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1

2 **Channels of collaboration for Citizen Science and the Sustainable Development Goals**

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7 **Abstract**

8 Citizen Science, known as the participation of individuals and groups in scientific processes,
9 is an increasingly growing discipline, which can contribute for the achievement of the
10 Sustainable Development Goals. The UN Agenda 2030 for Sustainable Development is all-
11 inclusive, where every contribution is valid. Participation, partnerships, education, sustainable
12 living and global citizenship, all of which can build on Citizen Science activities, are crucial
13 for the Sustainable Development Goals. In this context, this study aims at exploring several
14 collaboration channels for Citizen Science-related activities and the Agenda 2030. Challenges
15 and critical aspects are discussed based on the opinions of practitioners collected through a
16 comprehensive online survey. Furthermore, recommendations for future involvement are given
17 on a framework of interactions at different levels for Citizen Science and the Agenda 2030.

18

19 **1. Introducing Citizen Science**

20 Citizen Science (CS) works alongside science, education, and civic engagement and is
21 increasingly being a discipline in its own right (Science Europe, 2018). There are several
22 definitions, but CS is often considered as the participation of lay people, individuals, or groups
23 in scientific processes (Kullenberg and Kasperowski, 2016). These contributions differ from

24 informal learning due to engagement in science-related processes (Jordan 2002), such as
25 modelling, new discoveries, observations, data collections and analyses, technological
26 processes, and evidence-based policies (Raddick et al., 2009).

27 Citizen Science has existed for a long time, but it has especially expanded in recent years due
28 to more collaborations between volunteers and researchers, emerging technologies and new
29 ways of data collection such as crowdsourcing, digital sharing, online projects and social
30 networks (Socientize, 2013). Common synonyms for CS are "amateur science," "crowd
31 sourced science," "volunteer monitoring," and "public participation in scientific research"
32 (<https://scistarter.org/citizen-science>). A citizen scientist, without necessarily a scientific
33 background, volunteers to collect or process data for scientific research (Silvertown 2009). CS
34 has changed the professional-amateur relationship because of an increased accessibility to the
35 internet and tolerance of the web (Dowthwaite and Sprinks, 2019). The field of CS is growing
36 towards scientific literature and policy making, but there is a need to foster trust in CS results,
37 so to increase their use and consequently strengthen the field (Rasmussen, 2019). Barriers to
38 the implementation of CS projects, either practical (lack of funding or training) or theoretical
39 (whether the projects live up to the standards of scientific practice) are context dependent
40 without necessary reducing results quality (Elliott and Rosenberg, 2019). CS is more successful
41 in some fields than in others. For instance, in soil science or ecosystem ecology, although it
42 facilitates conservation, technical expertise and samples quality are perceived as obstacles
43 (Reed et al. 2018). Capacity building processes for CS can be important for future policies, but
44 necessitate the involvement of wide range of people and institutions (Richter et al., 2018).
45 Citizen Science is implemented mainly in industrialized countries such as the US, European
46 nations and Australia (Guerrini 2019), and it is increasingly witnessed in China as well as in
47 the Global South. CS is less visible in developing countries (Pocock 2018), challenged by
48 accountability, data accuracy, lack of trust, and specific cultural issues among others. Despite

49 that, CS has potential for developing countries, as it facilitates long-term datasets and
50 monitoring (Gouraguine et al., 2019).

51

52 **2. Citizen Science and the Sustainable Development Goals**

53 Several features of the UN Agenda 2030 for Sustainable Development can build on Citizen
54 Science, such as encouraging participation, partnerships and collaborations, education,
55 sustainable living and global citizenship. CS related activities can address sustainability
56 challenges and contribute to the implementation of Sustainable Development Goals (SDGs).
57 Citizen Science encourages social cohesion, a crucial element for the moral dimension of the
58 Agenda 2030, which aspires to benefit all people and leave no one behind through global
59 citizenship and shared responsibility (UN 2015). The Agenda 2030 document assigns the
60 principal obligation to the member states, depending on their capacity and political will. The
61 role of non-state actors and individuals during the SDGs implementation process is ambiguous,
62 affected by national actions (Bexell and Jönsson, 2017).

63 Sustainable development does not require a top-down approach, but rather a networked,
64 problem-solving attitude, where all actors, and especially young people, are engaged (Sachs,
65 2012). It is widely accepted that the implementation of the SDGs requires a full integration
66 across sectors, disciplines, countries, and actors. Explicitly in Goal 17, “Partnerships for the
67 Goals,” the role of non-state actors in multi-stakeholder partnerships is emphasized as a way
68 to engage with and enhance cooperation (UN, 2015). Furthermore, in order to use the SDGs as
69 a “common language,” it is necessary to scale them down to all levels of society such as
70 individuals, communities, organization, networks etc. For sustainable development, public
71 participation is crucial (Leal Filho, 2019). As a consequence, CS actions performed by
72 individuals, teams, or networks of volunteers with a significant contribution to the societal

73 changes cannot be neglected. Citizen Science can contribute to attaining the SDGs by
74 pressuring governments and businesses to take action, through defining national priorities,
75 monitoring, and implementing processes (West and Pateman, 2017). The role of CS for the
76 SDGs is acknowledged by the United Nations institutions through the “Citizen Science Global
77 Partnership” (CSGP), launched in December, 2017. This network seeks to promote CS for a
78 sustainable world and to support existing CS associations such as the European Citizen Science
79 Association (ECSA), the US Citizen Science Association (CSA), the Australian Citizen
80 Science Association (ACSA) and other emerging networks. Its purpose is to coordinate NGOs,
81 governments and businesses that work with the global CS community and to track the
82 contributions of CS towards the SDGs implementation (<http://citizenscienceglobal.org>).
83 Furthermore, a task group “Citizen Science for the SDGs - Aligning Citizen Science outcomes
84 to the UN Sustainable Development Goals” was established in order to facilitate and encourage
85 the inclusion of data generated by Citizen Science projects in the official framework to monitor
86 the SDGs ([http://www.codata.org/task-groups/citizen-science-for-the-sustainable-](http://www.codata.org/task-groups/citizen-science-for-the-sustainable-development-goals)
87 [development-goals](http://www.codata.org/task-groups/citizen-science-for-the-sustainable-development-goals)).

88 Citizen Science actions or processes can drive society transformations (Chari, 2017). To
89 achieve a sustainable transition of societies, it is mandatory to prioritize the citizens’ concerns
90 and to appreciate their knowledge (Wildschut, 2017). Citizen Science can advance a better
91 understanding of science as a whole (NACSEM, 2018). The movement is driving the necessity
92 for transparent processes and access to science (Irwin, 2018). The benefits of researchers are
93 related mainly to research quality, dissemination and science appreciation in the future (Knack
94 et al. 2017). Citizen Science actions reduce mistrust through collaborations and orient science
95 to react according to the necessities of the society (Smith et al. 2017).

96 Citizen Science can also advance a better understanding of the Agenda 2030. The engagement
97 of scientists in the SDGs’ by fostering evidence based policymaking by the UN Institutions

98 would result in a stronger process of policy design and implementation (Elliott et al., 2019).
99 Furthermore, the SDGs are an opportunity to revive the sustainability research agenda, due to
100 the importance of sustainable development principles for policies and quality of life (Leal Filho
101 et al, 2018). In order to contribute to sustainable development, individuals must understand the
102 ambiguous and complex issues of sustainability and become “sustainability citizens”
103 (UNESCO, 2018). Some elements that influence CS as it is related to sustainability are
104 innovation, citizenship, ethics, education and knowledge. The Agenda 2030 debate on the goals
105 can be informal for a wider non-specialist public, thus raising the world population’s awareness
106 about the urgency for sustainability challenges (Josephsen, 2017).

107 This study considers theories of governance and partnerships for sustainable development.
108 Governance facilitates the political dimensions of CS, showing its impact outside the
109 government and policy aspects (Gobel at al. 2019). For progress towards sustainability,
110 governance structures should enable coordination in uncertain and complex environments with
111 multiple actors at all levels (Kemp et al., 2005). Complementary, to empower citizens to inform
112 decision making a combination of social and technological innovation is needed (Groom et al
113 2019). Governance of a CS project is also important to explain how much it contributes to the
114 SDGs. Unlike social enterprises, CS projects are based on operational rather than business
115 models (Bio Innovation Service, 2018). Citizen Science processes can take place on a global
116 level, as virtual, huge interactions, or on a local level as more continuous, hands-on
117 interventions (Socientize, 2014). Social or governance frameworks usually define the position
118 of CS at governance level, in the process of linking institutions with citizens (DITOS 2019b).
119 CS challenges in policy are related to issues of data quality and management, governance and
120 policy implementation (Hecker et al, 2019)

121 There are many visible and invisible ways in which individuals, groups, or organizations can
 122 influence the SDGs. This study considers five collaboration channels of CS, as presented in
 123 Table 1. These channels will be useful throughout the paper.

124 Table 1. Collaboration channels of Citizen Science

a) Influence through the representation of organized Citizen Science networks in the multi-stakeholder partnerships and engagement mechanisms created for the SDGs, at the national and international level	Goal 17 explicitly stresses the importance of alliances for the SDGs and encourages non-state actors' involvement in the multi-stakeholder platforms. The communities engaged in CS are getting better organized, but the contribution to the SDGs through the multi-stakeholder platforms depends on many factors such as the degree of institutionalization in each country, the infrastructure of involvement, and the willingness of national institutions to collaborate with CS organized groups or networks.
b) Influence through contribution to each of the SDGs individually, by actions that contribute to addressing sustainability issues and themes, i.e. nature conservation, climate change, health, etc.	Although environmental contribution is considered a strong point for CS, tackling sustainability can depend on outreach to society through project structure and governance. Usually, CS projects, even small, cannot reach all layers of society for instance citizens with a tertiary education (Hecker et al. 2018).
c) Influence through involvement in the policy cycle	Citizen Science contribution in policy processes enhances science, society interactions and evidence-based policies. Yet, its impact is difficult to track due to the policy cyclic features and the space of scientific evidence for decision making (Bio Innovation Service, 2018). The Agenda 2030 addresses public participation in many targets, i.e. <i>Target 11.3, by 2030, enhance inclusive and sustainable organization and capacity for participatory, integrated and sustainable human settlements planning and management in all countries.</i> The integration of Citizen Science into policy remains challenging, because CS projects achieve multiple outcomes and contribute to different fields (Haklay et al., 2018).
d) Influence through education	Citizen Science contributes to the citizens' empowerment by subject competency and education. It complements Education for Sustainable Development (Pettibone et al., 2016), and Global Citizenship, embraced in the Agenda 2030 in Targets 4.7, 12.8, 13.3. Citizen Science can address Goal 4 in quality education by being included in the curricula, as an educational tool that combines non-traditional and traditional learning (DITOS, 2019a). While in relation to civic education, it fosters a broad

scientific mentality, encouraging democratic engagement and addressing complex modern problems (Ceccaroni, 2017).

e) Influence through the SDGs' monitoring and reporting, as a source for data provision

The complicated process of the SDGs' data management and monitoring requires additional sources of data provision. Data provided by CS-related activities can be valuable for the national statistical offices or the UN Statistical Office, i.e. as a non-traditional data source. Citizen Science is also acknowledged as a complementary source by policymakers for environmental policies, environmental monitoring and reporting, especially valuable for early warnings of environmental issues (European Commission, 2017).

125

126 The objective of the study is to explore several “collaboration channels” for Citizen Science
 127 and the Agenda 2030 for Sustainable Development, by analysing challenges and critical
 128 aspects, and by providing a framework of interaction from the top-down and bottom-up
 129 prospective in order to encourage a broader and more effective engagement. The analyses are
 130 based on information from the current practices and opinions of practitioners, researchers,
 131 scientists, policy makers, citizen scientists, and organizations that involve citizens in scientific
 132 projects, and representatives of CS networks.

133

134 **3. Methodology**

135 In order to provide a better understanding of the contribution of CS to the implementation of
 136 the SDGs, an international survey was performed. At first, a list of topics of interest was
 137 developed and reviewed by the authors, aiming to ensure that all pertinent questions were
 138 considered and to remove potential overlaps among them. The survey was then disseminated
 139 using the online application Google Forms, and responses were collected between March and
 140 July 2019. The survey was composed of 11 questions encompassing the “collaboration
 141 channels” (a), (b), (c), (d), and (e), as displayed in Appendix 1, including the respondents' role
 142 in CS, forms of engagement in CS-related activities, forms of participation in the SDGs'

143 processes, and, in particular, the involvement with each Goal. Furthermore, questions about
144 the motivation for CS to contribute to the SDGs, critical points, challenges and opportunities
145 were also assessed.

146 The survey was designed to collect data from a wide audience, including practitioners from
147 diverse disciplines, citizen scientists, policy makers and researchers. The authors disseminated
148 the survey by email to the network of the Citizen Science COST Action and to other networks
149 or CS national or international platforms and projects, as presented in Appendix 2.
150 Furthermore, the office of Inter-University Sustainable Development Research Programme
151 (IUSDRP), (<https://www.haw-hamburg.de/en/ftz-nk/programmes/iusdrp.html>), disseminated
152 the survey by email to the researchers connected to IUSDRP. As stated in the introductory note
153 about the survey, knowledge about Citizen Science was fundamental for participation, as
154 respondents were to express their opinions based on their personal experience. The survey was
155 also applied (and disseminated to the participants) during two workshops organized by the
156 COST Action CA15212: 1) Workshop of WG4 and EU-Citizen Science: co-creating the
157 European Citizen Science platform of the future and the 2) Workshop of WG5, on citizen-
158 science ontology, standards and data.

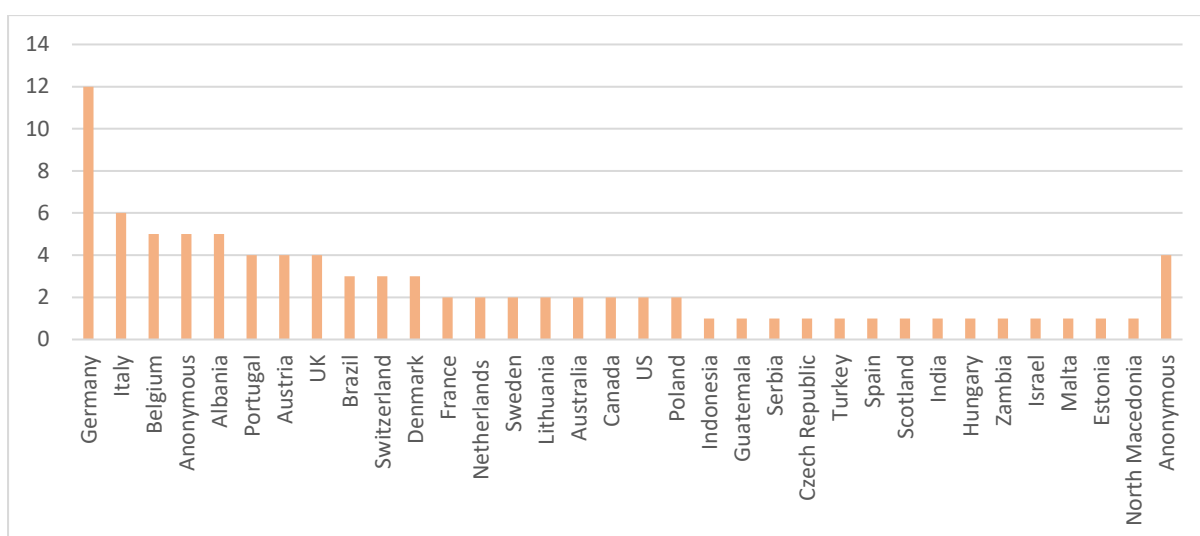
159 The survey results were analysed through simple descriptive statistics in order to summarize
160 and combine the collected information. Quotes from open spaces were used to support the
161 results, presenting real and practical experiences/concerns from the respondents. These
162 responses were investigated through content analyses and its inductive approach – in which the
163 organisation of responses includes open coding, creation of categories, and abstraction (Elo &
164 Kyngäs, 2008).

165

166 **4. Results**

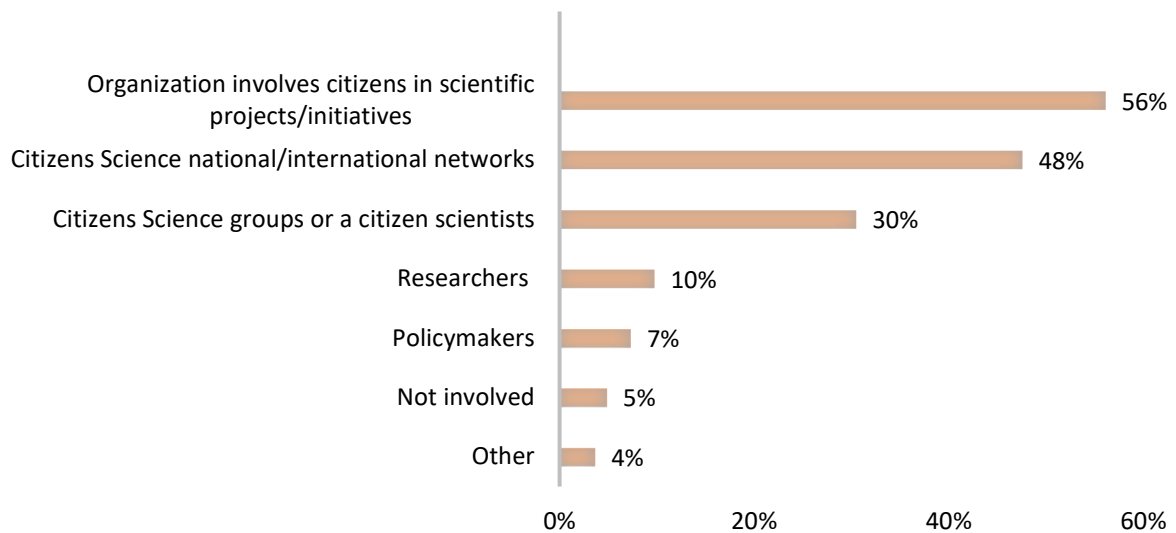
167 This section presents an overview of the survey findings, related to the respondents' countries
 168 and role to CS, their contribution to the SDGs, the processes of implementation, motivation
 169 and challenges.

170 The survey received 84 responses in total and the respondents were based mainly in Europe
 171 (73%, n=61). The demographic distribution of the participants is detailed in Figure 1. It can be
 172 observed that approximately 21% of the respondents are from other continents and some of
 173 them (presented as "Others") opted for not stating their countries.



174
 175 Figure 1. Location of the 84 respondents and number of responses per country

176
 177 The majority of the respondents are part of organisations that involve citizens in scientific
 178 projects/initiatives or belong to the CS national/international networks. The percentages of
 179 respondents according to their role in CS are shown in Figure 2. Some participants who selected
 180 the option "Other" belong to organizations that coordinate CS projects, or are game creators or
 181 providers of data collection infrastructure for Citizen Science.



182

183 Figure 2. Group of respondents according to their role in CS (% , n = 84)

184

185 The gathered responses show that some efforts are already in motion to align the CS-related
 186 activities with the Agenda 2030 for Sustainable Development. While 31% of respondents stated
 187 that they are integrating the SDGs in existing CS projects or research and 25% are in the process
 188 of aligning policies with the goals, 12% indicated not having started this process. Most of the
 189 participants (60%), on the other hand, declared that they are working broadly on SDGs themes
 190 (i.e. health, water, biodiversity, education), which contributes indirectly to achieving the goals.
 191 The participants mentioned additional specific information about their involvement, as
 192 illustrated in the quotes in Table 2. In some cases, respondents also mentioned to be working
 193 with specific targets of some SDGs.

194

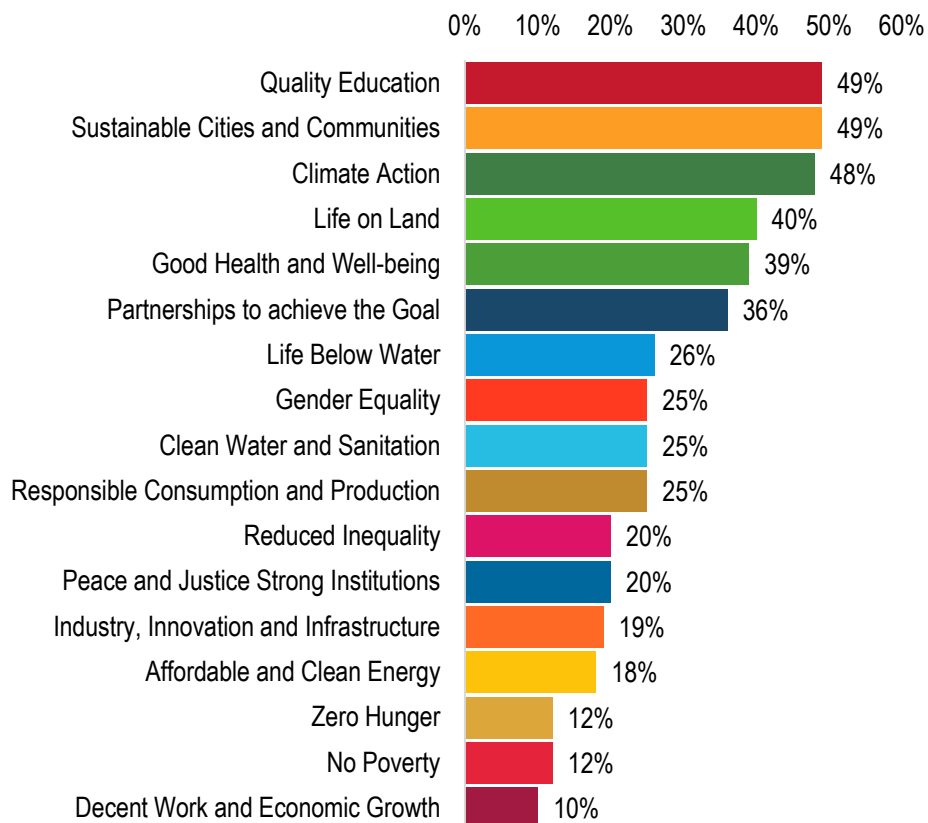
195 Table 2. Quotes presenting additional information on the alignment between CS and the SDGs

Main aspect	Quotes
SDGs and CS integration	<i>"A section for SDGs is being included in work for the preparation of the Ontology of CS, by Working Group 5, of COST Action CA15212".</i>
Align policies with SDGs	<i>"Our infrastructure implements standards-based data and metadata capture which should allow for citizen science data to be more readily used in data analysis for SDGs".</i> <i>"ECSA is part of CS GP which is working to link CS with SDGs".</i>

Work with specific Targets	<i>“Including citizens to record data to map invasive alien species, it aligns with target 15.8 “By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species” and indirectly with other SDGs in terms of increasing awareness on environmental issues, and increasing scientific literacy”.</i>
Research	<i>“In my PhD research I linked CS with the notion of the “commons” that is with the idea of sustainability and accessibility” “I research if and how policy making guidelines such as Agenda 2030 are “done”/practiced during CS activities connected to museum public engagement”.</i>

196

197 Regarding respondents’ work with specific Sustainable Development Goals, Figure 3 presents
 198 a ranking from the most to the less used SDG. Goals 4 (Quality Education), 11 (Sustainable
 199 Cities and Communities) and 13 (Climate Action) were the most selected ones, following the
 200 same trend presented by Salvia et al. (2019).



201

202 Figure 3. Ranking of the most used SDGs by the survey respondents

203

204 When it comes to the goals prioritised by countries with higher number of respondents, there
 205 are some interesting differences. For Germany, the goals are 4, 5, 11, 12, and 13; Italy has
 206 SDGs 13, 15, and 17; Belgium has the goals 2, 7, 11, and 12; and finally but not least: Albania,

207 with SDGs 10, 11. These topics tend to be related to the strengths and weaknesses of each
 208 region (Salvia et al., 2019), therefore being more researched by CS as well.

209 The respondents of this survey participate in the SDGs implementation processes through
 210 creation of partnerships or collaborating with existing networks (32%), and through actions
 211 organized by national/local entities or by international organizations (29%). Furthermore, 30%
 212 of them invite CS groups or networks in national/local initiatives, i.e. to participate in public
 213 consultations and expert workshops. 23% of the respondents are not participating in SDGs
 214 related processes. Other forms of participation, mentioned by 13% of the respondents, mainly
 215 related to dissemination and engagement, are shown in the quotes in Table 3:

216 Table 3. Quotes presenting additional forms of participation in SDGs processes

Main aspect	Quotes
Support in implementing actions related to the SDGs	<p><i>"We support scholars to implement projects that feature SDGs, including teachers and students"</i>.</p> <p><i>"We shape the projects we implement and some of these are actively engaging with SDGs"</i>.</p> <p><i>"By considering SDGs in the new EU Common Agricultural Policy indicators"</i>.</p>
Promoting awareness and local actions	<p><i>"By letting citizens address their own concern, with small action all around the globe for fixing local issues can help fixing global issues"</i>.</p> <p><i>"Awareness raising, simulation of local action"</i>.</p> <p><i>"By empowering citizens so they can address SDGs"</i>.</p>
International efforts	<p><i>"Contributing to international efforts on data and metadata standardisation and data mobilisation to data aggregators"</i>.</p> <p><i>"Integration into curriculum (K-12 and Higher Education) and weave into community science, including the global City Nature Challenge"</i>.</p>

217

218 Providing general data to fill the gaps of information for the 17 Goals is considered very
 219 important by 69% of the respondents, while 45% of them find it more useful to concentrate on
 220 the data for the environmental indicators. 48% consider it important to channel the data through
 221 national reporting and monitoring platforms and 30% through UN statistical offices. Other
 222 forms of data provision, selected by 13% of respondents are explained in the quotes in Table
 223 4:

224 Table 4. Quotes presenting additional forms of data provision

Main aspect	Quotes
National reporting	<p><i>"I find it important, through the national reporting and monitoring platforms because I think the data could certainly contribute to that, although I have no knowledge of those platforms in my country; however, CS data are already widely in use for meeting environmental reporting obligations".</i></p> <p><i>"Provide insight into the actual perception and penetration of SDGs in various sectors".</i></p>
Disaggregation	<p><i>"By establishing new indicators for those SDGs that don't have a specific indicator yet".</i></p> <p><i>"CS data serve not only for filling gaps but also adding complementary views".</i></p> <p><i>"There is scope for CS to not just provide data, but also raise awareness of the challenges".</i></p>
Non official channels	<p><i>"Through community non official data that can be contrasted with national environmental data".</i></p> <p><i>"By involving communities in their own implementation of SDGs, creating models for development of SDGs and understanding current bottle necks in some developments from a social perspective so that they can be efficiently tackled".</i></p>

225

226 Regarding the elements of the Agenda 2030 which can engage the cooperation of Citizen

227 Science, the expressed opinions were also balanced: 61% of the responses pointed out the

228 Educational element (including sustainable living and global citizenship); 56% highlighted the

229 importance of Collaboration and partnerships; and 54% of the responses identified the

230 participatory character of the Agenda 2030 as significant for CS efforts. Additional elements

231 mentioned by the respondents are explained in the aspects and quotes of Table 5:

232 Table 5. Quotes presenting additional opinions about the important elements of the Agenda
233 2030 for CS

Main aspect	Quotes
Institutionalization	<p><i>"Specific clarity and guidance around where gaps in SDG knowledge/data exist and clear project ideas, methods and protocols for community participation. It is critical that participatory projects be driven/promoted with a strong and simple goal focus and be well supported".</i></p> <p><i>"There is no actual enforcement"</i></p> <p><i>"I think that CS and SDGs are very close, regardless of the recent label SDGs".</i></p> <p><i>"CS and policymakers need to work in partnership or else the citizens will just do their own thing. They are not just a cheap labour force without their own agenda. Much can be achieved with CS, but it is not a panacea for the world's problems".</i></p>
Specific Goals	<p><i>"Promoting gender equality and social inequalities".</i></p> <p><i>"Specific Goals, such as SDG4, SDG5, and SDG17".</i></p>
Education and values	<p><i>"CS is a great way to teach science with plenty of added value. It should be integrated into schools' curricula".</i></p> <p><i>"Linking to the SDGs is essential for CS. It will support efforts to achieve the SDGs, but more importantly it will raise CS awareness for SDGs, and progress toward them".</i></p>

234

235 Regarding some of the challenges or obstacles that prevent CS from engaging with the SDGs,
 236 the lack of awareness for SDGs is the most considered by 64% of the respondents. Other
 237 problems are related to the lack of infrastructure of involvement (55%), data reliability,
 238 accuracy and ownership (38%), exclusiveness of CS related activities by institutions (36%),
 239 and the voluntary character of CS contributions by 33% of respondents. Other problems stated
 240 by 16% of participants include the information explained in the quotes in Table 6:

241

242 Table 6. Quotes presenting additional challenges that prevent CS in engaging with SDGs

Main aspect	Quotes
Political and institutional aspect	<p><i>"SDGs are a political tool, not sure if the citizens need to work with it".</i></p> <p><i>"To achieve something they believe in, politics make a link and 'box' it into SDGs Square".</i></p> <p><i>"The Goals are for policymakers, they are not for citizens".</i></p> <p><i>"CS projects could not be interested in policy making activity and prefer to focus on the local/community level without scaling up to global/institutional level".</i></p> <p><i>"Low credibility of official entities which promote SDGs, often hypocrite and/or using double standard"</i></p> <p><i>"Lack of capacity of National Statistical Offices to handle non-traditional data, their resistance to new data sources, data quality issues, etc. "</i></p>
Resources	<p><i>"Lack of funding from the National Statistics Offices and related public bodies".</i></p> <p><i>"For statistical offices, CS data is perceived to lack representativeness, too much bias".</i></p> <p><i>"Financing opportunities for long-term CS projects".</i></p>
SDGs aspects	<p><i>"Intrinsic contradictions/ target conflicts".</i></p> <p><i>"For indicators at global level, CS data has not the right coverage".</i></p> <p><i>"The lack of guaranteed delivery in the future".</i></p> <p><i>"Should be transparent the communication of SDGs".</i></p>
Educational institutions challenges	<p><i>"Academic reward schemes, deficit models in public engagement".</i></p> <p><i>"Pressure on school curricula, they may not feel they have space on SDGs".</i></p> <p><i>"Institutional mechanisms at higher education institutions supporting CS"</i></p>
CS limits	<p><i>"The term CS is very confusing, it's very broad and covers many definitions, and maybe it could be good to fix that first".</i></p>

243

244 Reasons for the motivation of individuals, groups or organizations involved in CS activities to
 245 contribute to the SDGs are very diverse. "Recognition" is the most selected reason (54%),
 246 followed by "possibilities for new partnerships" (48%), and "financing opportunities" (38%).
 247 Additional reasons stated by 29% of respondents include added value, peer pressure, ideology
 248 and responsibility, as shown in this sample of quotes in Table 7:

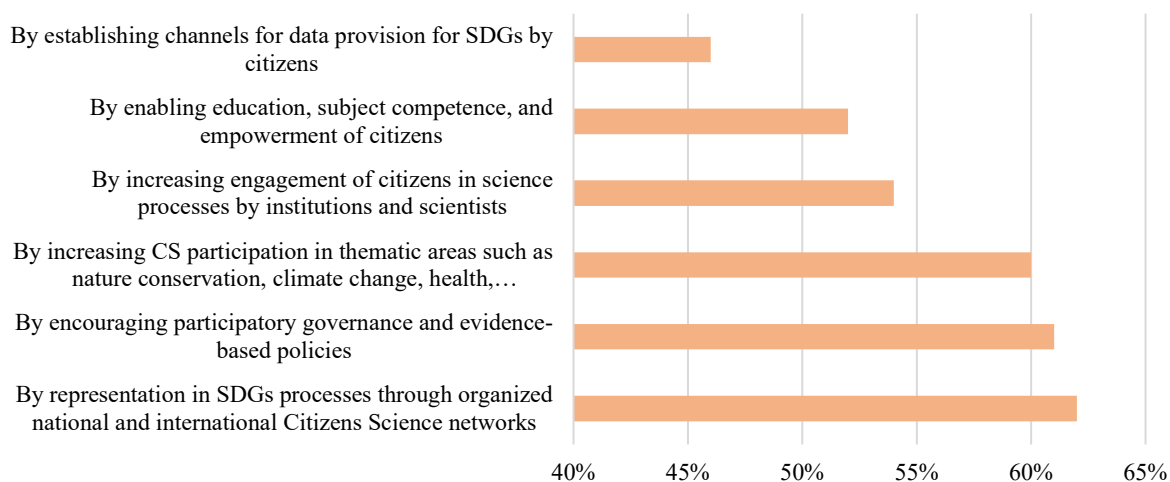
249 Table 7. Quotes presenting additional reasons of motivation of CS to SDGs

Main aspect	Quotes
Added value	<i>“Transformer role of Science in Society”.</i>
	<i>“A good context for work on Education for Sustainable Development”.</i>
	<i>“Impacts on participant’s life such as health effects of air pollution”.</i>
	<i>“Relevance and impact of CS if aligned with SDGs”</i>
Peer pressure	<i>“Creates new types of data, added value, and opportunities for financing, especially from big conservation NGOs”.</i>
	<i>“The others do it, so you have to do to”.</i>
Ideology and responsibility	<i>“Local communities and local experts should be involved in the implementation of SDG using a bottom-up approach”.</i>
	<i>“I think that CS is intrinsically linked with SDGs, explicitly or not”.</i>
	<i>“Contribute to big issues affecting humanity and the planet”.</i>
	<i>“Explicitly doing CS to reach SDGs”.</i>
	<i>“The opportunity to make an impact on society and environment”</i>
	<i>“Overarching societal goals, linked with projects and ‘co-benefits’”.</i>

250

251 While there is a general understanding that CS can contribute to reaching the SDGs and feed
 252 into the 2030 framework, the responses show balanced opinions on how this contribution can
 253 be increased, as presented in Figure 4.

254 Figure 4. Initiatives to increase the contribution of CS towards the SDGs



255

256 More opinions were expressed in the option “Others” and are explained in the quotes in Table

257 8:

258 Table 8. Quotes presenting additional opinions how CS contribution to the SDGs can be
 259 increased

Main aspect	Quotes
-------------	--------

International aspect	<p>“By supporting the already existing CSGP in their work with the UN (hopefully beyond environmental issues)”.</p> <p>“By complementing and following up global efforts on national, regional and local scale, in a coordinated manner and in collaboration with Citizen Science associations (where they already exist)”.</p>
CS standard	<p>“Through developing standards for CS data, working closely with NSOs and UN custodian agencies, etc”.</p> <p>“By placing this work in the context of citizen generated data”.</p> <p>“Through making finance available for CS projects that adhere to SDG”</p>
Research and education	<p>“Through education of professional scientists”.</p> <p>“Researcher-driven partnerships and projects with citizen participants”</p> <p>“Through research on the potential of CS to implement the SDGs and in particular on the transformational learning aspects within CS projects to implement the SDGs”.</p>

260

261

262 5. Discussion

263 5.1 Critical aspects for Citizen Science and the Agenda 2030 for Sustainable Development
264 according to the 5 “collaboration channels”

265 While similar critical elements in respect of the concept of citizen science in relation to
266 sustainable development exist, this paper specifically focuses on the differences amongst
267 those. Therefore, Table 9 presents the two perspectives considered: 1) The Agenda 2030
268 political perspective and 2) the Citizen Science perspective, with the purpose to point out to
269 possible problems and challenges.

270 Table 9. Critical aspects for each of the 5 channels of collaboration from the Citizens Science
271 perspective and the Agenda 2030 for Sustainable Development perspective

Collaboration Channels	1. Critical aspects from Citizen Science perspective	2. Critical aspects from the Agenda 2030 perspective
a) Influence through representation of organized CS networks, in the multi-stakeholder partnerships and engagement mechanism created for the SDGs, on the national and international level.	<p>Not all countries have organized CS communities or networks.</p> <p>CS is more widespread in developed regions (US, Europe, Australia).</p> <p>Not all countries have strategies of CS in place at national or local levels.</p> <p>No infrastructure of involvement in national or local levels. (55% of respondents)</p>	<p>Not all countries have created multi-stakeholder partnerships for SDGs.</p> <p>Not all the countries have extended participation of non-state actors to the national platforms or committees for SDGs.</p> <p>Differences in the country’s political will and commitment toward SDGs</p>

	The CS international networks and organizations do not have enough resources to be very active in the national or international platforms for SDGs	Difficulties in coordination and securing a fair representation of all stakeholders in multi-stakeholder platforms.
b) Influence through contribution to each of the SDGs individually, by actions that contribute to solving sustainability issues i.e. nature conservation, climate change, health, etc.	Citizen Science contribution is mainly for the environmental issues and environmental Indicators.	Difficulties to connect local sustainability challenges with SDGs.
	CS contribution is very low in some fields, i.e. agriculture.	Trade-offs and negative effects between some of the Goals.
	Participation of Citizen Scientists in projects for specific SDGs depends on the degree of involvement of the organizations or scientists.	Organizations need extra work and resources to identify the links to SDGs.
	Organizations do not explain the project connection with SDGs to the Citizen Scientists.	The ambiguity of organizations for SDGs can keep the projects contributing to the sustainability challenges, without feeding to the SDGs reporting framework. (Shulla et al, 2019).
	The participation doesn't extend to all level of citizens.	Lack of awareness for the Agenda 2030.
	Lack of the tools of technologies that allow CS to contribute, i.e., air quality, water quality.	
c) Influence through involvement in the policy cycle.	Exclusion of CS by institutions	Difficulties in aligning national and local agendas to the SDGs Targets and Indicators.
	Insufficient coordination	
	No official rules are in place by Public Institutions to include CS.	Lack of coordination at different levels and sectors.
	Lack of participatory approach in governance.	No commitment to the SDGs from local governments of some countries.
	Resistance from decision-makers and difficult to identify policy linkages.(Turbe et al. 2019)	
d) Influence through education	Confusion in CS of what is really learned by the participants.	SDG 4, on "Quality Education" influence all the Goals but there is no clear understanding of how (Shulla et.al 2020).
	Not always CS projects contribute to the empowerment or education of the citizens or increase their subject competency.	Long term process to receive the results of education.
	Lack of CS in the curricula.	Does not reach all levels of society.
	CS harvests only the knowledge of educated people.	Lack of awareness about the SDGs and lack of their communication
	Organizations or scientists that include citizens neglect to give the required training when necessary. Environmental ethics of companies drive environmental training and performance (Singh et al, 2019)	
e) Influence through the SDGs' monitoring and reporting, as a	No recognition of data provided by CS.	Slow process of data monitoring and reporting.
	Problems with data accountability, ownership, validity.	

source for data provision.	No infrastructure for data provision. Limitations in data portability, central to citizen science, for transferring the data to other sources (Quinn, 2018)	For some of the SDGs indicators, classified in Tier III, no internationally established methodology or standards are yet available (UNDESA 2019).
	No continuity after the project is closed. There is a major CS contribution on the virtual level and provision of data on line, which make it difficult to feed to the SDGs monitoring framework.	No infrastructure capacities for harvesting unofficial and non-traditional data.

272

273 **This table is based on the survey results, takes into account the available literature, and**

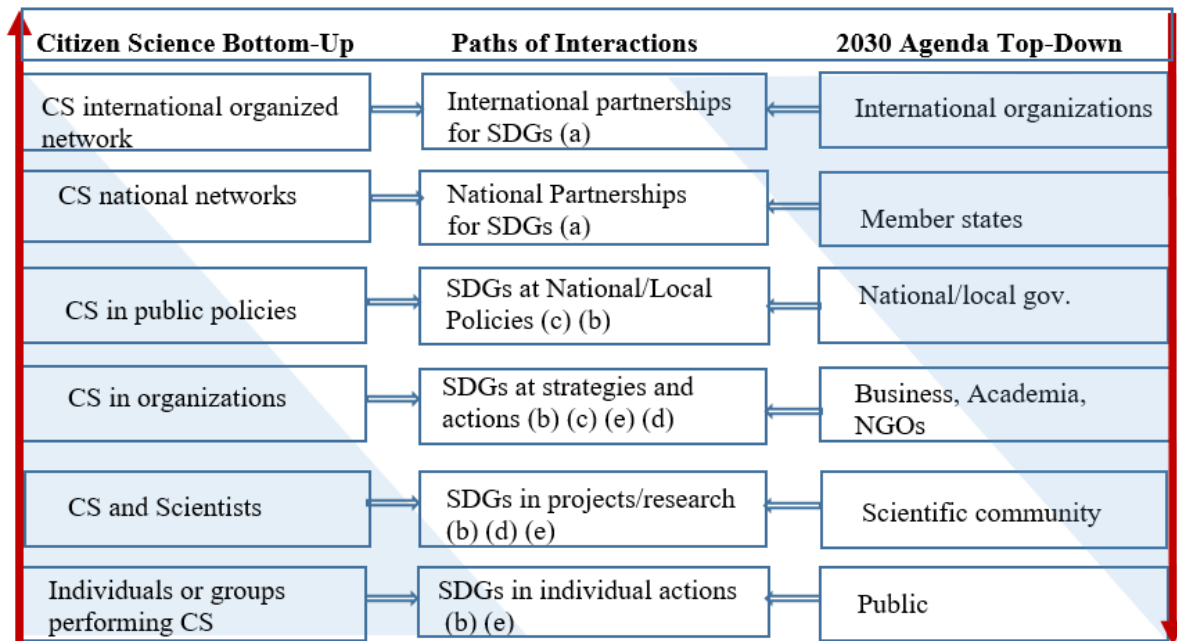
274 **the authors' reflections on this combination of resources.**

275

276 *5.2 Framework of interactions for CS and SDGs on different levels*

277 A framework for the potential interactions between CS and the SDGs is developed in order to
 278 explain a broader and more effective engagement. This model is based on different approaches
 279 (top-down and bottom-up) and involves specific actions, main actors, and potential
 280 collaborations. This framework is presented in Figure 6. It illustrates the paths of contributions
 281 between actors, identifying their connection with the collaboration channels (a) the
 282 representation of organized networks in the multi-stakeholder partnerships; (b) the contribution
 283 to each of the SDGs; (c) the involvement in the policy cycles; (d) education and (e) data
 284 provision, on different levels.

285 Figure 6. Framework of interaction for Citizen Science and the Agenda 2030 for Sustainable
 286 Development



287

288 The framework of interaction considers the paths of contribution by starting bottom-up for CS,
 289 in the sense that input coming from the citizens can influence more the Goals than other forms
 290 of engagement. Bottom-up examples, such as civic and DIY (Do It Yourself) projects have
 291 more potential for contributing to diversity in the SDGs (European Commission, 2017). The
 292 citizen's involvement in science can be either top-down, to generate data for scientists, or
 293 bottom-up, i.e. students or teachers raising new research questions (Mueller et al., 2012), but
 294 the level of engagement or position in the top-down and bottom-up spectrum can change during
 295 time. To support the growing movement of CS in Europe and beyond through communities
 296 and international players, both top-down and bottom-up approaches are necessary (Socientize,
 297 2013).

298 On the other hand, the influence of the Agenda 2030 for CS starts from the top-down, given
 299 the national commitments role. Paragraph 47 of the Agenda 2030 states that governments have
 300 the primary responsibility for follow-up and review of the progress, at the national, regional
 301 and global level, in relation to the progress made in implementing the Goals and Targets until
 302 2030 (UN 2015). Despite the encouragement, the bottom-up initiatives have not yet reached

303 all levels of society. For example, the German Federal Government, in order to implement the
304 SDGs, is committed to the “top-down” approach, but also supports the individual federal states,
305 and a wide range of actors to accelerate the “bottom-up” approach (Scholz et al., 2016). The
306 enforcement of the links between CS and the Agenda 2030 (as shown in Figure 6) implies
307 mutual benefits and bigger contribution to the 17 SDGs, as focus areas for the achievement of
308 sustainable development and the well-being of the people (UNSSC, 2019).

309 *5.3 Implications for each “collaboration channel”*

310 The results of this paper contribute to generate the following discussions, organised by
311 “collaboration channels”:

312 a) Channel (a): Influence through the representation of organized Citizen Science networks in
313 the multi-stakeholder partnerships and engagement mechanisms created for the SDGs, at the
314 national and international level

315 A certain degree of institutionalization is needed to participate in partnership processes for the
316 Goals, both on the national and international level. Organized CS groups or networks can be
317 more present in multi-stakeholder settings that national governments are organizing in order to
318 fulfil their SDGs commitments, for instance in national councils, inter-ministerial groups, and
319 multi-stakeholder committees for consultation processes (UNDP, 2017). Thus, an increase of
320 CS organized groups, where is not yet widely practiced, can facilitate their representation and
321 can diversify the engagement of non-state actors to the whole SDG processes. While the
322 coordination of European Citizen Science networks across Germany, Austria, Switzerland, and
323 Spain have resulted in active national online platforms (Strasser and Haklay, 2018), more
324 governmental support from other countries is needed to include CS in national strategies.
325 Furthermore, an agreement of citizen Science understanding and criteria must be established
326 to ensure consistency and data consideration by policymakers (Heigl et al., 2019). On the other

327 hand, the lack of a generally accepted definition of CS allows for methodical innovation and
328 considerable heterogeneity (Eitzel et al., 2017).

329 b) Channel (b): Influence through contribution to each of the SDGs individually, by actions
330 that contribute to addressing sustainability issues and themes, i.e. nature conservation, climate
331 change, health, etc.

332 Citizen Science has the potential to make a major contribution at the local level, as SDGs will
333 be delivered locally. Progress could be reached by including contribution and data from citizens
334 for Goal 11, “Sustainable Cities and Communities” (Klopp 2017), for example. Exploring
335 funding sources for this purpose would increase the resources for participation, as highlighted
336 by the quote of a respondent: “*Encouraging CS projects to incorporate SDGs into their funding*
337 *and reporting*”. Despite the voluntary character of CS, local governments can provide funding
338 programs for citizens with specific focus to the SDGs. [Often voluntary commitments](#)
339 [compromise the success of practices \(e.g. failures in the Corporate Social Responsibility on a](#)
340 [case study presented by Patnaik et al. \(2017\)\)](#). Investing in CS can help local governments to
341 facilitate the SDGs because participatory approaches and citizen involvement in policy making
342 are required to reach the several targets. CS can also help localize the SDGs, such as Goals 3,
343 4, 11, 13, 15, which were also among the Goals mostly chosen by the participants of this study
344 (see Figure 3). Community’s role for climate change adaptation is very important and can be
345 dependent on gender, values, individual point of views and places (Brink and Wamsler, 2019).
346 The contribution of CS projects in agriculture is low, but they can be useful for addressing food
347 safety and nutrition, which contribute to Goal 3 on health and well-being (Ryan et al., 2018).

348 c) Channel (c): Influence through involvement in the policy cycle

349 Stronger involvement of CS in the policy cycle **could** result in **a** better implementation of the
350 **Agenda 2030**, especially for achieving the Targets and Indicators that depend on participatory

351 practices. Governments can benefit from Citizen Science as a tool for public participation or
352 as a source to close information gaps (Hadj-Hammou et al., 2017). Successful participation can
353 also depend on how the participatory practices are designed. For instance, when designed as
354 research, apart from the learning, they can feed to data gathering and a better outreach of
355 science-policy in society (Damon, et al., 2016). Ineffective participation can increase decision-
356 making costs, but participation of the public and enterprises in the government processes can
357 increase the efficiency, e.g., air emissions control, and contribute to reaching the SDGs (Li et
358 al., 2018). **The influence of Citizen Science and community engagement in public health**
359 **policies is** increasing, mainly through contributing to health literacy, cohesion and rationality
360 (Den Broeder et al., 2018).

361 d) Channel (d): Influence through education

362 An increase of CS-oriented projects from organizations or individuals can also contribute to
363 the educational element of the **Agenda 2030**, by increasing the competence of the participants.
364 The selected quotes below were added as additional information from the respondents.

365 *Quote: “SDGs are more a vision of politics. When somebody takes part in the*
366 *project, they do not realize the dimension of the project. If SDGs are clearly*
367 *mentioned people would know what they do. Scientists must explain to the*
368 *participants of the project the link to SDGs. It is the task of organizations to make*
369 *the alignment”.*

370 *Quote: “CS projects often arise from a scientific problem which doesn't naturally*
371 *relate to the SDGs. However, finding the connections and highlighting them would*
372 *increase the success of both CS projects and SDGs”.*

373 Increasing the presence of CS in the private sector, civil society and academia is needed, but it
374 has to be based on equal terms of partnerships. Many companies and organizations are under a

375 lot of pressure to implement sustainability (Caiado et al., 2019). It can be achieved through
376 alignment with the Agenda 2030, integration of the SDGs into existing projects, and by
377 involving more citizen scientists and communicating the SDGs to them. It can require
378 innovation, which is important for [technology, economy and social development](#), (Oliva et al,
379 [2018](#)) and [organizational changes towards more sustainable policies and practices](#) (Jabbour et
380 [al, 2019](#)). Furthermore, [transformative leadership plays a role in green innovation and](#)
381 [environmental performance of organizations](#) (Singh, 2019).

382 e) Channel (e): Influence through the SDGs' monitoring and reporting, as a source for data
383 provision

384 Citizen Science data are important for the Agenda 2030, if integrated in the SDGs' reporting
385 and monitoring frameworks. The five dimensions of CS data- spatial, temporal, thematic,
386 process, and management, based on their various features appear to be valuable for the SDGs
387 (Fritz et al., 2019). They are particularly useful, if distinguished from traditional science data,
388 for instance in recording species in diverse areas where other methods are not possible
389 (Klemann Junior et al., 2017). [Managing big data, from a variety of sources, can help](#)
390 [companies overcome technological challenges](#) (El-Kassar and Singh 2017), and [facilitate the](#)
391 [development of their sustainable capabilities](#) (Singh and El-Kassar, 2018). Citizen-generated
392 data can improve monitoring practices by offering alternative measurement methods
393 (Lämmerhirt 2018). The e-infrastructure of data provision is an important aspect of CS, because
394 CS often happens on the virtual level. "Online citizen science" can reinforce scientific research
395 infrastructure with very few resources (Nov, 2014). In order to foster specific policies, CS
396 programs should keep their internal sustainability through internal evaluations, publishing
397 studies and leadership diversity (McGreavy et al., 2016). Effective tools for integrating CS
398 data to the SDGs framework should be established, (for instance e-infrastructure of SDGs data
399 reporting and monitoring) and open access to CS research should be encouraged.

400 **Conclusions**

401 Citizen Science and the SDGs share the same values for global sustainability challenges and
402 empowering people. The partnership character of the Agenda 2030 allows for collaboration at
403 different levels of society, and envisions the voluntary contributions that are often overlooked.
404 Citizen Science has multiple outcomes, and every single commitment is essential for the SDGs.
405 Citizen Science commitments to sustainability can comprise not only sensitive environmental
406 issues but address all three dimensions of sustainability.

407 The results of this study indicate a big potential of **interactions** through the five “collaboration
408 channels”. The results point out to the involvement of Citizen Science activities mainly with
409 SDG 4 “Quality Education”, SDG 11 “Sustainable Cities and Communities”, SDG 13 “Climate
410 Action” and SDG15 “Life on Land”; to the need for institutionalization of CS representation
411 in the national and international SDGS processes; to the importance of CS data infrastructure
412 for the SDGs monitoring framework; to the mutual benefits of CS and SDGs from
413 strengthening education and competencies; to the increase of presence of Citizen Science in
414 companies through fair partnerships; and to the importance of Citizen Science in the policy
415 cycles which helps the governments in fulfilling their commitments to the SDGs. Enforcement
416 of CS links and paths of interaction with the SDGs can increase CS recognition and
417 acknowledgment as a valuable source of contribution for sustainable societies. It can also help
418 citizens and organizations to develop a better awareness of the value of the Agenda 2030 for
419 the Sustainable Development.

420 **Implication for Theory and Practise**

421 The study contributes to the literature on Citizen Science. It explores the role of the CS
422 discipline in achieving the global objectives toward a sustainable society. Regarding practical
423 contributions, it supports the CS community, practitioners and policy makers by providing

424 better insights and hints for synergizing their work and raising awareness about the potential
425 of CS contributions for the Agenda 2030. Furthermore, the study contributes to the research on
426 the Agenda 2030 and the SDGs, and the necessary collaborations needed between disciplines
427 and actors. It points out critical aspects of these contributions and gives practical
428 recommendations for increasing CS involvement with the SDGs.

429

430

431 **Limitations of the study and suggestions for future work**

432 Reaching a greater number of participants in the online survey would have certainly
433 strengthened the results of this study, as it would have assured a wider and more diverse
434 representation of participants, since a major part of them belong to national or international CS
435 networks or organizations. The aim was not to narrow the results by focusing only on network
436 administrators, but instead to welcome responses and insights from a wide range of CS
437 practitioners with various disciplinary backgrounds. The majority of the participants are from
438 Europe, so the relatively small sample size of participants from the other continents does not
439 allow for representation of a larger population. The sample represents the overall group
440 surveyed, and despite being a small sample, the data reliability is assured since the sample is
441 composed of researchers who are really engaged with Citizen Science and familiar with its
442 concept and practice.

443 The optimal sample size was not calculated in advance, as it was expected to reach the largest
444 possible number of participants, considering their availability and degree of involvement. The
445 Cost Action on Citizen Science community network is composed of about 275 practitioners.
446 Thus, the response rate is approximately 25%, which includes also the participants from other
447 domains as described in the methodology.

448 More participation from citizen scientists and policymakers would have provided a better and
449 more representative understanding of their points of view. For this purpose, dissemination to a
450 broader audience outside the above groups would have obtained more diverse results. Another
451 limitation of this study is the lack of information on examples or case studies of current actions
452 of CS and the SDGs related activities.

453 Future research should focus on the different channels of CS contributions for the
454 implementation of the Agenda 2030 for Sustainable Development and in identifying new forms
455 of cooperation. More specifically, future research can consider the following:

- 456 - Governance aspects of Citizen Science organized networks and institutionalization of
457 CS actions for SDGs
- 458 - Financial aspects of Citizen Science and SDGs
- 459 - Citizen Science and SDGs in developing countries
- 460 - Citizen Science's role for thematic issues of the SDGs related to, for instance, climate
461 change, agriculture, sustainable cities, education etc.
- 462 - Role of Citizen Science for localizing the SDGs, by contributing to the attainment of
463 the SDGs Targets related to participatory planning and public involvement
- 464 - Citizen Science's contribution to sustainable development in different sectors, such as
465 the private sector, civil society, the public sector and academia
- 466 - Citizen science, Global Citizenship and Education for Sustainable Development
- 467 - Exploring tools to integrate CS data in the SDGs framework

468

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751 **Appendix 1. Summary of the survey instrument**

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Survey: The role of Citizen Science for the Sustainable Development Goals

1. Where are you located?

My organization involves citizens in scientific projects/initiatives; Part of

2. What is your role in Citizen Science?

CS national/international networks; Part of CS groups or a citizen's
 scientist; Policymaker; Not involved; Other

3. How do you align your CS work with the
 Agenda 2030 for Sustainable Development?
 (multiple answers possible)

Integrating SDGs to the CS existing projects; Working broadly on SDGs
 themes (i.e. health, water, biodiversity, education etc.); Align policies with
 SDGs; Not aligned with SDGs; Other

4. Do you identify your CS work with any
 specific Goals? (multiple answers possible)

List of the 17 SDGs and their descriptions

5. How do you participate in the SDGs
 processes? (multiple answers possible)

Through creating partnerships or collaborating with existing partnerships
 for SDGs; By participating in SDGs implementation processes, national
 local or international; By inviting CS groups or networks in national/local
 initiatives; Do not participate; Other

6. How can CS provide data for the SDG?
 (multiple answers possible)

Providing general data to fill the gaps of information; Mainly provide data
 for environmental indicators; Through UN statistical offices as 'non-
 official' data providers for the SDGs; Through national SDGs reporting and
 monitoring platforms; Other

7. What motivates CS to align with SDGs?
 (multiple answers possible)

Recognition; New partnerships; Financing opportunities; Other

8. What are the barriers and challenges for CS toward the SDGs? (multiple answers possible)	Lack of awareness toward SDGs; No infrastructure of involvement; Exclusiveness by institutions; Problems with data reliability, accuracy and ownership; Voluntary character of contributions; Other
9. According to your opinion, how can CS contribution toward the SDGs be increased? (multiple answers possible)	By representation in SDGs processes through organized national and international Citizen Science networks; By increasing engagement of citizens in science processes by institution and scientists; By increasing CS participation in thematic areas, as nature conservation, climate change, health, education etc.; By encouraging participatory governance and evidence-based policies; By establishing channels for data provision for SDGs by citizens; By enabling education, subject competence and empowerment of citizens; Other
10. Citizen Science cooperate between science, education and civic engagement, what elements of Agenda 2030 enforce that?	Educational element, including sustainable living and global citizenship; Participatory character; Collaboration and partnerships; Other
11. Please let us know if you have any comments or wish to add/highlight anything.	

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754 **Appendix 2. Citizen Science networks, platforms and projects which received the survey**

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Citizen Science Cost Action CA15212	https://www.cs-eu.net
European Citizen Science Association (ECSA)	https://ecsa.citizen-science.net/
WeObserve Project	https://www.weobserve.eu/
International Institute for Applied Systems Analysis (IIASA)	https://www.iiasa.ac.at/
EU-Citizen.Science project	http://eu-citizen.science/
Doing it Together Science	http://www.togetherscience.eu/
Australian Citizen Science Association (ACSA)	https://citizenscience.org.au/
Atlas of Living Australia	https://www.ala.org.au/
Stifterverband	https://www.stifterverband.org/veranstaltungen/2016_06_23_citizen_science
OpenAIRE	https://www.openaire.eu/

