International Institute for Applied Systems Analysis
IIASA www.iiasa.ac.at

Address: IIASA, Schlossplatz 1, A-2361 Laxenburg, Austria
Email: repository@iiasa.ac.at **Telephone:** +43 (0)2236 807 342

YSSP Report

Young Scientists Summer Program

Responsible Scaling of Citizen Science projects for farmers: developing a SDGs-guided Toolkit

[Janet Molina Maturano janet.molinamaturano@ugent.be]

Approved by

Supervisors: Juan Carlos Laso Bayas, Steffen Fritz

Program: ESM

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Abstract

Although Citizen Science (CS) has great potential to contribute to achieve the Sustainable Development Goals (e.g. to define indicators, tracking and implement), determining scaling impacts remains a challenge. Moreover, comprehensive assessments that allow to systematically match outcomes with Sustainable Development Goals (SDGs) and design for scale are not yet available, especially for agricultural CS projects. This study focused on developing and testing a rapid scaling toolkit that could help researchers and CS teams to define scaling ambitions that are sustainable and responsible. The study starts from a logical framework and integrates a tool for sustainable systems change at scale, as well as a sustainability assessment module. The toolkit was tested with academic experts for content, usability and preferred formats using a hypothetical case. It was found that the toolkit can inform and support decision making at early stages of a project, in contrast with current assessments completed at the end. The preferred formats selected include a web-based tool as well as workshops, aiming to bring together a rich diversity of views and information. Further development of the tool includes displaying it as a stand-alone website, and the validation with real cases both agricultural and non-agricultural. This exploratory study also highlights the benefits of combining disciplines, i.e. literature from agricultural research for development (and impact at scale) and CS projects contributing to the SDGs.

Acknowledgments

The year 2020 will be definitely a year the world will remember, a painful one. However, the virtual YSSP at IIASA have added a bit of sugar in my life in the middle of this pandemic, both personally and professionally. I am and will extremely grateful for my supervisors' support and trust even before starting the program. If there is something the pandemic is teaching me is to be more kind to myself, I'm a human before a researcher I doubt myself and get overwhelmed, and that is ok to ask for help when needed. A special thanks to Juan Carlos for all the help, wisdom and constructive feedback provided during the difficult moments. Once again, you have been one the best mentors I've ever had. Deep thanks to Steffen Fritz for your trust, and for all the inspiring advices and ideas. Thanks as well for the gesture of supporting me in attending the SDGs conference, it has not only made me gain confidence about the importance of this work but it has inspired me personally in getting more involved in these topics - this is more than I could ever wish for! Thanks to all in the Earth Observation and Citizen Science team, specially to Dilek F., Linda S., Gerid H., and Ian M. for all your availability and the interesting exchanges. Being inspired each day by such passion-driven scientists was priceless. Thanks to all for the (virtual) conversations! Thanks to the YSSP team, colleagues, and YSSPers who were very supportive, kind, and open. Thanks to Brian F. for always being there for us and for the interesting topics he shared. Thanks to Monika B. for the talk, and to Katya Perez for getting in touch!

About the author

Janet Molina-Maturano, from México, is finishing her Ph.D. at the 'Economics & Management of Natural Resources' group of the Department of Agricultural Economics. She holds an international master's degree in Environmental Technology and Engineering (Gent University–Belgium, University of Chemical Technology-Czech Republic and IHE Institute for Water Education-The Netherlands). Before joining the Agricultural Economics department, she did her master thesis at the Centre of Microbial Ecology and Technology (CMET) about wastewater treatment in Gent University. During 3 years, she gained professional experience while working for a multinational company (Procter & Gamble). She is part of the 'Diversity Team' at the Faculty of Biosciences Engineering, and has co-organized the 'Women in Science Day'. She is a former volunteer at Water Youth Network – NGO and co-founder of 'Mexicans at Ghent University' Association, and 'Dare to Open Science' initiative.

Responsible Scaling of Citizen Science projects for farmers: developing a SDGs-guided Toolkit

Janet Molina-Maturano

1 Introduction

The United Nations 2030 Agenda with its 17 Sustainable Development Goals (SDGs), and 169 targets calls for sustainable transformation of societies across the world. Even with its limitations [1], it is one of the most ambitious global agreements in recent history and represent a framework towards which any activity can be evaluated. Having only 10 years to achieve the goals, there has been a growing interest on the potential contribution of Citizen Science (CS) and crowdsourcing applications to support the definition of indicators, monitoring and implementing the 17 SDGs [2,3]. Hence, for bringing innovation potential for science, society and policy [4]. Countless projects have piloted solutions that could make an important contribution to achieving the UN SDGs if only applied at scale. Scaling is the process of expanding beneficial technologies and practices over geographies, and across institutions and levels to impact large numbers of people [5,6]. Therefore, the potential of CS must yet be unravelled at scale to contribute meaningfully to the SDGs, and move from local to regional or even country levels.

However, one of the main challenges for Citizen Science (CS) is to determine the impact and formulate indicators that are meaningful for stakeholders [7] as it involves different actors (NGOs, citizens, academy, public authorities, museums) interacting in a complex way [8]. Measuring CS impact remains a challenge and have been performed only in a macro level [7]. Nevertheless, the scaling processes should consider the what, why and how of scaling in their specific contexts to avoid unintended consequences [9]. Scaling in agriculture normally refers to the adaptation, uptake & use of innovations across broader communities of actors and geographies [5] that joined with accountability and reflection of unintended effect, outline a responsible scaling.

Although CS applications in environmental topics have the greatest potential to contribute to SDGs [3], few examples in agriculture are called as such [10,11], and few applications target small-scale farmers and take into account unintended consequences resulted from the increase of Information and Communication Technologies (ICT) such as the digital divide. Not always named as crowdsourcing or Citizen Science, a variety of agricultural development projects integrate mobile phones technologies intended to scale and contribute to the achievement of the UN SDGs (i.e reduce hunger, poverty and promote sustainable agriculture). Among others disciplines addressing this, systems approaches a and the interdisciplinary study of systems offers a way forward to understand complexity of development challenges. A system is a set of connected interdependent elements as a web on interrelations [12], system approaches focuses on relationships versus components, but these approaches are still the exception rather than the rule in scaling agricultural innovation [13]. Hence, a systemic approach to responsible scaling is worth to explore further and find practical application taken from research for

development interventions in agriculture to the CS and crowdsourcing applications. Similarly, current Citizen Science (CS) or Citizen Observatories (CO) impact assessment efforts could benefit from systems change approaches to responsible scaling to unleash its contribution to SDGs; and move towards approaches to scaling responsible and iteratively [14]. It is therefore important to (1.) define the scaling ambition and (2.) assess the impact of scaling ambition and the associated risks beyond the geographic, social, and time boundaries set by the project. In this context, responsible scaling has gained attention, with tools developed such as 'The Scaling Scan' [15]. To date, a tool for Citizen Science projects has not been developed nor empirical research has examined ingredients for a responsible scaling of these projects, specifically during the pilot and demo phases.

The purpose of this research is to develop and test a rapid toolkit as a compass for researchers and CS teams to define scaling ambitions that are sustainable and responsible. Therefore, it will couple the UN SDGs, responsible scaling and CS and CO impact approaches found in literature, into a comprehensive toolkit. This study constitutes a novel contribution to further define potential outcome of success rooted on the SDGs in early stages of a CS project in contrast to just at the end, but also, to draft mitigation plans and recommendations for further developments based on responsible scaling. This study is structured as follows. The literature reviewed is summed up in section 2 and serves as the theoretical background of the present work towards developing the toolkit. The development of the toolkit is described in Section 4.1, and the preliminary feedback from the testing phase is discussed in section 4.2. Limitations are discussed in section 5. Finally, in Section 5, conclusions, recommendations, and the research outlook are presented.

2 Literature review

In the following section, the literature that delineates the development of the toolkit is summarized.

2.1 Measuring impact of Citizen Science and Citizen Observatories projects

Citizen Science struggle to measure the impact, devise indicators that are meaningful for stakeholders; and emphasize its value in the research and innovation process [7]. Therefore, efforts applying different approaches to impact assessment have been developed either as part of a Citizen Observatory (CO) or Citizen Science (CS) project to address challenges at measuring CS impacts (Table 1). An effort in the European context to this respect is the on-going MICS project (https://mics.tools) aiming to develop metrics and instruments to evaluate Citizen Science impacts and their cost-benefit. Another recent effort is the CS Track project that aim at broaden the knowledge of the potential benefit of Citizen Science activities on individual citizens, organisations, and society (https://cstrack.eu/).

Commonly, the existing CS projects applied an impact assessment based on pre-defined indicators at social and environmental impacts at different levels of society: academic, citizens and policy-makers. From the projects that applied impact assessments, only GroundTruth 2.0 explicitly expressed economic impact in its impact assessment to promote market uptake (Table 1). Half of CS projects seems to aim at scalability from local to regional or country level. However, no available scaling ambition or plan could be directly linked to the SDGs (Table 1).

Furthermore, CS projects focus mostly on environment management and citizens in typically urban areas rather than projects in rural areas around agricultural applications with farmers, as shown in Table 1 and pointed before in literature [10]. Only the GroundTruth 2.0 project includes demo cases in Zambia and Kenya, and the LandSense project aims at agricultural (land use, landcover) applications. Contrary to general approaches to assess impact at the end of the project, the GroundTruth 2.0 and Making Sense projects followed a participatory and iterative process for defining indicators at a community level. Therefore, the GroundTruth 2.0 methodology for Validation and Impact Assessment [8] results in a suitable option to explore in rural areas outside Europe when iterative approaches are preferred for defining indicators. The GroundTruth 2.0 project developed a logic of Citizen Observatories (CO) impact intervention based on EC (2015) and draw on generic approaches such as Impact Assessment, Evaluation, Theory of Change, Outcome Mapping and Environmental Impact Assessment (Fig 1). A similar matrix approach has been proposed to guide outcome evaluations for tracking informal learning in a systematic way [17,18]. Even though the scale of a Citizen Observatory (CO) compared with crowdsourcing applications in agriculture is different, the CO demo cases are comparable to geographical areas where applications are being tested and is worth to explore in the context of systemic approaches to assess impact.

Table 1- Impact methodologies of Citizen Science and Citizen Observatories projects, geography and references

Project	Scope	Country of operation	Impact Methodology	Include SDG measures or assessment?	Scaling ambition or strategy?	Name of the Report/Source	Reference	Website
CS track EU	Across topics	European partners	Disseminating good practices and formulating knowledge-based policy recommendations in order to maximise the potential benefit of Citizen Science activities on individual citizens, organisations, and society at large.	No	Yes, European area.	Deliverable 2020: web-based and other tools and frameworks for analysing CS activities	Outputs planned for 2021	https://cstrack.eu/
CurieuzeNeuzen	Air pollution	Flanders (Belgium)	Longitudinal, multiple-group quantitative field study across 3 societal groups: citizens, policy-makers and academics.	No	Yes, at regional level	Societal impact of the CS project "CurieuzeNeuzen Vlaanderen"	Van Brussel & Huyse (2018), Final Report "CurieuzeNeuzen Vlaanderen"	https://curieuzeneuzen.be/in-english/; http://www.curieuzeneuzen.eu/en/experiment-results/
eu.citizen.science	Various	Various	Evaluation and impact framework define the indicators, instruments and time plan for the internal evaluation of the project objectives and an assessment of the achieved impact during the project period. Output, intermediate outcome, long-term outcome.	Partially yes	No	Deliverable 7.1. Evaluation & Impact Framework Authors: Teresa Schaefer & Barbara Kieslinger	EU-Citizen.Science Consortium, 2019. EU-Citizen.Science: D1.1 Data Management Plan, MFN, Berlin.	https://eu-citizen.science/
GroundTruth 2.0 *	Water	Rural and urban areas (Zambia, Kenya, Sweden Spain, The Netherlands, Belgium)	Iterative logic of intervention (set up and validated 6 CO in real conditions). A combination of approaches including Theory of Change	No	Yes (market uptake strategy)	Methodology for Validation and Impact Assessment	Deliverable D1.10	https://gt20.eu/
GROW*	Climate, soil and food	Across 13 European countries	Environmental and social generic impacts	Partially yes at Goal level	No	Impacts	GROW Summary Report p. 79 Impacts	https://growobservatory.org/

LandSense*	Urban, agricultural, and forest monitoring issues	Across various pilot sites within the EU	Linked with WeObserve (community level indicators). Based on key performance indicators for dissemination and communication tools.	No	Yes, partially for using regional data	Impacts and Monitoring and Evaluation	Deliverable 6.2 Dissemination Tools and Communication Strategies I	https://landsense.eu/; https://www.weobserve.eu
Making Sense	Air/Noise pollution	Cities (Barcelona, Amsterdam, Kosovo)	Participatory sensing. Defined community level indicators (accountability, community assessment, short-, long-term evaluation, policy change, capability). Tracking change (indicators, strategy, and data acquisition).	No	No	Assessment of impact and policy outcomes using community level indicators	Deliverable D5.4 and D5.5	http://making-sense.eu
Measuring Impact of Citizen Science (MICS)	Nature based solutions	Rural (Italy, Hungary, Romania, UK)	Metrics and instruments to evaluate citizen-science impacts on the environment and society	Yes	No	Project scoreboard and progress indicators, Project Management Handbook	Deliverable D1.1, Deliverable 1.2	https://mics.tools/

*CO – Citizen Observatory

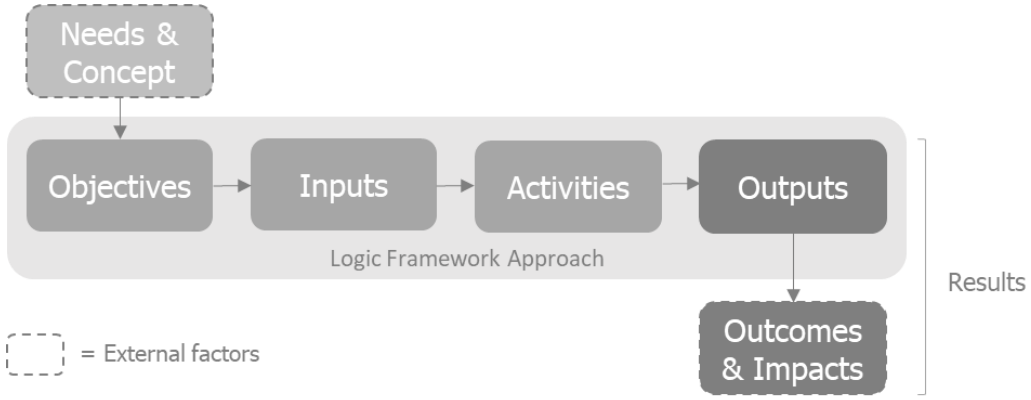

Figure 1: Logic Framework Approach

The concept is the what and how to manage problems (adapted from GroundTruth 2.0 logic of intervention).

In contrast, other studies have referred to CS and impact from an academic standpoint such as the MoS (Measures of Success) evaluation tool for Earthwatch-supported projects [19]. These includes 12 general indicators related to scientific publications, engaging users, partnerships, informing policies and environment. Similarly, a science products inventory (SPI) tool have been iteratively developed through an expert panel and case studies, mainly related to science productivity [20]. Moving beyond academic products, Kieslinger et al. (2018) propose a Citizen Science evaluation framework that integrates three assessment dimensions: scientific advancement, citizen engagement and socio-ecological/economic impact (Fig. 2). The framework contains an evaluation criteria matrix and supporting questions can be tailored to different purposes during the project phases [4,21].

2.1.1 Citizen Science and the Sustainable Development Goals

Although the SDGs are to be implemented by nations, they also represent a framework towards which any activity can be evaluated. Very few attempts have been done systematically to match CS project outcomes and assessments with the Sustainable Development Goals (SDGs). One attempt initially matched CS indicator (s) with SDGs and with the 'Monitoring the evolution and benefits of Responsible Research and Innovation' (MoRRI) framework. This attempt is shown for the eu.citizen.science project [22] (Fig. 2). MoRRI was a project tasked with implementing a monitoring system for responsible research and innovation (RRI) across its five dimensions (gender equality, science literacy and science education, public engagement, ethics, open access/open data), and governance. In addition to identifying indicators for the evolution of RRI, it identified social, democratic, economic and scientific benefits of RRI, and also conducted preliminary work to lay out routes towards implementing impact indicators (morri-project.eu/) [23]. Apart from Governance as the use of science in policy making, the eu.citizen.science project highlighted the following SDGs to which the expected outcomes might mostly contribute to:

- SDGs Goal 4 Quality education and the degree of global and citizenship education for sustainable development

- Goal 16 Inclusive institutions to provide public access to information and ensure inclusive and participatory decision making. In a more general sustainability and SDGs topic governance.

However, a detailed reason/explanation and a further assessment have not yet been completed and no SDGs outcomes or indicators were defined by the team at early stages of the project. Similar to the impact assessments found in literature (Table 1), the abovementioned example (Fig. 2) does not integrate an SDGs assessment as such. Plenty of sustainability assessments exist for products and services (e.g. Life Cycle Assessments (LCAs), ecological footprints); and sustainability assessment methodologies for projects in general [24]. Most recently, an undergoing discussion about the role of Citizen Science in sustainability transitions is taking place [25]. However, these approaches are normally data exhaustive, requiring a certain level of knowledge and taking long time spans. An ideal SDGs framework for CS should be a rapid and comprehensive assessment adapted to constraint-based contexts such as the lack of data in remote rural areas. Moreover, the assessment does not only need to be addressed at the end of the project or when the product/service is finished, but rather from its early design through the innovation and improvement process [26]. Because of a resource-constraint context where farmers live, a comprehensive Sustainability Framework Assessment [27] is explored as a feasible option to be adapted and integrate it to what has been previously used for assessing sustainability of different innovations [27,28].

2.2 Responsible Scaling of agricultural innovations & crowdsourcing applications

Agriculture lies at the heart of sustainable development and because of its centrality to Sustainable Development Goals, potential for synergies and trade-offs arises [29]. Although not always labelled as Citizen Science or crowdsourcing applications, a long tradition of setting participatory approaches exist in research and development projects in agriculture, attempting to facilitate the farmers-researchers interactions or to simply collect and aggregate agricultural information from farmers [10,11,30]. Successful examples include participatory learning applied to agricultural research and development projects, helping to bridge the gap between scientists and farmers [31]. More recently, crowdsourcing applications are being developed with a wide range of objectives from detecting crop varieties [11,32] to plant, weeds and pest disease identification [10,33]. Recently, Beza et al. (2017) identified crowdsourcing of farmers' data as an alternative way of getting field observations to conduct yield gap analysis, alongside with remote sensing and sensor networks. Nevertheless, the uptake, scale and sustainability of the projects still face challenges of impact [9]. Moreover, other factors such as mobile ownership, different groups involvement in decision making or gender-related factors can also play an important role but rarely feature in existing research on agricultural mobile services [34]. For example, a study of M-Farm, an app that connect with buyers and farmers in Kenya finds that women felt empowered by their participation in the training in how to use the m-service because it had familiarised them with the use of the mobile phone, which they were then able to use for other purposes [35]. Also, a study shows that women are equally interested in the agricultural extension information but appear less able to act on it because of their limited direct involvement in agriculture [36].

Collaborative projects in both research for development, Citizen Science and crowdsourcing represents farmers enabled by Information and Communication Technologies (ICTs), and involve communities of actors such as extension agents, scientists interested in field data collection, and decision makers, as well as sector data aggregators engaged in complex system and social practices ad behaviours [8]. Similarly, scaling agricultural innovations are recognised as complex systems with multiple overlapping areas (economic, social, technical, and political) and actors across them [9]. Hence, capturing progress, outcomes and impacts in CS projects requires a tailored conceptual frame that captures (un)expected, (un)intended, positive/negative outputs [8]. The later resonates with a call by researchers for responsible scaling in agriculture around recognising that large changes may have "unintended consequences for the population, geography/landscape, value chain, or society concerned" [15]. Scaling in agriculture normally referred to the adaptation, uptake & use of innovations across broader communities of actors and geographies [5] that joined by accountability and reflection of negative unintended effects outline a responsible scaling approach (Fig. 2).

Figure 2: Responsible scaling components

It is therefore important to anticipate the impact of reaching the scaling ambition and the associated risks beyond the geographic, social, and time boundaries set by the project. With these considerations in mind, Jacobs et al. (2018) propose a "Responsibility Check" of scaling's potentially negative side effects on social (gender and age equality, inclusiveness, power equity, resilience) and environmental (use and quality of natural resources and climate change) indicators. Toolkits are being used as well to define a complete scaling strategy or scale a project/programme such as SUM (Scaling Up management framework), IFAD framework, ASAT (Agricultural Scalability assessment tool), GIZ Guidelines and The Scaling Scan. An overview of these tools to support frame scaling can be found in [9]. However, they are meant to evaluate readiness or a proper final strategy, and most tools required extensive and detailed information. Just few examples exist as rapid tools for early phases for instance 'The Scaling Scan' by PPPlab & CIMMYT [37] which focuses on parts of the ambition then is suitable for testing ideas of new features both technological and non-technological. Nevertheless, the step 1 of this tool does not include SDGs and indicators, nor specific features for responsible and ethically data management for smallholders relevant for mobile phone applications in CS. Crowdsourcing applications in agriculture cannot only provide inputs that meet the agricultural researchers' needs, but also help closing the knowledge dissemination loop between researchers and practitioners and foster farmer-to-farmer interactions. Therefore, the development of such applications must consider the role of smallholder

farmers with respect to the Sustainable Development Goals (SDGs) who play a double function in the adoption of the SDGs and their socio-economic limitations that have made it difficult for them to fulfil the expectations as promoters of sustainable development [38]. The present work aims to develop a toolkit for Citizen Science context and complement it with further recommendations for responsible data management with already existing tools such as checklist for effective design of digital Decision Support Systems [39], data ethics checklist, FAIR DATA and CGIAR data plan that can be integrated in a toolkit.

3 Methodology

As a first step, a literature review was conducted to identify frameworks that already offer impact assessments of Citizen Science projects, Crowdsourcing or Citizen Observatories. In addition to academic sources, grey literature, deliverables and reports were used in this step because updated information could be found in on-going projects, with so far limited publications. In addition, a review of literature on systems approach to scaling agricultural innovation was conducted in the context of agricultural development projects. A database was produced and managed in the NVivo software. Based on the applicability of literature findings to CS/Crowdsourcing projects in resource-constraint contexts (e.g agriculture, rural areas outside Europe) a logic of intervention was selected. The selection was informally discussed with 4 experts and practitioners. We assessed its applicability in terms of coherence with the objective of the toolkit and the comparable size of the demonstrations used in current Citizen Observatories (CO). These CO had already defined regions where scaling ambitions were to be pilot tested in a second phase. Afterwards, an Excel-based tool was developed integrating 1) a logic framework approach derived from existing CS projects (GroundTruth 2.0 logic of intervention), and 2) a practical tool, currently being applied to determine strengths and weaknesses of scaling ambitions for agricultural innovations [37]. These approaches were then coupled to an existing SDGs framework [27,28], developed to evaluate constraint-based innovations in South African and Mexican contexts. We further improved and adapted this framework for the purpose of the toolkit.

To gain early feedback on the toolkit relevance, 4 additional informal interviews were conducted. Additionally, a usability survey was designed, and the toolkit was tested by 7 practitioners at the International Institute for Applied Systems Analysis (IIASA). The survey included a section for the position and working topics of the respondent, questions about the toolkit content and usability (easy-to-use, etc.) and open questions for feedback and recommendations (Annex 1). Finally, the tool was used by an app developer, a project manager, and a CS practitioner in a hypothetical case during 1-hour session. The participants were also asked to respond to the survey. Figure 3 shows a sketch of the methodology employed and the sequential steps taken.

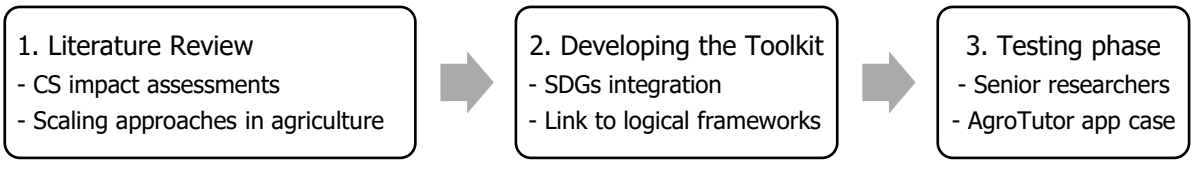

Figure 3: Flowchart of the methods applied

4 Results and discussion

4.1 Developing a toolkit to define Responsible Scaling Ambition

The development of the toolkit integrated a SDGs assessment/framework into current CS approaches of impact definition and measurement and to bring closer systemic approaches for 'responsible scaling' (research-for-development) to agricultural Citizen Science and crowdsourcing applications. The toolkit consists of 3 steps (Fig. 4) to serve as an initial guide for developers and practitioners towards designing for responsible scaling at the early stages of an agricultural CS application development or project. The tool can be used as a planning instrument for designing projects, but also as a mid-term self-evaluation for projects. It is not aimed to assess and develop a complete scaling strategy, a final evaluation process or as an external evaluation for funding agencies. From a project cycle standpoint, it is been recommended starting with articulation of project outcomes, then working backwards to determine not only what can be achieved and how, but also what can be reasonably measured [17,18]. Hence, the 3-step toolkit (Fig. 4) supports practitioners to define outcomes and a scaling ambition that is responsible and is grounded in and triggered by the SDGs. In addition, the results can be easily coupled to current Citizen Observatory logic of intervention or used in proposals to define impact on SDGs. The respondents can choose to go through the toolkit individually or invite collaborators. Ideally, a moderator, a small group with different perspectives and a workshop setting are recommended.

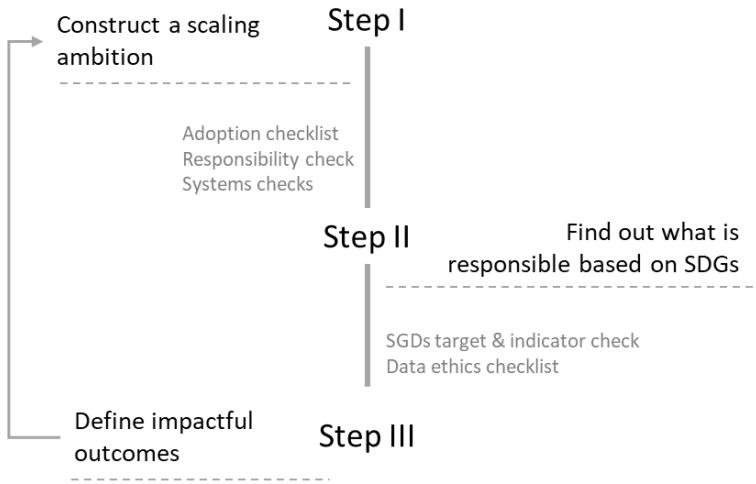

Figure 4: The 3-step of the SDGs-guided Toolkit

In the current Excel-based version (Annex 2), the toolkit starts at the **About** tab where a description of the tool is showcased (what? why? to whom? /who? when?). The 3-steps are described briefly and a scheme of the results obtained in each step. Additionally, limitations of the tool are communicated to the user. Under **Start Here** tab, the information of the case to be evaluated are required as well as the instructions for how to fill in the toolkit. In general, the respondents need to fill in the cells in blue colour and only go through the yellow tabs for the rapid version. Additional (recommended) but optional checks were also added in grey tabs. In the following paragraphs the three steps are described in detailed.

4.1.1 Step I: Construct a scaling ambition

This step is based on the *Step 1: Construct your scaling ambition* of 'The Scaling Scan', a practical tool to determine the strengths and weaknesses of a scaling ambition [37]. The objective of this step is to come up with a scaling ambition that is realistic, responsible, and geared towards a sustainable system change. The scaling ambition describes what the respondent(s) wants to scale, for whom, where and when. The 'Responsibility Check' include a list of 7 topics and questions to assess the impact of reaching the scaling ambition and the associated risks [37]. Among others the check contains questions about inclusiveness and power equity covering social and environmental sustainability (Fig. 5). If the respondents need an extended assessment or if the ambition is closer to implementation, the Systems Map check can be added, although it is optional for the rapid assessment.

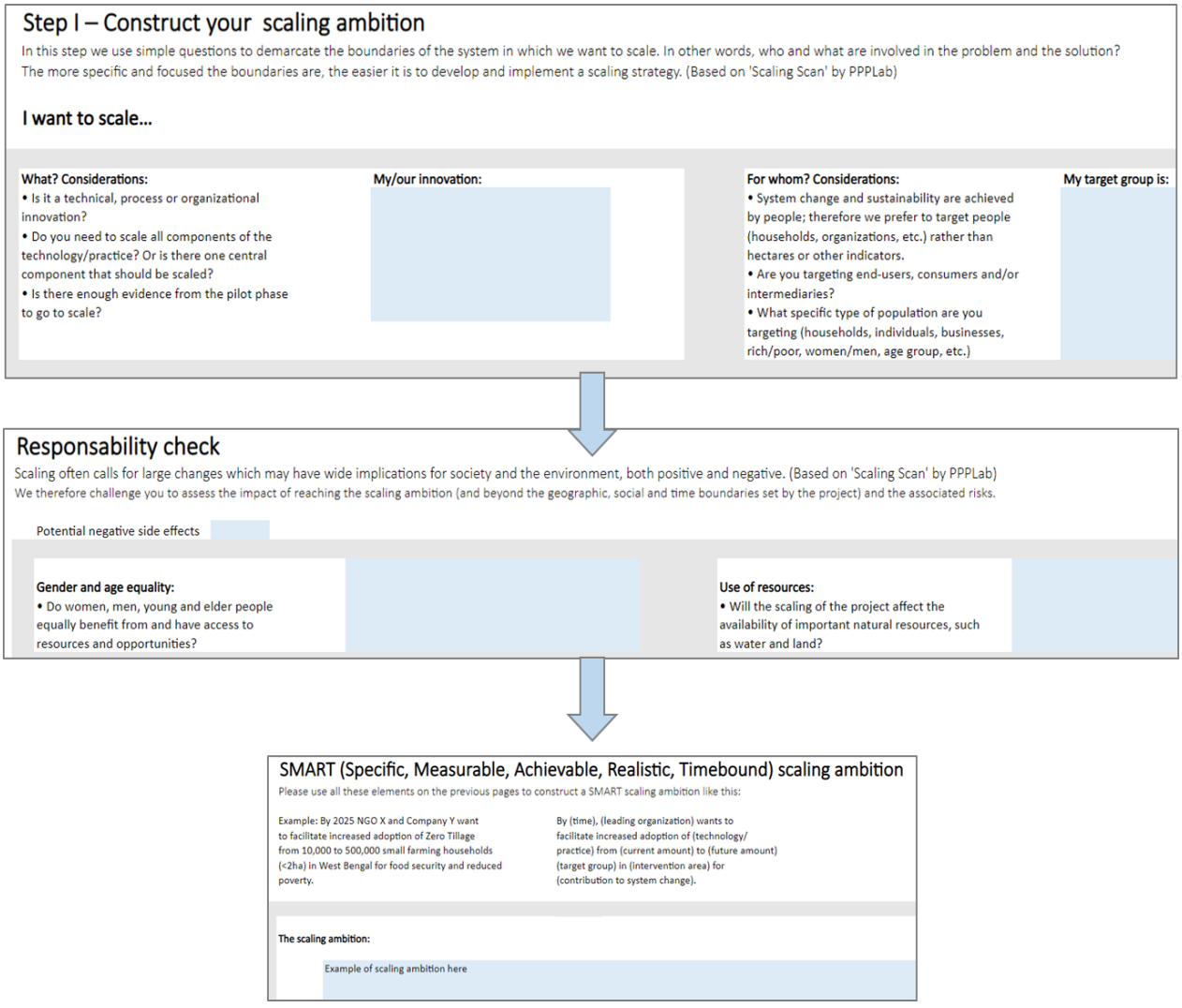

Figure 5: Step I (screenshot) 'Construct a responsible scaling ambition'. Based on The Rapid Scan by PPPlab and CIMMYT [37]

4.1.2 Step II: Find out what is responsible and sustainable scaling (SDGs check)

This step is based on the SDGs framework previously applied to different innovations in different geographical zones (South Africa and Mexico) [27,28] and adapted to a CS context (Fig. 6). In comparison to the original framework, potential negative effects and infringed SDGs are also accounted for. The objective of this step is to identify which feature(s) of the scaling ambition defined in Step I contributes positively or negatively to SDGs goals. This is done first by going through each SDG, answering if the ambition infringes or not the SDGs and explaining briefly the answers. Then, the participant specifies which specific features of the ambition could contribute positively (labelled as 'Green Flags'), and have potential to define, monitor or implement one or more SDGs. A feature is an observable characteristic of the scaling ambition (technology, setting, etc.) that can be delivered by the project and team. Features that have a potential positive contribution to SDGs, are categorized as 'Social + institutional', 'Economic' and 'Ecological/Environmental' clusters using elements of sustainability. If the ambition and features infringe SDGs (or have potential negative impact), these are labelled as 'Red Flags' or points of attention that need a preliminary mitigation plan. In addition, for every mitigation plan, the means of verification and source of data to check through the project cycle are required.

Finally, the results are summarized as the number of 'Red Flags' and 'Green Flags' and the clusters under which the positive and negative features might fit. Results of Step II also show if there is a mitigation plan for every 'Red Flag'. Contrary to other SDGs Impact Assessment Tool (IAT), and impact approaches in CS shown in Table 1, the toolkit here presented includes additional SDGs targets and indicators check (to monitor and/or measure) due to the potential of CS to contribute to SDGs [3]. An optional data ethics cycle checklist is also added in step II in response to risks and privacy concerns for smallholders found in literature [40].

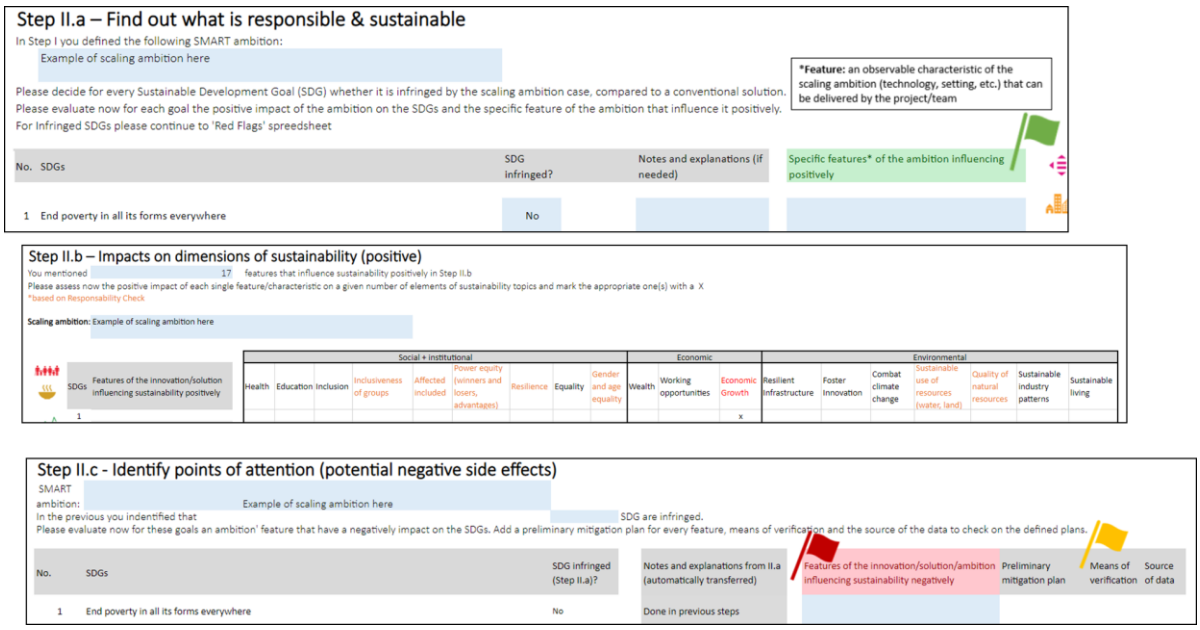

Figure 6: Step II (screenshot) 'Identify potential positive and negative impacts of each feature'.

4.1.3 Step III: Define success & impact outcomes

This step uses the results of Step II (SDGs check) to define wider and specific outcomes based on the logic framework approach described in section 2 (Fig. 1, Fig. 4). This means that the features with 'Green Flags' and the mitigation plans for the 'Red Flags' from Step II are used to define outcomes in the form of Key Performance Indicators (KPIs) that are clear, relevant, economic & available at reasonable cost, adequate, and monitorable (CREAM). Finally, the scaling ambition can be (re-) visited to ensure that the outcomes are included somehow. The toolkit is meant to be iterative and integrative whenever new knowledge or new insights arise in the complex tasks of promoting sustainable development. The scaling ambition, grounded on the SDGs, could be easily plugged in into logical frameworks or logic of interventions by including and defining specific inputs and activities (Fig. 1). Even though the latter is out of the scope of the proposed tool it might help to identify strong and weak points that need attention in the scaling strategy.

4.1.4 Additional (optional) checks

Based on the adoption challenges found in literature, additional (optional) checks and assessments not directly linked to the SDGs, were added to the toolkit. These additional checks cover the adoption challenge for digital decision support systems by farmers based on the well-known theory of Unified Theory of Acceptance and Use of Technology (UTAUT) [41]. Some optional checks are also available and respondents can decide to use these based-on capability/skills, time, and stage of the project. This additional set of checks include a systems check, also from [37], a frugal development check based on [42], adoption check and decision support systems checklist [39], and a data ethics checklist with recommendations for smallholders.

4.1 Findings from the testing phase

In the following section, the results from the survey during the testing phase of the toolkit are presented. Results from the virtual workshop, in which the Step I of the toolkit was completed, are summarized in section 4.2.2. In Section 4.2.3 changes made accordingly towards a final website version are described.

4.2.1 Academic experts' perceptions about the content and usability of the toolkit

The toolkit is designed for anyone involve in CS projects looking to scale impact. *Who is the toolkit for? And when to use it?* were open questions discussed during feedback conversations in order to define the further end-users and needs. Project coordinators, and teams specially in the academic realm who define a project and its priorities will be those most able to take advantage of the toolkit. The potential usefulness of the toolkit for research proposal preparation was highlighted by experts. This is consistent because the toolkit integrates an application of a logical framework approach (LFA) as a baseline, and researchers are familiar with it and other variations. The LFA is a methodology mainly used for designing, monitoring, and evaluating international development projects dealing with Activities, Outputs, Purpose and Goal. Similar tools are known as Goal Oriented Project Planning (GOPP) or Objectives Oriented Project Planning (OOPP) and are not unknown by researchers [16,43]. However, also innovators, practitioners and implementing staff might still find the toolkit useful, especially if applied while designing pilot or demo cases of Citizen Observatories.

A total of 7 responses of senior researchers and project managers at IIASA and the International Maize and Wheat Improvement Centre (CIMMYT) were obtained. Except for one senior researcher working around environmental topics, the rest indicated that 'Agriculture (land use, landcover, crops)' was the main topic of their work around Citizen Science. Similarly, all respondents except one agreed that the 3-steps tool was relevant to their work, and at least half of respondents agree that the toolkit is useful for their colleagues (Fig. 7). All respondents agreed with the statement of "The objective of the tool is clear". Furthermore, respondents suggested that it can be applied within a range of sectors, where CS is embedded, beyond the agricultural sector. It also can be used by individuals as well as (project) teams, and partnerships. Yet, the later might need further validation but is so far feasible due to the flexibility of the assessment that has been previously used for non-agricultural innovations in South African, and water social innovations in Mexico [27,28]. Moreover, the Scaling Scan as such can be applied within a range of sectors, despite being based on experience from the agriculture and the water sector [37].

"I found it very useful exercise, and it gave me ideas / considerations I / my project have not considered before."

Figure 7: Respondents agreeing with the the toolkit' usefulness for colleagues.

In contrast, all the respondents were either neutral or disagreeing with the next statement: *"The instructions of the tool are clear and understandable."* Then, the instructions needed to be simplified, especially in step II and III. A video-tutorial was then produced to clarify the instructions (Fig. 8).

Figure 8: A 5-min video tutorial

About the **content of the toolkit**, it was found good enough and no additional content was suggested to be added. Instead further efforts will require to simplify it. For example, the option that respondents must not only match the scaling ambition with a general SDG goal but with one or more specific SDG targets and indicators can be made somehow optional and dependable on respondents' drives. An example of this is shown in Fig. 10 where respondents can choose either goals or targets or both. Nevertheless, it will be highly recommended to produce a scaling ambition that best reflect the SDGs compliance also with targets. Different from other online SDGs assessments such as the SDG SDGs Impact Assessment Tool (IAT) (Fig. 9) the toolkit is focused on features of scaling ambition within a Citizen Science context. Furthermore, the present toolkit provides the following additional features:

- Target and indicator checks, and focuses on specific ambition features (vs. only objectives) based on the recent potential contribution of Citizen Science projects to define, implement and monitor SDGs indicators [2].
- A responsibility check and mitigation plan for indirect negative effects
- Match of features/outputs with outcomes under a Citizen Observatory/CS logic framework

Figure 9: SDG Impact Assessment Tool (IAT) (screenshoot)
SDG IAT by Gothenburg Centre for Sustainable Development, SDSN Nothern Europe and Mistra Carbon Exit
Source: www.sdgimpactassessmenttool.org

With respect to **ease-of use**, six out of the seven respondents referred neutrally to the statement *"The toolkit is easy to use"*, the other respondent stated to agree with the statement. As well, 4 respondents replied to neutral to the following statement *"The toolkit is fun and I enjoy using it"* (Fig. 10). These results outline the improvements of the toolkit to simplify the tool and to present it in different formats. Consequently, the intention to use was low among respondents as only 2 respondents referred the intention to use it in the near future.

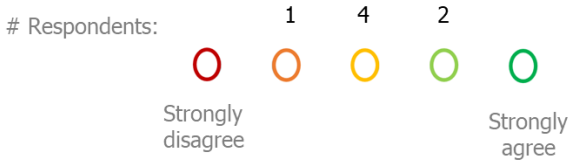

Figure 10: Replies to the statement on the use of the toolkit being fun and enjoyable.

Therefore, replies from the open question '*What will you improve to make the tool easy to use, useful and/or enjoyable?'* suggested that a change in **format** might make the toolkit easy to use will be a web survey or format instead of a excel file. To this respect, respondents marked a website followed by workshop, as the preferred formats, and excel and documents as less preferred formats for using a toolkit. Ideally, Step I should be conducted via a workshop with facilitation aids (see Section 4.2.2) to make it easier to use. It needs to be recognised that any SDG impact assessment is dependent of the data available at that time, knowledge level and ambition of the teams performing the assessment. Hence, it is inherently subjective and preliminary, and should be open and flexible for review at any stage or whenever new information arises. Therefore, the ideal will be that the toolkit remains a living instrument through the project. Still, whenever teams are more diverse (e.g. different multi-stakeholders) the more complementary its knowledge is to evaluate how the scaling ambition impact the SDGs while teams might learn more about the opportunities and difficulties of implementing the SDGs agenda. Then, even if the toolkit can be conducted individually or in small teams it is recommended bringing as many perspectives as possible.

4.2.2 Testing a virtual workshop format for applying the toolkit

In order to explore further the different formats, a trial 1-hour session (14/08/2020) was conducted with senior researchers at CIMMYT using a hypothetical case of the on-going development of new features of the AgroTutor app. AgroTutor — available on Android and iOS — is a crowdsourcing application and offers free information to farmers in Mexico, including historic yield potential, local benchmarks, windows of opportunity, recommended agricultural practices and commodity price forecasting [44]. During the workshop, the facilitation faced practical challenges due to the virtual setting and limited experience of the facilitator. Some areas of improvement included:

- Before the workshop
    - Communicate more extensively and before the objective of the toolkit and workshop
    - Align expectations of the outcomes of the toolkit.

- Request a pre-definition per participant of the ambition

- During the workshop
  - Explain the toolkit and steps with an example or with the video-tutorial
  - Responsibility check: better explanation and emphasis on negative side effects as the tendency was to keep focusing on the positive parts of the ambition with less room to critical discussions

- Number of participants
  - Small groups have advantages for virtual settings however bringing additional participants, for example non-related to the project but experts in agricultural apps or scaling could add integral perspectives.

Despite the facilitation challenges, the definition of a scaling ambition and the responsibility check (Step I) were conducted with 3 team members, and using an interactive tool (https://miro.com/). The results were shared with the participants in a brief report (Fig. 11, Annex 3). In the future and for the real case, experts at CIMMYT from Scaling Research group who had experienced on the 'The Scaling Scan' [37] could be contacted to facilitate a future workshop.

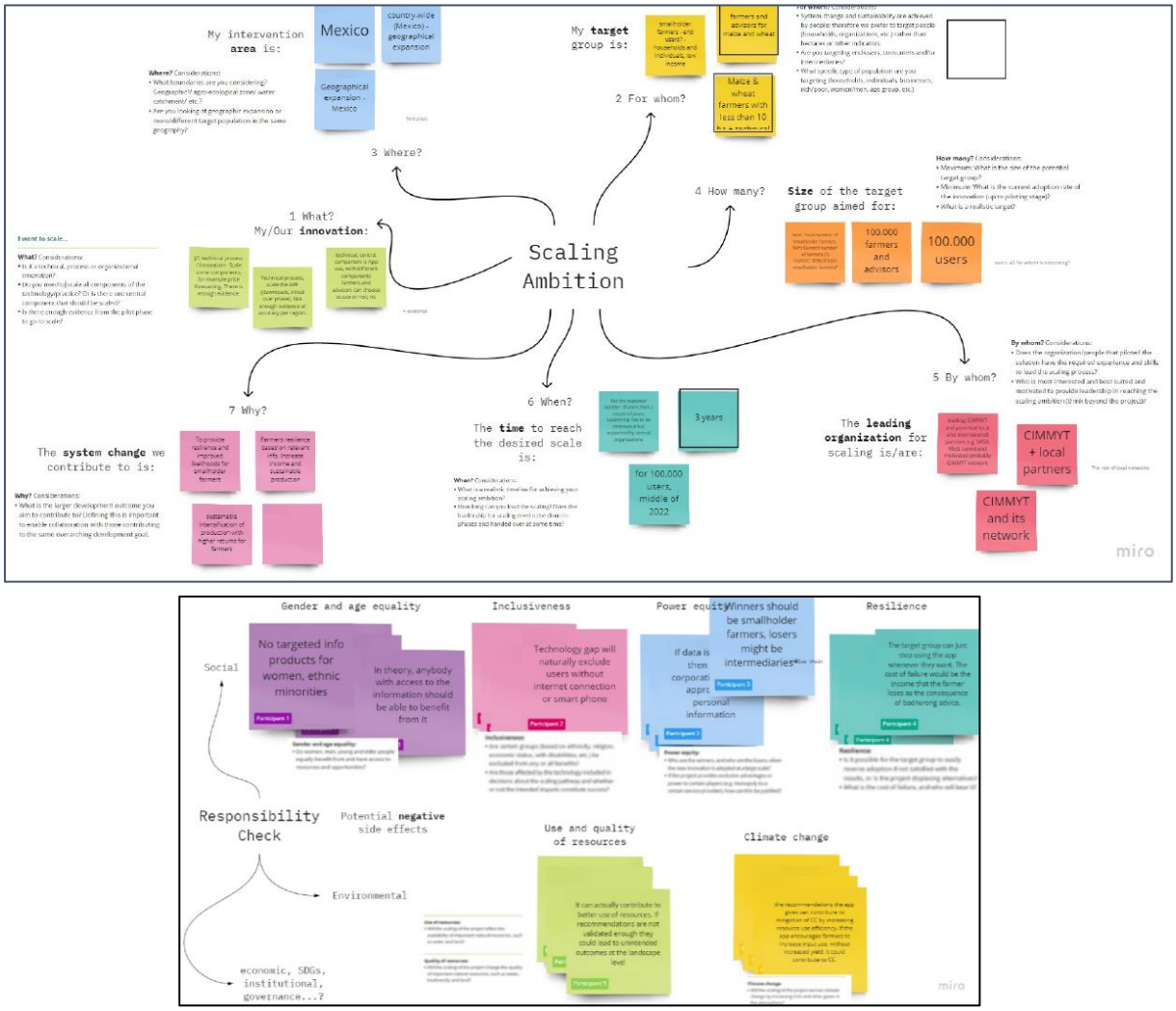

Figure 11: Example of result from the pilot workshop: Scaling ambition and Responsibility check

If many perspectives as possible are aim to be integrated, conducting a 1-2 hours workshop for only Step I can be a feasible option. Step II can be done individually at the respondents' own time, and then results can be compared and discussed. Step III then again is recommended to be done with a team including the decision maker, or resource responsible because outcomes and activities are assed and defined. If there is time and resources, one further option can be to prepare the case study and then request to a panel of (3-5) experts to reply to the Step II. Therefore, a further validation of the team' assessment can be done by comparing the team results with external parties once the scaling ambition is defined and aligned or after implementation.

5 Limitations

Despite the important and practical insights found in the testing phase, the toolkit still needs further validation with a real case study. However exploratory, this study may offer some insight into matching, in an early and systematic way, the scaling ambition (and impact at scale) of a Citizen Science project with its impact on SDGs. Every assessment done by a practitioner has its own limitation, most concretely the subjectivity introduced by the practitioner. Care must be then taken when trying to make inferences, when the information needed to reply is not available, or whenever limited perspectives are brought together. It also needs to be noted that any SDG impact framework is dependent on the knowledge level and ambition of the researcher or team replying to the toolkit questions as well as the information available at that time. Hence, the toolkit is inherently subjective and preliminary and should be open for revision and discussion. Still, when an evaluation is conducted on how an ambition might impact the SDGs, respondents could learn more about the SDGs and the opportunities and difficulties of implementing them. To work with sustainable development and the implementation of the SDGs can be complex since it entails almost all aspects of human societies, and knowledge of societies, and the environment are continuously being produced.

6 Conclusions and outlook

A rapid scan toolkit was developed to define responsible scaling ambition (s) of Citizen Science (CS) projects in agriculture in response to the need of matching project outcomes with the SDGs goals, indicators, and targets in a systematic way, as well as to offer a way to monitor and evaluate these outcomes along the project, instead of just at the end of it. A first testing phase of the toolkit was conducted with researchers involved in Citizen Science projects acting as final end-users and the feedback was integrated into a final version of the toolkit. The main contribution of the rapid scan toolkit relies in the integration in CS projects of design for scaling and responsible scaling at the earliest design or implementation phase possible. With only 10 years to act on SDGs achievement, design for scale approaches are of key importance to unravel Citizen Science efforts to this respect.

Despite limitations of the exploratory nature of the study and testing phase, the final toolkit is the first assessment designed for Citizen Science (CS) projects based on SDGs. In contrast with existing impact assessments conducted at the end of a project, the toolkit might be a ground for early stage evaluations of the CS scaling ambition. The toolkit is a systematic and flexible guide that can be used and reused throughout the project cycle whenever new information arises. Although it aims to be easy to use and rapid, it urges to involve as many perspectives as possible, differing from impact measurement where sometimes limited perspectives are involved. This means that creative ways of using it play an important role, especially in circumstances such as the current Covid19 situation, where web-based formats or virtual workshops are the norm. Based on a virtual testing result, it is recommended to conduct Step I together with small teams (3-5 people) for around 1.5 hours including a facilitator, and then Step II can be done individually. The results of both steps can be later compiled.

Further steps include developing a web-based form or website in the EOCS website (see Section 6.1), apply the toolkit in a real case study and evaluate its applicability for Citizen Science projects apart from agriculture. The toolkit applicability will be assessed by working closely with the existing communities of practice (CoPs) in which IIASA researchers are currently involved, such as the SDGs and Citizen Science CoP, and the WeObserve Impact CoP. As a first stage of dissemination and once the toolkit is ready, it can be uploaded to the resource database and search engine of the 'Responsible Research and Innovation (RRI)' website, and can be disseminated via the RRI Twitter account with around 5,000 followers, including IIASA's and other CS accounts. Other collaborations might include linking in with on-going efforts for Citizen Science such as the MICS project for environmental projects. Makers or different actors within academic Citizen Science communities (e.g. companies offering technological solutions) for Citizen Science projects can be mapped too, to explore their needs and interest in the toolkit to evaluate feasibility or willingness to use.

6.1 Post-testing enhancements: extra modules and the roadmap towards a website

Based on the results of the survey, feedback and comments, the toolkit was improved in the following aspects producing the final version. Under the Instructions part, the 'logic of intervention' scheme was added to introduce the roadmap and a link to the Video-tutorial containing the instructions on how to use the toolkit in excel. In Step I, a systems map [37] is offered as optional to be applied depending on the scaling ambition stage. Because of engagement and adoption are at the core of most Citizen Science projects using digital tools; then a check for design and adoption of digital decision support systems by farmers [39], and responsible data management checklist are also added as optional. Further on demand checks could include a frugal check [42] to design low-cost innovations in resource-constraint contexts. Therefore, in Step II, optional checks are added and will be up to researchers and respondents whether to use it based capability/skills, time, and stage of the project or specific interest.

Also, in Step II, the transformed SDGs in the opposite way were removed to avoid confusion. In the original assessment each target was formulated with a negative association (e.g. 'The innovation supports poverty') making possible to refer Yes or No. As well, the Impact on dimensions of sustainability were as well removed and further sorted in the last part of Step II by social & institutional, environmental and economic to keep it simple. Steps aiming at identify the specific target and indicator to be tackled based on UN SDGs are made optional, and it will be up to respondents and stage of the project or specific interest to completed it. In Step III, the box of definition was moved to another spreadsheet to be consulted separately and a set of new instructions and comments in the filling boxes were added. Further steps include developing a webform or website in the EOCS website: https://www.geo-wiki.org/ (Fig. 12).

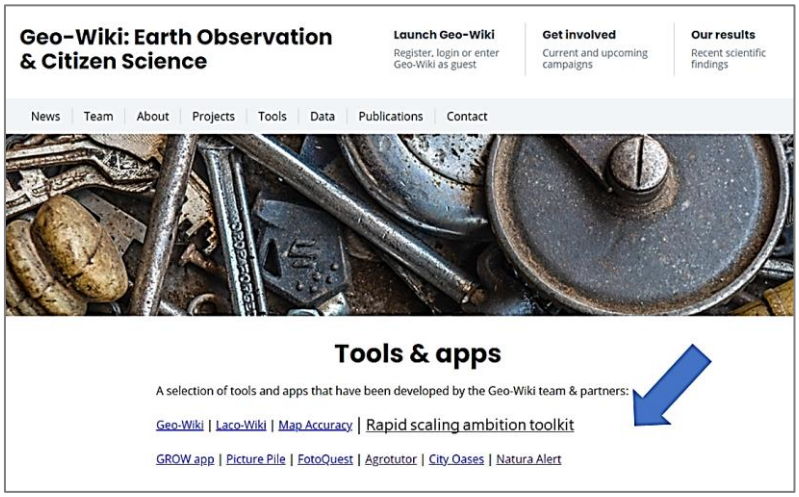

Figure 12: Additional Toolkit under Geo-Wiki website

The CS scaling features defined could be adapted from existing online tools where the respondents are asked to sort according to relevance. It means choosing/clicking on the following buttons: "Relevant", "Not relevant" or "Don't know - More knowledge needed". Later those appeared already sorted into those categories. For every SDGs, a new page can appear with the goal, its targets and indicators optionally. After reading through the introduction of the goal, targets, and indicators the

respondents could click on one of the buttons of 'direct', 'indirect' or 'no impact' according to how your solution affects this SDG. Then, a motivation similar to our notes and explanation are requested. In the present toolkit, the specific features of the ambition will be requested too. A feature is the output and an observable characteristic of the scaling ambition (technology, setting, etc.) that can be delivered by the project/team adding more levels of details. The outputs/features will be then converted into outcomes in a final step.

The features will then appear sorted into "Green Flags" for opportunities and positive impacts, "Red Flags" for risks or negative effects, and "White Flags" for knowledge gaps. The features, actions to mitigate trade-offs and risks (mitigation plans), actions to take on knowledge gaps are required. In the last step, the respondents might need to go through all features and mitigation plans to define further outcome. Different from the SDGs Impact Assessment Tool (IAT), in a new page, a short introduction into the CS logic of intervention will be provided as well as examples of outcomes from literature. The results will be presented in a similar matrix of the SDGs assessment tool with a target-level definition instead of only the goal (Fig. 13). If you click in each target, the explanation, feature or mitigation plan and outcomes appears. And the results can be easily printed.

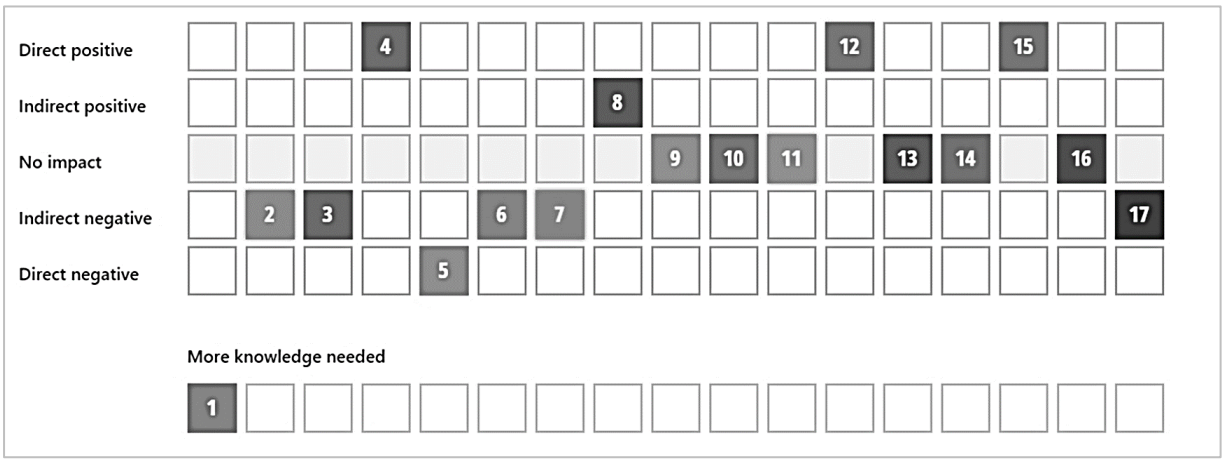

Figure 13: Results visualization matrix
Screenshot taken from the www. sdgimpactassessmenttool.org

Finally, the following questions might be presented below the results matrix to i. reflect on the defined scaling ambition and check whether the outcomes are included in the ambition first defined and ii. to prioritize and define strategic choices: which positive outcomes can you strengthen even further? which negative outcomes can you eliminate or minimize? and what is needed and who can help you to fill the knowledge gaps? Then, focus on what can be done here and which additional partners or competencies might need to be involved or developed.

6.2 Future validation with real projects

Additionally, two agricultural projects, in which IIASA is involved, can serve as case studies to apply the toolkit and prepare a scientific publication. The first is AgroTutor, a mobile application which was built to provide specific and timely agricultural recommendations to farmers across Mexico and

complement the work of extension agents [44]. The Step I of the toolkit was conducted in a pilot virtual workshop session, using AgroTutor as guidance where a preliminary ambition was defined, and a responsibility check was completed. The second project where IIASA leads the CO work package is called FRAMEwork System for Biodiversity-Sensitive Farming, starting at the beginning of 2021. Among the deliverables, developing the Citizen Observatory and Information Hub (as a web-platform) and develop biodiversity monitoring schemes together with farmers based on their needs and interests are included [1]. The two projects are in different stages, which is beneficial since this will allow to explore advantages and disadvantages at different phases. The toolkit and methods are meant to be iterative, especially since promoting sustainable development is an ongoing, continuous process where knowledge is always evolving. Hence, reassessing ambitions and their impacts in the face of new knowledge might yield new outcomes at different the project stages. As a conclusion, the rapid scan toolkit is therefore an instrument that allows an ever-improving modification and fine-tuning of Citizen Science projects, which will in turn produce a rapid and enhanced contribution to the SDGs.

[1] Project Executive Summary, Personal e-mail communication team members

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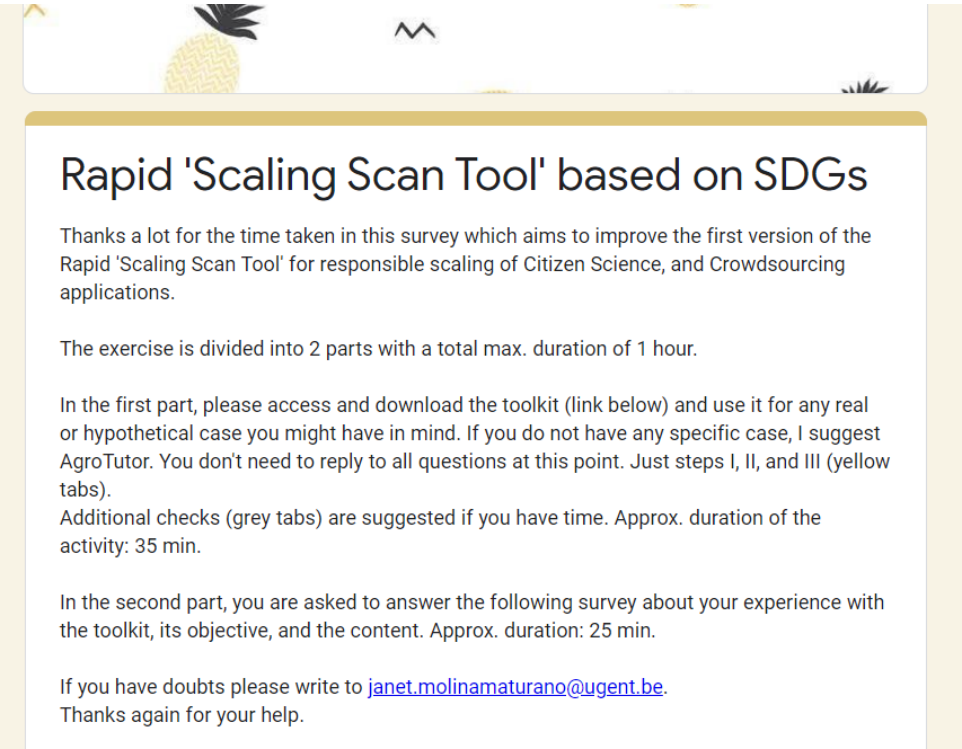
8 Annexes

Annex 1: Survey



Rapid 'Scaling Scan Tool' based on SDGs

Thanks a lot for the time taken in this survey which aims to improve the first version of the Rapid 'Scaling Scan Tool' for responsible scaling of Citizen Science, and Crowdsourcing applications.

The exercise is divided into 2 parts with a total max. duration of 1 hour.

In the first part, please access and download the toolkit (link below) and use it for any real or hypothetical case you might have in mind. If you do not have any specific case, I suggest AgroTutor. You don't need to reply to all questions at this point. Just steps I, II, and III (yellow tabs).
Additional checks (grey tabs) are suggested if you have time. Approx. duration of the activity: 35 min.

In the second part, you are asked to answer the following survey about your experience with the toolkit, its objective, and the content. Approx. duration: 25 min.

If you have doubts please write to janet.molinamaturano@ugent.be.
Thanks again for your help.

https://docs.google.com/forms/d/e/1FAIpQLScMISbV5BzPm4_fUhz07Bt0cQ_136ZvALHW88bO5h_KTVfgjA/viewform

Annex 2: Toolkit in excel v2
File in Sharepoint

Annex 3: Extract from the workshop report

SMART SCALING AMBITION

It was defined following Step 1a of The Scaling Scan by PPPLAB and CIMMYT.

"By 2023, CIMMYT & partners* want to facilitate increased adoption of the AgroTutor app from around 30 to 100,000 users in Mexico for promoting farmers' resilience and sustainable intensification."

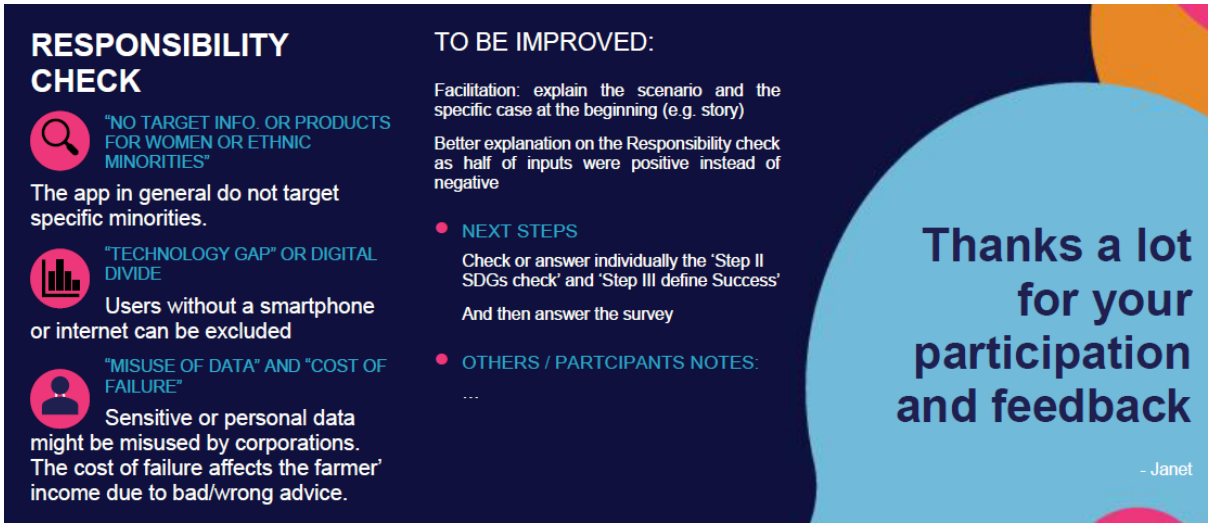
*partners (to be defined)

**users include both advisers (at least 10-15% of the total users) + wheat and maize farmers owning <20 ha.

REPORT OF THE SESSION

TESTING "STEP I" OF THE TOOLKIT

Testing phase of a rapid toolkit for define a responsible scaling ambition of crowdsourcing and citizen science projects. This tool is being developed as part of the Young Scientist Summer Program 2020 at IIASA.


RESPONSIBILITY CHECK
"NO TARGET INFO. OR PRODUCTS FOR WOMEN OR ETHNIC MINORITIES"
The app in general do not target specific minorities.
"TECHNOLOGY GAP" OR DIGITAL DIVIDE
Users without a smartphone or internet can be excluded
"MISUSE OF DATA" AND "COST OF FAILURE"
Sensitive or personal data might be misused by corporations. The cost of failure affects the farmer' income due to bad/wrong advice.
TO BE IMPROVED:
Facilitation: explain the scenario and the specific case at the beginning (e.g. story)
Better explanation on the Responsibility check as half of inputs were positive instead of negative
NEXT STEPS
Check or answer individually the 'Step II SDGs check' and 'Step III define Success'
And then answer the survey
OTHERS / PARTCIPANTS NOTES:
...
Thanks a lot for your participation and feedback
- Janet