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Enhancing collective intelligence through citizen science

Hemment, Drew; Woods, Mel; Ajates Gonzalez, Raquel; Cobley, Andrew; Xaver, Angelika

Enhancing collective intelligence through citizen science: The case of the GROW citizens' observatory

DREW HEMMENT, UNIVERSITY OF EDINBURGH
MEL WOODS, RAQUEL AJATES GONZALEZ, ANDY COBLEY, UNIVERSITY OF DUNDEE
ANGELIKA XAVER, VIENNA UNIVERSITY OF TECHNOLOGY

1. INTRODUCTION

Citizens' observatories (CO) are a recent innovation connecting people, science and technologies to create collaborative data, knowledge and action around environmental challenges, both local and global (Hemment et al. 2016a). We argue COs present a novel framework for collective intelligence, with reference to the GROW Observatory (GROW), which builds community and insights through the collaborative sensing of soil, in particular soil moisture. The ambition in GROW is to enhance and harness collective intelligence through data and knowledge derived in collaboration between community food production networks, soil and satellite scientists, and policy makers, and thereby to play a vital role in addressing issues related to climate action, food security, and life on land.

2. ENHANCING COLLECTIVE INTELLIGENCE THROUGH THE GROW OBSERVATORY

The European Commission (EC) is supporting the development of an ecosystem of COs to inform and empower citizens to participate in environmental decision making, and to move towards more inclusive, sustainable and smart economic development (European Commission, 2014). The potential to scale citizen science (CS) to such a level of involvement, due in part to increasing access to portable devices with sensors and connectivity, has been identified as a robust methodology to involve the public in data collection and evidence-based policy making (Craglia and Granell Canut, 2014). The value of collective intelligence has been recognised in CS, exemplified in different ways by OpenStreetMap (collective mapping), Wikimapia (description of places), eBird (recording and describing birds), iNaturalist and iSpot (wildlife), and iRecord (biodiversity). COs bring a scope and scale to enhance collective intelligence through the technical, human and contextual dimensions of CS at once. However, challenges remain, such as sustaining participation over time, trust and uptake in data, and new service innovation for such diverse stakeholders.

GROW is one of four projects funded by the EC in 2016 to demonstrate the concept of COs (Hemment et al. 2016b). It is the first attempt to deliver an operational CO at a continental scale and with a long term, sustained commitment. Soil is a threatened resource, and is being degraded at an alarming rate (FAO and ITPS, 2015). Soil moisture plays an important role in regulating climate, and in extreme climate events such as floods, droughts, heat waves, desertification and wildfires. Additionally there is an urgent need to support food production techniques that preserve or regenerate soils. In order to support decision-making to deal with the aforementioned issues, we propose to enhance the veracity of climate forecast information, and amplify the knowledge on regenerative food growing practices. To this end, GROW is generating an unprecedented crowdsourced soil moisture dataset to ground-truth Sentinel-1 satellites of the European Earth observation program Copernicus, and create information and visualisations that can improve the way people grow food and care for soils.

GROW is a coordinated network and action made up of scientists, NGO's, communities and individuals with an interest in land and environment, collectively they deploy sensors, use data, and various online and mobile interfaces, and global monitoring systems. This creates a novel

socio-technical system (Geels, 2010) that brings together these different actors to create innovative datasets and learning. On the one hand, GROW employs the power of mass education, online networking, open data in place based communities to create knowledge on a peer-to-peer level. On the other hand, it bridges between domains and scales, connecting hyper-local and global, and citizens, scientists and policymakers. GROW empowers participants to measure the same parameter(s) while addressing local context and issues, and the power of open and decentralised knowledge creation is leveraged to address intractable environmental, social, technical and organisational challenges.

Technically, GROW builds on existing state-of-the-art, both in platforms and components. The system has been designed to handle the speed, volume and variety of data from low-cost sensors, and with the adoption of interoperable standards the potential to integrate data from additional devices. We build on the application of established and standard methodologies for collecting and analysing data on soil and land cover/land use (Zaman et al., 2015) through the use of a mobile app, DIY and off the shelf sensors, and data muling infrastructure. Trust in data quality is addressed by a strategy and checks at two stages: before and after data collection. Citizen focused assurances include training, robust design of protocols and submissions forms, sensor calibration, trials, and data quality checks.

GROW aims to close the loop to sustainability through service innovation with the continual update of citizen generated data, producing valued information and services. This is a holistic approach to collective intelligence, enacting an entire ecosystem. Thus, we propose COs represent a novel approach to collective intelligence through CS at scale (Buecheler et al., 2010 and 2011; Tinati et al., 2014). This is represented by a participatory design framework that sets out values and a seven-stage process to bring together social learning and engagement strategies such as digital storytelling methods with innovative data collecting tools and infrastructure.

3.   RESULTS

GROW results include adoption of new practices and emergent outcomes within *GROW Places* (GPs), as well as applications of data by professional scientists, data artists and community participants.

3.1   Extending and enhancing the collective intelligence of GEOSS

GROW adds a novel *in-situ* component to the Global Earth Observation System of Systems (GEOSS). Currently, there are 3,300 GROW sensors operating and returning data across nine sites (GPs) in the EU, increasing up to 12,000 over a nine month period. Analysis is underway to use these data to validate the new generation of remote sensing satellites, Copernicus' Sentinel-1. The availability of observations on the ground is vital, not only for validating Sentinel-1, but also for further developing the emerging high-resolution products. GROW furthermore brings designers, artists, grassroots communities, policymakers and small and medium-sized enterprises into the GEOSS community.

3.2   Dynamic visualisation of data to generate insights and wisdom

Citizen-generated sensor data are being used to create dynamic maps and visualisations for growers, scientists and policy makers (Jimenez et al., 2018). Continuous estimations of soil moisture over the region in which the sensors are placed are generated by interpolating satellite and sensor data. The information is visualised through data exploration and design (Fig. 1). These maps can help food growers benefit from the crowdsourced data, aninform policymakers on decisions about environmental policies, such as where to invest public funds to reverse desertification or prevent floods.

3.3   Stimulating innovative ideas through art

GROW has worked with artists Kasia Molga and Scanner to develop an online networked digital artwork, *By the Code of Soil* (Fig. 2). Custom code and algorithms translate dynamic soil moisture,

temperature and light data from the nearest cluster of GROW sensors into graphical shapes and electronic sounds, creating a 'data portrait' of soil properties in each GP. This networked artwork is triggered by the transition of Sentinel-1A overhead – once every 6 days – encouraging reflection on the instrumentation of Earth observation.
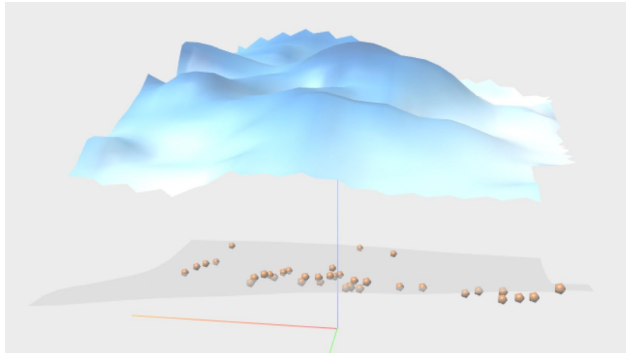

Fig. 1. Concept exploration for visualisation of GROW dynamic soil moisture map © Moritz Stefaner 2018
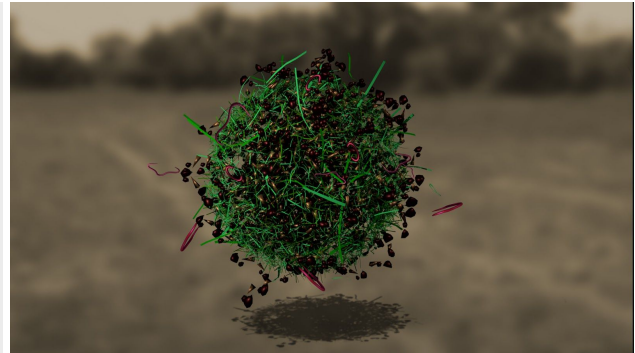
Fig. 2. *By the Code of Soil*, artistic representation of GROW soil data © Kasia Molga & Scanner 2018

3.4   Social innovation through collective intelligence

GROW has introduced a social dimension to CS activities, namely developing a hybrid of face-to-face and online communities of practice (CoP) focused on social innovation outcomes such as ensuring that citizen generated data are useful and usable by communities. Place-based engagement in GPs is spearheaded by a network of *Community Champions* (CCs). Complementary, citizen engagement is underpinned by peer-to-peer online learning to foster the power of collective decision-making, resulting in changes to practices of soil and land management, as well as food production.

4.   LIMITATIONS AND NEXT STEPS

Insights to inform future iteration and development of GROW, and the emergence of a CO ecosystem, are being developed to cover both social and technical barriers to implementation. A case study approach is being applied to generate recommendations focused on the advantages and challenges of using a place-based CoP approach as an engagement and sensor deployment strategy. There are limitations in reporting such a user-centred approach when longitudinal analysis is needed both of continuous time-series data, and of the sustainability and resilience of participating communities. These limitations are being addressed through a planned release of toolkits (methods and tools) to support continued activity, and through a business plan for the continuation of the CO.

5.   CONCLUSION

GROW has formalised connections between CS and widely available technology to create impact and more effective problem solving, bringing multi-users from different networks and different scales together. GROW's contribution is an ecosystem approach addressing many dimensions at once and at scale. This enables GROW to overcome gaps in each of the levels. For example, the pressing need for satellites to be ground-truthed, is addressed through a human-scale set of technologies, such as smartphones and handheld sensors, and online interaction and data platforms are grounded in place-based communities, art, and education. The hybrid model not only triggers novel interactions, data generation and knowledge to address urgent challenges for science and society, but harness them into a coherent unit that gives rise to collective intelligence.

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