distributed a “Usage Agreement” duly describing the terms and conditions of receiving sensors from the project, which needed to be signed by the participants before receiving one or more free Flower Power sensors. An introduction to sensing and the sensors with a placement of sensors and was described in a presentation, see Fig. 9 and Fig. 10.

Fig.10 participants introduction to the Flower Power Sensors

Workshop 3: Celebration and Reflection

The workshop took place on 29th November 2017 in the premises of the Municipal Public Library of Alexandroupolis. Ten participants attended the workshop. The purpose of the workshop was to collect feedback from participants about the Sensing Mission. Participants sat on a circle, introducing themselves and their experience of installing the Flower Power sensors and collecting data for the first time.

Participants agreed that the best part of the Sensing Mission was the sense of acquiring new knowledge and participation in an international, interdisciplinary project. In particular, they seemed to be impressed by the fact that although they have been working with the soil for such a long time, there is still a lot that they can discover through the different GROW experiments and activities. This positive sentiment was evident in an overall motivation to improve the performance of the GROW Observatory, by mobilising more people to join the Sensing Mission.

The Community Manager emphasized the need to keep the sensors in the soil and continue collecting data throughout the winter. This will now only allow for continuous sensing, but will also help test the capacity of the Flower Power sensor to over-winter. Participants were reminded of good practices in maintaining their sensor(s) operative, which included checking the batteries regularly and changing them as appropriate.

The last part of the meeting was dedicated to announcements regarding the activities of GROW over the next year. Besides recruiting communities in more GROW Places across Europe, the Living Soil Mission was announced, which will be open to everyone, everywhere. This has sparked a new discussion about the potential of GROWers from Greece being able to interact and share knowledge on various regenerative soil management practices. The upcoming online courses were also announced, describing how they are expected to contribute in raising awareness and increasing understanding on diverse issues, such as citizen science, remote sensing and soil sensors. The discussion has emphasized on the potential ways in which GROW can contribute in improving growing for food and climate adaptation.

The team has agreed to continue the discussion online, in a dedicated closed Facebook group that was specifically developed for the GROW Place. It was also agreed that the best way to engage the community is to keep this dialogue alive, and by visiting regularly in similar meet-ups during the Mission.

3.5 Insights and Feedback from Missions and Plans for Implementing Participants' Feedback

Sensing mission feedback draws on an exploratory survey aimed at gathering opinions about the first run of GROW Sensing Mission undertaken in 3 GROW places and an interview undertaken with a GROW community champion. The findings will inform the bigger Sensing Mission which will be undertaken in 9 GROW places in 2018.

The survey collects information from the participants about their experiences in using Flower Power Sensors to measure soil moisture, written materials, protocols and instructions and the support that they received during the process. This evaluative survey mainly consisted of the matrix and multiple-choice questions with a few short text questions to expand on the observations. The survey was conducted during the final workshop of the sensing mission in December 2017. Few participants, in total 10% response rate, have completed it. Due to the nature of questions (ordinal and nominal), and the very limited number of responses, the resulting data were analysed through using a simple descriptive statistics approach.

Findings

Limited but consistent survey responses indicate that overall the sensing manual and field handbook provide good quality information and is relatively easy to understand and concise. However, at certain points further clarifications required as some difficulties were experienced including placing sensors, identifying land cover and stone content and carrying out soil tests. Participants also experienced some technical problems while connecting their sensors and uploading their data. For some participant, the difficulty was a result of the low Internet connectivity in the growing fields.

Interview data suggest that participants with multiple sensors found it more demanding to fill in the form for land and soil survey, as it would necessitate completing the form for each individual sensor. This would also involve additional efforts to undertake the soil test and to calibrate the app. Due to the nature of running the pilot mission, the team made some minor changes in carrying out soil test. This would require asking participants to do the test again. Similarly, the website to view the uploaded data was not available during the pilot, which appeared to be an obstacle to engagement.

Certain growers found data and science exciting and were enthusiastic about gathering data for a purpose. However, it cannot be assumed that all growers are necessarily interested. Growers found it difficult to understand the importance of the sensing mission to their growing practices unless it is framed under climate change.

It is not possible to arrive at any general conclusion based on the small number of responses. However, positive responses indicate that most of the participants seem to be pleased with their experience and the support they received during the sensing mission. It appears that there were a right number of workshops accompanied with good facilitation and content to support participants throughout the mission. Some of them were willing to participate in the upcoming sensing mission.

Services such as an online discussion forum on the GROW website where growers can ask questions to other growers around Europe and share experiences were found useful by the respondents as well as data from collected through the sensor(s) visualised on maps and/or graphs, combined with other data to give meaningful insights. It has been also suggested that online services could also allow growers to upload the data they measure from the fields, including soil texture and nutrients as a complement to the data sensed and measured in GROW, to create an extended database for their fields.

Suggestions:
Placing sensors: Further details about correct placement of the sensors can be added in the manual.

Land survey: The manual can remind to take pictures around sensors.
To match the canopy or stone content with the illustrations provided, a certain level of abstraction is required. An example with a photograph can be included in the manual.
Connecting the sensors: Sensing manual could advise updating the sensor's firmware at places where a good Wi-Fi connection is available. (It is more like to have low reception in the fields).

Paper recording: Current manual can include an extra field to record how many centimetres is the dry soil (before adding water)

Timing of the mission: If possible, the upcoming mission can consider weather forecast and busy schedules of growers. For example, November is a challenging month (rain and overlaps with olive harvest) in Greece.

Land use: The upcoming mission which would last 2 years requires the sensors undisturbed during that period. It could be emphasised certain land use such as perennial crops or woodlands where it might be easier to keep sensors longer and narrow down to places where there would be the minimum disturbance for the sensor due tractor use or walkers passing by.

Summary
The workshops carried out in Hungary, Greece and Ireland have provided us with very useful insights to incorporate into the timeline and structure of future Missions in 2018 and how they fit with the timeline for the GROW app, the revised version of the training materials and the planned MOOCs. Training materials for the Changing Climate Mission (the roll out of the pilot Sensing Mission that took place in 2017) include:

a) Written training materials translated into the languages of the selected GROW Places (i.e. the Sensing Manual and field handbook).
b) The GROW app, also translated, that will serve as the main mechanism for GP participants to upload the land and soil survey data of the specific spot where they place the sensor/s.
c) An alternative data submission mechanism to complement the above has been suggested (the GROW website) in case the app fails or is delayed or participants are unwilling to use it.
d) MOOCs will be available as additional training for GP participants who will be strongly encouraged to take part in the courses, especially in the Soil to Sky MOOC and Sensing MOOC. They are also welcome to join the Living Soils Mission that will have 2 associated MOOCs (in April and Oct/Nov respectively).

The written materials were updated based on the insights from the pilot Sensing Mission to incorporate:

1) feedback from participants
2) changes for the soil texture protocol and
3) a guide to the app

The materials will be made available on the GROW website in different languages.

The workshops in GROW Places will be scheduled to take place at the same time as the start dates/weeks of the MOOCs: Citizen Science: from soil to sky (19th Feb 2018) https://www.futurelearn.com/courses/grow-from-soil-to-sky , Citizen science: sensing the world (19th March 2018) and Citizen science: living soils, growing food (9th April 2018) in order to encourage engagement and where possible, collective participation.

4. GROW Service Development

It is GROW's aim to offer data visualisation in the Collaboration Hub that helps diverse audiences to understand the data that they are others generate and draw meaningful and useful conclusions from it. This work supports the investigation of promising service propositions, and is developing operational information services addressing specific user needs and emergent issues for GROWers.

4.1 Data Visualisation Workshops Strategy

Participants with sensors in Ireland, Greece and Hungary are being surveyed to get a broad sense of which is most useful for them - online discussion with other growers or data visualisation. The hub will offer both but this question will help us know where to focus more of our efforts when developing new features for the hub.

The survey also asked broadly about what services i.e. data visualisations may be most useful. We plan to build on our understanding with a face-to-face workshop in Ireland. After the workshop the first design sprint for data visualisations will take place, with growers re-engaged to feedback on outcomes. After feedback, we will draw on the scientific expertise of partners within the consortium select, prototype and deliver a visualisation using sensor data as well as datasets from external sources.

For the launch of the sensing mission in March 2018 we will focus on offering data visualisations from sensor data alone and later in 2018 we will move on to bringing in external data sources as well.

4.1.1 Workshop Structure and Tools

A workshop in Cloughjordan in Ireland in January 2018 follows the following stages:

1. Document growers' current practises and processes related to their growing.
2. Solicit a broad overview of the growers' needs and problems.
3. Gain insight into what growers currently understand about their sensor data and identify gaps in their knowledge.
4. Gain insight into how the growers would use sensor data to improve their growing practices or yields and identify information they would need that is currently not provided.

This information will be gathered using paper-based tools and group discussions.
After the workshop we hope to be able to answer these questions:

- What are the information needs for growers and other users?
- What valuable information services and visualisations can GROW provide?
- How can data be made meaningful and accessible for citizens and science?
- How can people be supported to query and make sense of the data themselves?

4.2 Data for Expert Stakeholders

One of the fundamental objectives for GROW is to offer insights of value to science derived from GROW data. The detail of this activity is described in detailed D3.1 with the workshop approach and insights summarised here.

4.2.1 Designing a useful and meaningful experience for expert users

Originally, a workshop format was proposed to explore the following questions with expert users:

- What are the information needs of expert users?

- What valuable information services and visualisations can GROW provide?
- How can soil moisture data be made meaningful and accessible for science?

GROW proposed a workshop aimed to get scientists from a wide range of disciplines together to explore the use of GROW data within their work. We discovered through early engagement with stakeholders, through partner MET Office, that scientists' requirements were quite diverse. From this we foresaw that a single workshop format over a half or full day workshop was unlikely to offer the focus or wide engagement required. An alternative recommendation was talking to scientists in a one-on-one interview context, which we anticipated would give us a deeper understanding of their current use of soil moisture data and their future requirements. This had the additional benefit of lowering time input from individuals at this early stage, making their engagement more likely both now and in follow on activities.

A series of interviews with scientists from across the MET Office, all of whom have an interest in soil moisture, took place in summer 2017.

The purpose of the interviews was to find out the current activities in the MET Office that involve soil moisture data, what appetite and market for GROW's soil moisture data there might be, and what formats would be most useful for the data to be provided in.

4.3 Initial Concept(s) for Information Service(s)

The following data services for participants with sensors have so far been discussed within the consortium:

• A map of soil moisture recorded by all GROW sensors in a GROW place.
• A map of soil texture, recorded by other participants in a GROW place.
• Sensor data combined with rainfall data for the corresponding date range.
• Sensor data compared with historic data from previous years.
• Sensor data compared with the profile of a drought year, for early prediction of a drought year

The user research explained above will help to identify which services (from the above list or new ideas) will be most useful to growers. The aim is that any data services we provide do not just present data to growers but also explain why the data is useful and how they can use it.

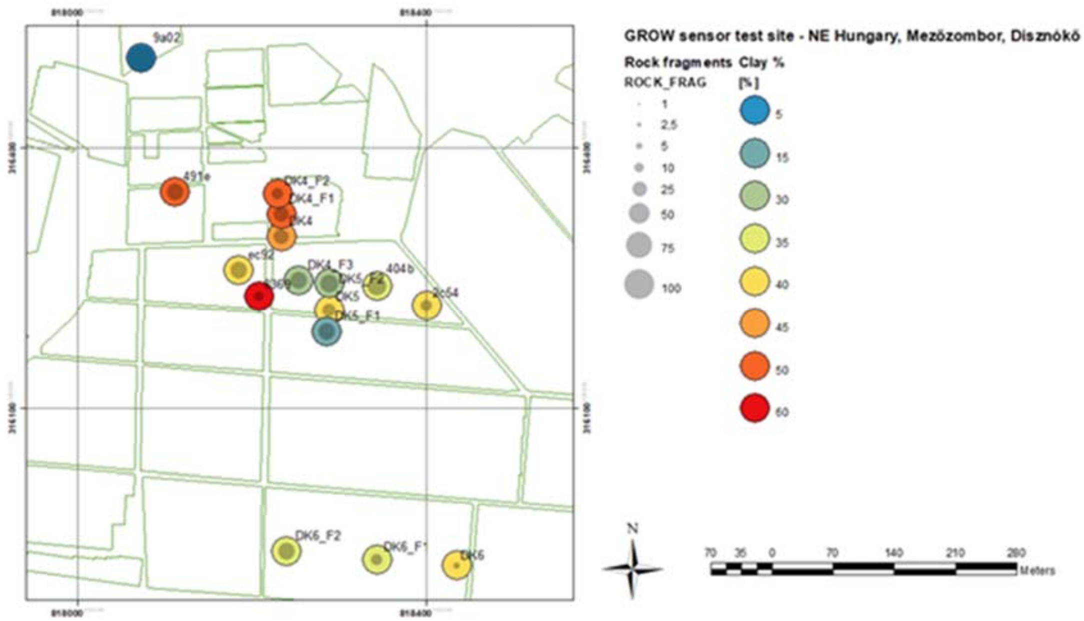


Fig. 11 An example of point measurements for the sensor locations.

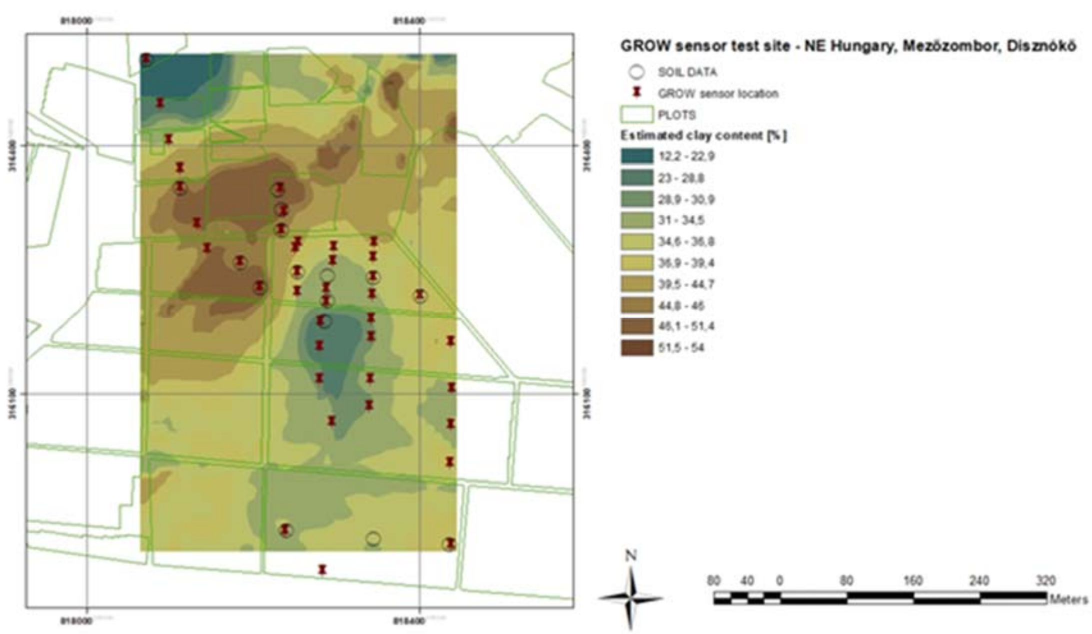


Fig. 12 Interpolated maps of estimated clay percentage derived from point observations.

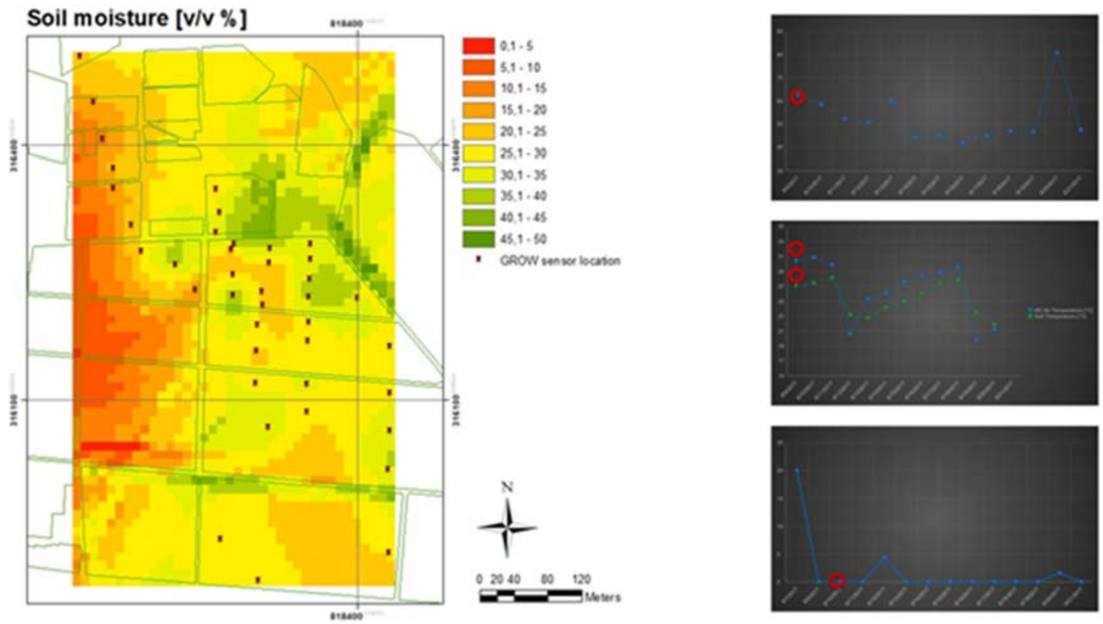


Fig. 13: Interpolated maps of soil moisture content derived from the point observations.

The participants in the pilot Sensing Mission in Greece, Ireland and Hungary found the following data visualisation suggestions useful (Fig. 14).

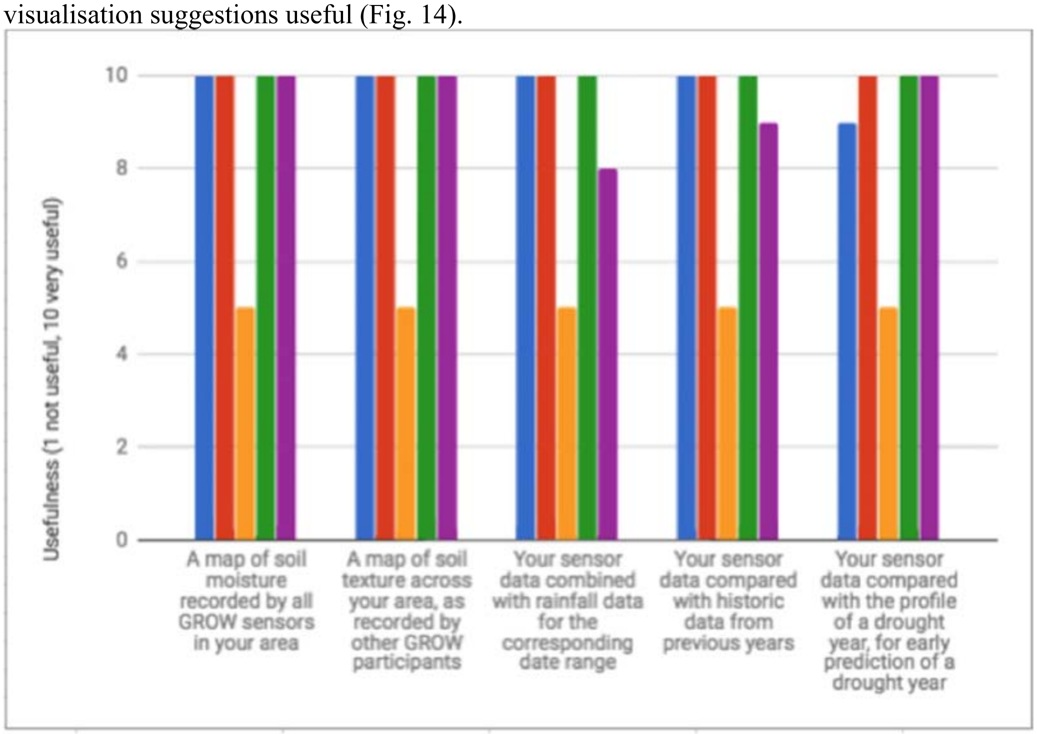


Fig. 14: Data visualisations

The GROW projects aims to demonstrate the potential use of soil sensor measurements and the added value that can be achieved by post processing activities of the data. The project will develop raster maps – gridded products – for the GROW places for all quantitative variables, static and dynamic soil parameters that will be collected by the participants or the measured by the sensors.

The GROW places will have a great variability of covariant accessibility and general environmental setting – different soils with different significance of the soil forming factors. The differences in the available data set will define the toolset to be used for deriving the gridded layers. The more and better quality background data are generated, the better, more sophisticated tools will become available for the modeling. Therefore the GROW places will represent a wide variety of potential data and environmental settings, data quality and tools to be used.

These different sites will be used to demonstrate the importance of the accuracy assurance, data reliability and accessibility for producing marketable added value products from the sensor location data. We aim to characterise/validate the results in the function of the different approaches given by the modeling infrastructure – data, accuracy, resolution. A citizen observatory is not a conventional scientifically designed setting, and may have logical, spatial or thematic data gaps, which may limit the value of the final products. This demonstration exercise will provide an opportunity to compare the performance of different given – non-conventionally scientifically designed – settings of “randomly” structured citizen engagement driven spatial settings - monitoring system.

Insight generation is a fundamental part of the GROW Observatory framework. Both the Changing Climate Mission through GROW Places, and the Living Soils Mission will continue to iterate methods and multimedia tools, and develop training and opportunities to foster insights across our three key audiences: growers, scientists and policy makers.

Appendix 1

Land Cover Summary

Size of growing space

Total number of entries received – 49 and is summarised in table 1, and figure 1.

Parcel areas	Numbers	as %
0–0.05 ha. (0–500 sqm.)	37	75.5%
0.05 – 0.1 ha. (501 – 1000 sqm.)	3	6%
0.1 – 0.5 ha. (1001 – 5000 sqm.)	5	10%
0.5 – 1 ha. (5001 – 10000 sqm.)	0	
1–5 ha.	4	8%
10 ha.	0	0%
no data		0%

Table 1

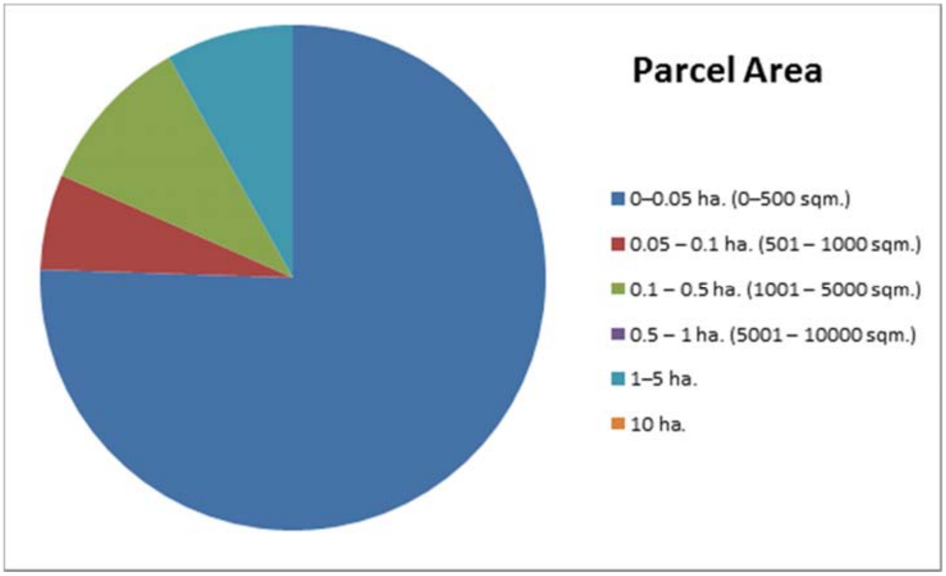


Figure1

Ground cover on that space.

Participants were then asked what structures, plants, and other ground cover occupied their growing space. This was covered in 6 sections; structures, trees, shrubs, common herbs, vegetables and crop, and other surfaces. Table 2. expressed as number of participants and percentage of participants for these categories.

Structures		
No artificial structures	21	43%
Other artificial structures, e.g. small sheds, raised garden beds with non-native soil	23	47%
Greenhouse	15	31%
Trees		
No trees	13	27%
Common trees	23	47%

Fruit trees	28	57%
Both	15	31%
Shrubs		
No Shrubs	7	14%
Common Shrubs	26	53%
Small (berry) fruit	33	67%
Common Herbs		
No common herbs	14	
Grass	29	
Other wild-growing herbs, e.g. fallow weeds, weeds in abandoned areas	31	
Vegetables & Crops		
No Vegetables & Crops	6	12%
Common crops	11	22%
Vegetable (including herbaceous fruit plants)	37	76%
Medical and aromatic herbs	26	53%
Ornamental and other cultivated herbs	18	37%

Other Surfaces		
Wetland	36	73%
Litter	7	14%
Mulched	28	57%
Bare Soil	24	49%
Other	11	22%
Natural Material	28	57%
Artificial Material	5	10%

Table 2

A Venn diagram (Figure 2), shows what participants are growing in their space; values are given in both participant number, and as a percentage. One participant has nothing growing and describes the space as "bare soil", and 30 of the 49 entries have trees, shrubs and crops growing in their space.

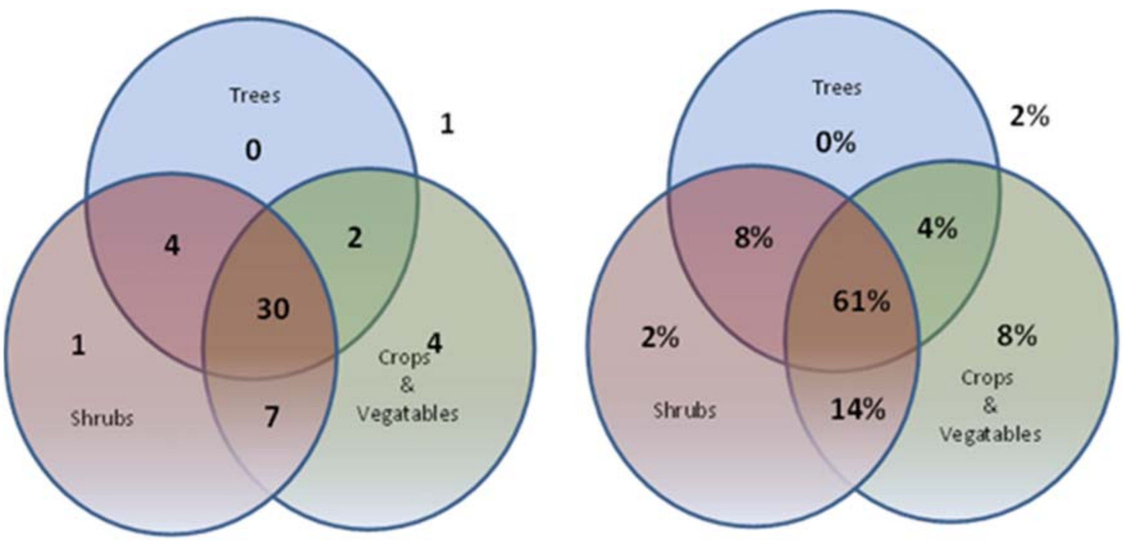


Figure 2

Canopy Cover

Canopy cover is recorded with a maximum number of 5 levels for participants to input, (LC1-LC5) LC 1 being the highest level (trees etc.) and the lowest canopy level being the final input (not necessarily LC5). Of the 74 entries, 3 participants indicated that they had no ground cover, and 17 input 5 levels of canopy cover. Table 3 summarises these entries, and is followed by 2 examples of participant inputs.

No cover	3
1 level	11
2 levels	13
3 levels	12
4 levels	18
5 levels	17

Table 3 – Canopy cover summary

Example 1.
LC1:26 - 50 %
LC2: 76 - 90 %
LC3: 0%
LC4: 0%
LC5: 0%

Example 2.
LC1: 76 - 90 %
LC2: 76 - 90 %
LC3: 26 - 50 %
LC4: 91 - 100 %
LC5: 26 - 50 %

Slope Angle and Aspect

Participants were asked to measure the slope of their growing space, and give the aspect estimated without compass, or using a compass. Participants were also asked to calculate the slope. These values have been grouped into 4 categories; NW-SW (225° - 315°), SE-SW (135° - 225°); NE-SE (45° - 135°) NW-NE (315° - 45°). A total of 86 spaces were described, with over 35% having no slope, and 40% having a northerly aspect. Bar chart (Figure 3) shows the distribution of aspects within 6 slope categories, expressed and percentage of participants.

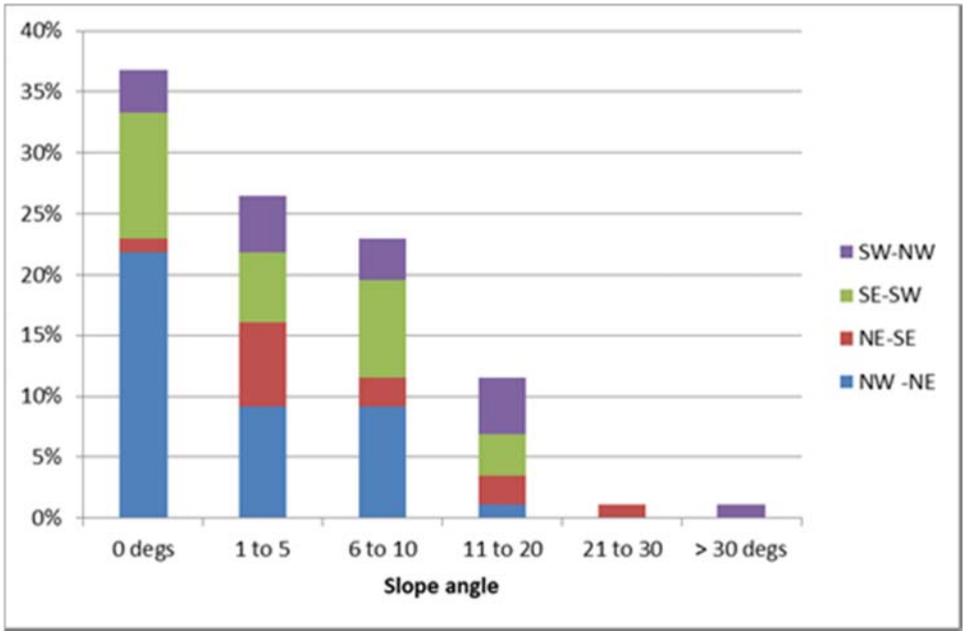


Figure 3

Slope Position and type

Participants were asked to describe their landscape as hilly or flat. Of the 45 entries 25 describer their growing space as "flat", and 20 as "hilly".

Maintaining your GROWing space

Methods

Participants were asked the methods and techniques they used to arrange and maintain their growing space. The categories are split into 4 sections, techniques used (figure 4.), growing space strategies (figure 5.), methods of covering the soil (figure 6.), and water management (figure 7.). Values are expressed as percentage of responses from the 49 participants.

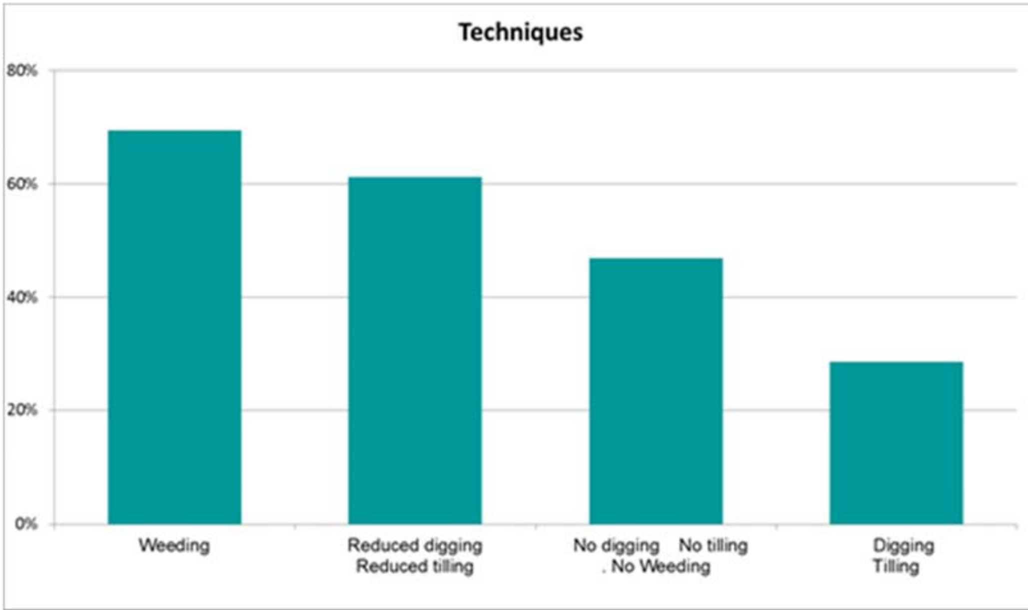


Figure 4

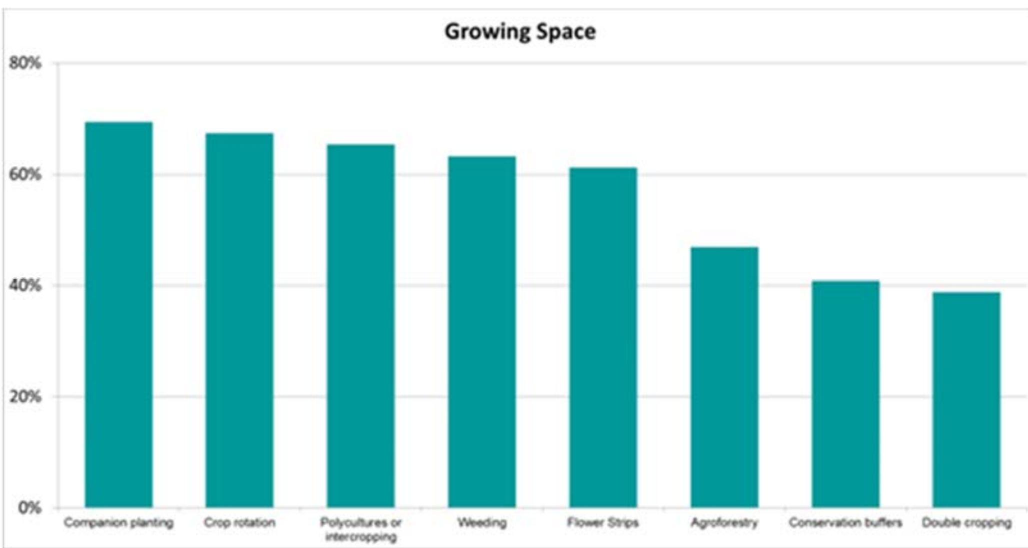


Figure 5

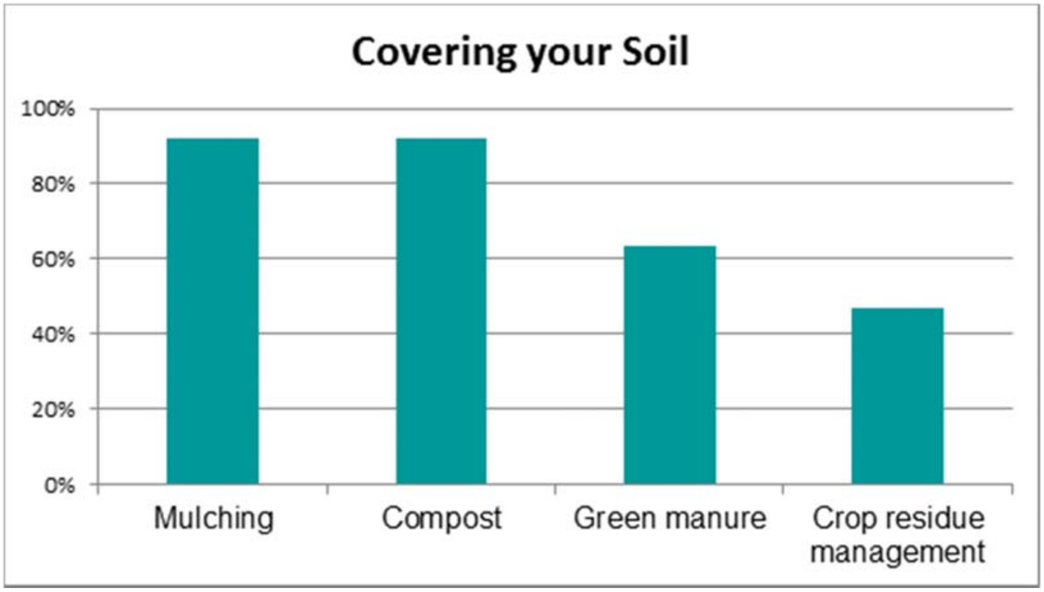


Figure 6

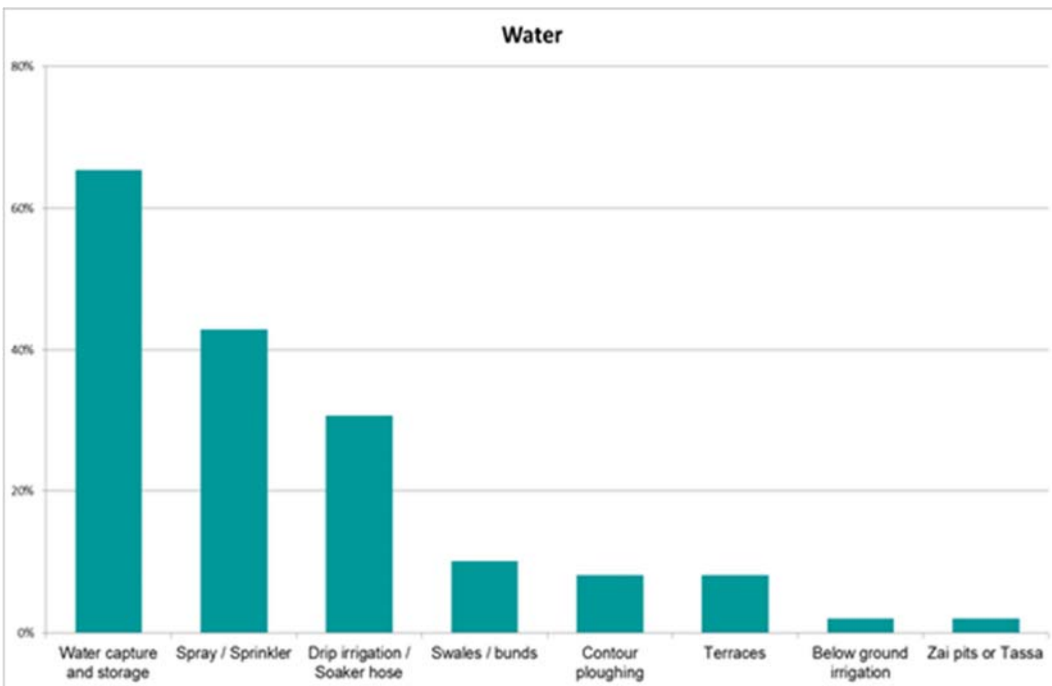


Figure 7

Soil

Participants were asked to take samples of their soil and perform a touch test; the results were recorded as a description of soil type. A sediment test was also done, and the percentages of sand silt and clay were recorded, and soil type re assessed, and volume of stones was also recorded. Of the 43 entries 23 recorded the same results for soil type across the 2 tests, and 2 only did the touch test. The volume of stones was recorded while conducting the sediment test. A summary of these results is shown in figures 8 and 9.

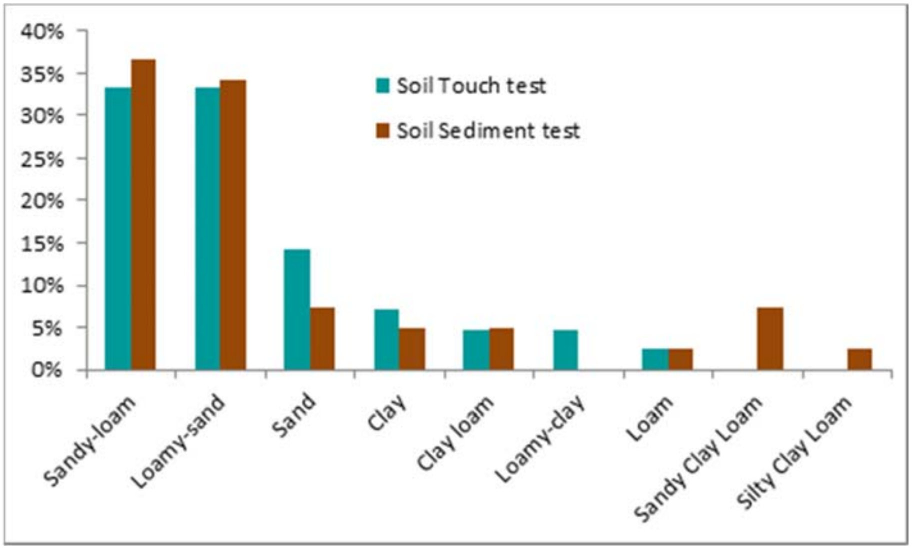


Figure 8

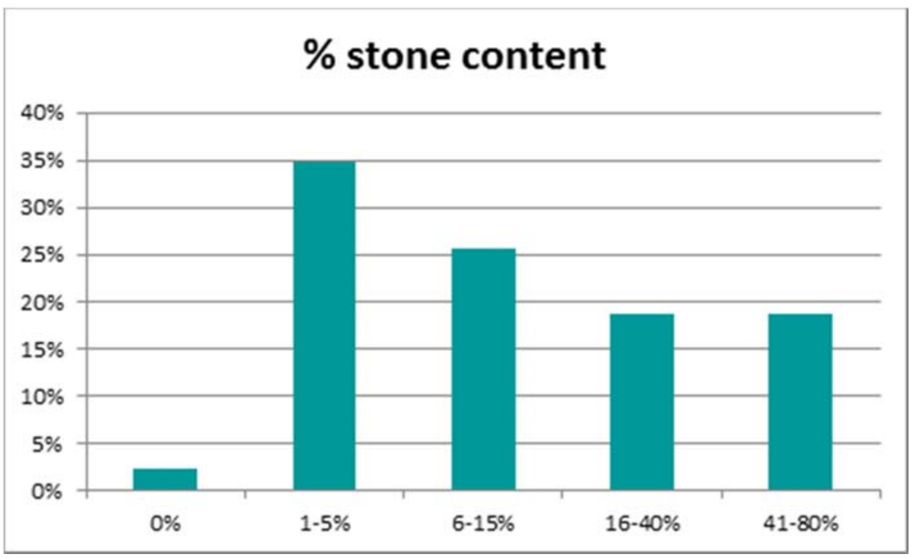


Figure 9

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