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Using new data sources for policymaking

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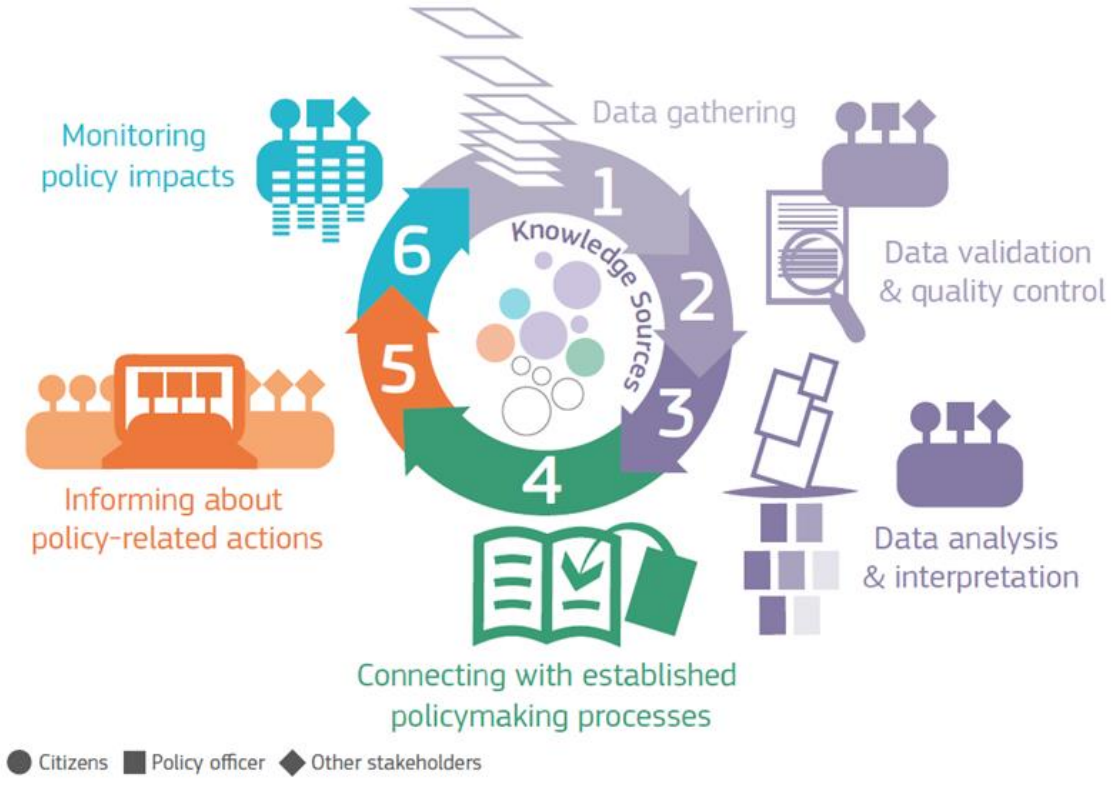

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Authors

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Abstract

This JRC technical report synthesises the results of our work on using new data sources for policy-making. It reflects a recent shift from more general considerations in the area of Big Data to a more dedicated investigation of Citizen Science, and it summarizes the state of play. With this contribution, we start promoting Citizen Science as an integral component of public participation in policy in Europe.

The particular need to focus on the citizen dimension emerged due to (i) the increasing interest in the topic from policy Directorate-Generals (DGs) of the European Commission (EC); (ii) the considerable socio-economic impact policy making has on citizens' life and society as a whole; and (iii) the clear potentiality of citizens' contributions to increase the relevance of policy making and the effectiveness of policies when addressing societal challenges. We explicitly concentrate on Citizen Science (or public participation in scientific research) as a way to engage people in practical work, and to develop a mutual understanding between the participants from civil society, research institutions and the public sector by working together on a topic that is of common interest.

Acknowledging this new priority, this report concentrates on the topic of Citizen Science and presents already ongoing collaborations and recent achievements. The presented work particularly addresses environment-related policies, Open Science and aspects of Better Regulation. We then introduce the six phases of the 'cyclic value chain of Citizen Science' as a concept to frame citizen engagement in science for policy. We use this structure in order to detail the benefits and challenges of existing approaches – building on the lessons that we learned so far from our own practical work and thanks to the knowledge exchange from third parties.

After outlining additional related policy areas, we sketch the future work that is required in order to overcome the identified challenges, and translate them into actions for ourselves and our partners. Next steps include the following:

- Develop a robust methodology for data collection, analysis and use of Citizen Science for EU policy;
- Provide a platform as an enabling framework for applying this methodology to different policy areas, including the provision of best practices;
- Offer guidelines for policy DGs in order to promote the use of Citizen Science for policy in Europe;
- Experiment and evaluate possibilities of overarching methodologies for citizen engagement in science and policy, and their case specifics; and
- Continue to advance interoperability and knowledge sharing between currently disconnected communities of practise.

This report is complemented by a number of recent publications offering a closer view on some of the issues discussed in the document. They are directly flagged and referred in the relevant body of the text, and are listed below:

1. J. Williams, et al. (in press). Citizen-science data, how should you maximise their impact and sustainability? In: A. Bonn, M. Haklay, S. Hecker, A. Bowser, Z. Makuch and J. Vogel (eds.) Citizen Science – Innovation in Open Science, Society and Policy, UCL Press.
2. J.M. Rubio-Iglesias, et al. (in press). Citizen Science for better policy formulation and implementation. In: A. Bonn, M. Haklay, S. Hecker, A. Bowser, Z. Makuch and J. Vogel (eds.) Citizen Science – Innovation in Open Science, Society and Policy, UCL Press.
3. S. Luna, et al. (in press). Developing mobile applications for environmental and biodiversity citizen science: considerations and recommendations. Multimedia Tools and Applications.

4. A. Bowser, et al. (in press). Citizen Science Association Data & Metadata Working Group: Report from CSA 2017 and Future Outlook, the Wilson Center.

5. U. Sturm, et al. (2017). Defining principles for mobile apps and platforms development in citizen science. Research Ideas and Outcomes 3: e21283 (10 Oct 2017), DOI:https://doi.org/10.3897/rio.3.e21283.

6. L. Bastin, S, Schade and C. Schill (2017). Data – and metadata management for better VGI reusability. In: L. See (ed.). Final book of COST Action IC1203: ENERGIC.

7. L. Bastin, S. Schade and P. Mooney (2017). Standards, encodings and tools for assessing fitness-for purpose. In: Bordogna, G. and P. Carrara (eds.). Mobile information Systems leveraging Volunteered Geographic Information for Earth Observation, Springer.

8. J. Lisjak, S. Schade and A. Kotsev (2017). Closing Data Gaps with Citizen Science? Findings from the Danube Region. ISPRS Int. J. Geo-Inf. 2017, 6(9), 277; DOI:10.3390/ijgi6090277.

9. S. Schade, C. Tsinaraki and E. Roglia (2017) Scientific Data from and for the Citizen. First Monday, Vol.22, August 2017.

10. A.C. Cardoso, et al. (2017). Citizen Science and Open Data: a model for Invasive Alien Species in Europe. Research Ideas and Outcomes 3: e14811 (04 Jul 2017), DOI:10.3897/rio.3.e14811.

11. U. Sturm, S. Luna, A. Albert, S. Schade, D. Kasperowski (Eds.) (2017). Report of the second workshop Defining principles for mobile apps and platforms development in citizen science: Interaction, Interoperability, Innovation, Gothenburg, April 25-27, 2017. Organized by Naturblick from the Museum für Naturkunde Berlin, University of Gothenburg and the European Citizen Science Association (ECSA).

1 Scope and Introduction

Following our earlier work on Big Data[1] we recently witnessed a strong trend within the community to discuss social aspects in science, and particular requests to address the peoples' dimension and point of view more explicitly, leading to what it is referred to as "technoscience". This included more contributions on possible ethical issues[2], but also the possible benefits of human computation[3], crowd sensing[4] and the like.

These developments were complemented by an increase of political messages about the "engagement" of citizen in science and policy-making. For example, the 2017 edition of the JRC Annual Conference "EU4FACTS: Evidence for policy in a post-fact world"[5] featured high level speakers such as European Commission (EC) Vice-President Jyrki Katainen and former Commissioner Pascal Lamy who postulated a deeper public engagement in policy and closer interactions between scientists, politicians and citizens.

Motivated by these developments and underlying principles, we decided to concentrate our work particularly on citizens' engagement in science for policy, and more specifically on Citizen Science. We consider Citizen Science as a concept that emphasizes on citizens' contributions, but at the same time also carries a strong data-centred dimension and is highly influenced by novel digital technologies in data gathering, management, processing and use. We investigated the arising benefits and challenges not only for policy-making (i.e. effective co-creation of new policies), but moreover – and especially also – for policy implementation and application, and for the monitoring of both, policy implementation and impact. This report provides a first synthesis of our initial findings.

The remainder of this document is structured as follows. In Section 2, we introduce the rationale supporting the increased attention given to Citizen Science. Section 3 summarises the many already established collaborations and joint achievements that provide a basis for future investigations on Citizen Science and a more integrated approach to citizen engagement along policy anticipation, making, implementation and evaluation. We then present the six-phased 'cyclic value chain of Citizen Science' as our integrated view on Citizen Science for policy in Section 4. This section also provides an overview of the major benefits and drawbacks that we identified based on our own work, desktop research and in discussion with colleagues and with Citizen Science practitioners. After pointing to additional policy areas that might be considered in the future (Section 5), we outline our future work and next steps in Section 6. In addition to the references underlying our work, we also provide a list of supporting EU policy documents and additional readings as annexes to this report.

[1] See, for example, S. Schade (2015) Big Data Breaking Barriers – First Steps on a Long Trail. 36th International Symposium on Remote Sensing of Environment Observing the Earth, Monitoring the Change, Sharing the Knowledge? p. 691-697 vol. XL-7/W3.

[2] See, for example, A. Delgado (Ed.), Technoscience and Citizenship: Ethics and Governance in the Digital Society, Springer, 2016.

[3] https://en.wikipedia.org/wiki/Human-based_computation

[4] R. Ganti, F. Ye, and H. Lei, Hui, Mobile crowdsensing: current state and future challenges". IEEE Communications Magazine. 49 (11): 32–39, doi:10.1109/MCOM.2011.6069707, 2011

[5] https://ec.europa.eu/jrc/en/eu4facts

2 Citizen Science and the policy-cycle

We see a strong need to concentrate more on the human/social dimension of (big) data handling. More than ever before, we witness requests for a more participatory approach to governmental decision-making that engages with more stakeholders, and involves citizens. 'Citizen engagement', 'citizen science', 'public participation', 'social innovation', and 'co-creation' are among the most prominent terms used in this context, all having a bottom-up/grassroots component in common.

While recognizing the need to reply to these general requests and improving the overall understanding of the underlying concepts and methodologies, we decided to focus our activities particularly on Citizen Science (or public participation in scientific research). Following the nature of the JRC as the EC's science and knowledge management service, we consider Citizen Science along the full EU policy cycle (see also Figure 1).

Figure 1: EU policy cycle (source: Better Regulation Agenda)

Citizen Science is a growing worldwide phenomenon, which describes the contribution of citizens to generate scientific information and knowledge (see Figure 2 for some impressions). Initially coined to generally describe local and traditional lay knowledge, Citizen Science refers today to a wide variety of activities ranging from mobilising the public to gather data, to the involvement of trained volunteers in interpreting data and providing solutions, to the full participation of citizens in science and policy cycles.

Figure 2: Citizen Science impressions, monitoring invasive alien species in the Danube Region (source: Teodora Trichkova)

Interest in Citizen Science has been rising rapidly during the last years, either in order to carry out research that would not have been possible otherwise, or to improve decision-making based on an evidence base that is extended with local and tacit knowledge. At the same time, it offers a unique opportunity to jointly explore, experience and exploit a topic of shared interest and thereby develop a common mutual understanding of the underlying issues and possible solutions.

Already in 2013, the Report on Environmental Citizen Science[6] recognised that the value of Citizen Science spreads across economic, social, scientific and political dimensions. It has a high potential to contribute to some of the Juncker's Commission priorities such as the "Digital Single Market" and "Democratic Change", especially through Better Regulation. In economic and scientific terms, the benefits of involving citizens in data collection are seen as a cost-effective way to gather the required evidence, detect emerging issues and fill in knowledge gaps, supporting public authorities to improve relevance and efficiency with less administrative burden. The awareness raising and educational aspects of engaging citizens in scientific research can also positively affect societal behavioural change, for example, on the attitude towards preservation of natural resources, littering, or issues affecting urban life. Politically, Citizen Science can help activating citizens, thrive democratic change, increase transparency and trust, and counter-play populism and post-truth politics[7]. A more detailed listing of EU policy support to Citizen Science is presented in Annex 1.

In order to meet these increasing policy requests, Citizen Science should be better integrated into the **EU policy cycle**, together with the provision of criteria, guidelines and tools that make this integration usable, relevant and useful for all participants, to eventually modernise knowledge creation and sharing. The collaborations between all stakeholders that could be involved in and affected by policy pose challenges. These challenges include, for example:

- Motivating and retaining the participation of European citizen, EU policy makers, scientists and all other relevant stakeholders, including the long-term sustainability of organisational structures.
- The mobilisation and proper use of Citizen Science data as part of the evidence base for effective and efficient policymaking.
- Reflections and evolutions on the notion of agency and definition of expert knowledge.
- Possible reconfigurations of the power relationships between direct and representative democracy.

With this in mind, it became our vision to **establish Citizen Science in Europe as an integral component of public participation in policy**. We address this vision by (i) developing a rigorous methodology to use Citizen Science along the policy cycle; and (ii) providing a technology platform – the Citizen Science Data Platform – that serves the enabling framework for targeted demonstrators of our approach (including, for example, data management, data validation and data integration) and as a means for knowledge exchange.

Whereas details about the Citizen Science Data Platform has already been provided previously[8] (see Figure 3 for impressions), the remainder of this report summarises our latest achievements to implement this vision, presents a structure to organise the required actions, and outlines our future work.

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[6] http://ec.europa.eu/environment/integration/research/newsalert/pdf/IR9_en.pdf

[7] http://www.economist.com/news/briefing/21706498-dishonesty-politics-nothing-new-manner-which-some-politicians-now-lie-and

[8] For more details see: EWOC: New data sources and citizens science platform (3826), Deliverable 201701 "Citizen Science Platform (Second Release)".

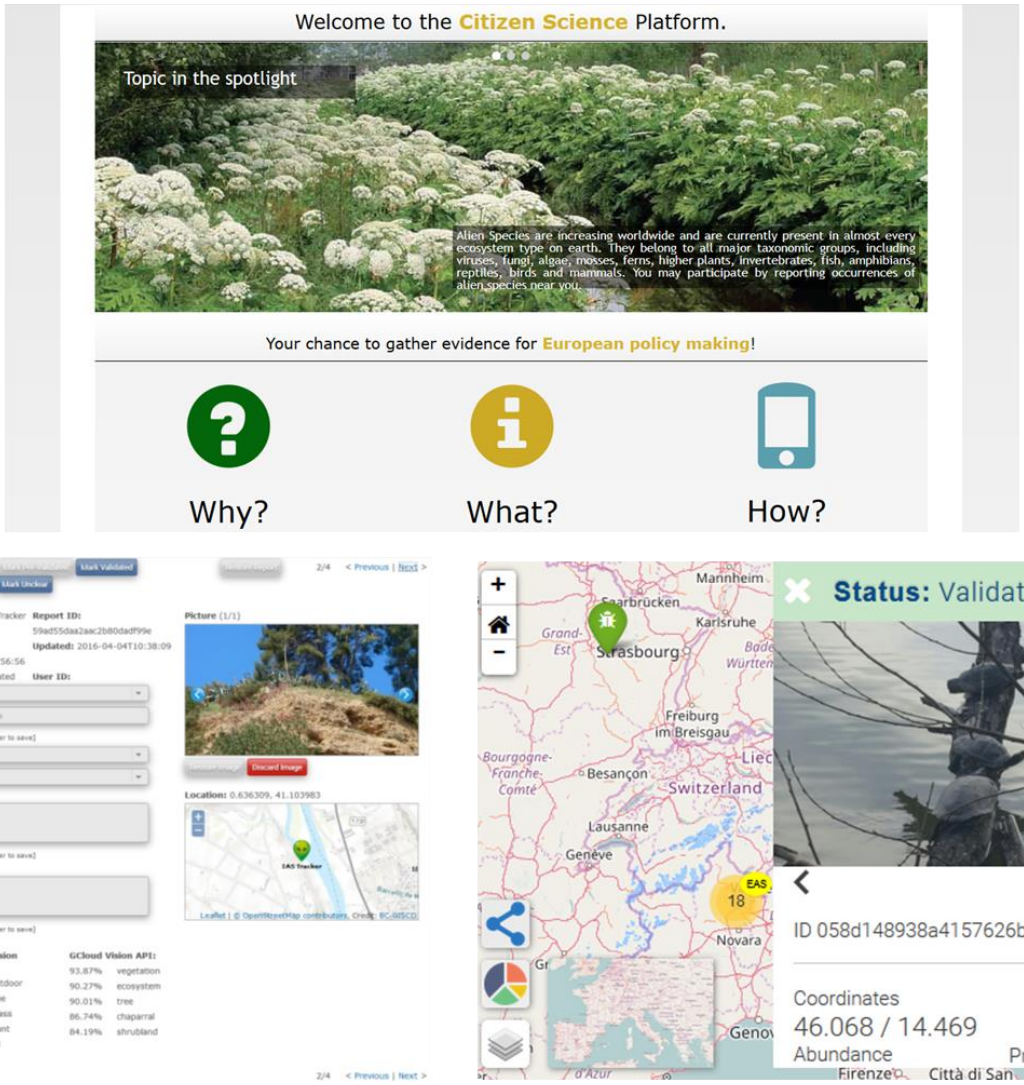

Figure 3: Impressions from the platform: overview (on top), data validation tool (bottom left) and visualization applied to invasive alien species application (bottom right)

3 Ongoing collaborations and achievements

While developing the Citizen Science Data Platform, we already took major steps in understanding the benefits and challenges of Citizen Science for policy by collaborating closely with colleagues inside and outside the Commission. At the same time, we succeeded to pair our own expertise with the needs and experiences of colleagues in policy DGs and agencies, and to take joint actions with EU-funded projects, as well as, with relevant world-leading organisations and networks. The findings from these activities contribute to both, the development of a robust methodology for using Citizen Science for EU policy, and the evolution of the platform.

In this section, we summarise our most central collaborations and achievements. Within the Commission those are focused on the interconnection with and support to policy DGs. Collaborations with stakeholders and partners outside the Commission context so far concentrate on the establishment of data sharing and interoperability standards for Citizen Science; improving the possible re-use of Citizen Science tools (applications and platforms); and the collaboration with highly relevant projects, networks and organisations in order to streamline activities so that the outcomes of the different lines of work are more meaningful to each other. It is largely the continuation and increase of these collaborations, which will empower our future work and determine our success in establishing Citizen Science in Europe as an integral component of public participation in policy

3.1 Collaborations and achievements inside the EC

A brief overview of the EC activities related to citizen participation in science and policy has been provided previously[9]. Below we highlight and provide an update of those activities that are most relevant to our work, and outline the results of our ongoing collaborations.

3.1.1 Environmental Citizen Science

The Environmental Knowledge Community (EKC) is an inter-service initiative between DG Environment (ENV), DG Joint Research Centre (JRC), DG Research and Innovation (RTD), DG Climate Action (CLIMA), DG Eurostat and the European Environment Agency (EEA). This collaboration was established in order to implement the 7th Environmental Action Program (EAP) and to meet the implicit need for better knowledge creation and exchange[10]. Whereas high-level decisions are taken once per year at DG-level, practical work is continuously carried out at desk officer level.

Under our lead, the EKC launched its Citizen Science activities at the DG-level meeting on 16 January 2016 in order to **explore the potentials of Citizen Science for environment-related policy in the EU**. The Citizen Science work of the EKC connects and interoperates between already existing technical systems and platforms in order to **leverage synergies and optimise knowledge re-use among the EKC partners**, while also carrying out **hands-on policy-focused demonstrators**. Intermediate results were presented at the DG-level meeting on 15 March 2017. This meeting led to the endorsement of the first EKC Policy Brief on Citizen Science[11], which highlights the major challenges and proposes a way ahead.

The work carried out so far underlines that Citizen Science can be a strategic tool for environmental policies, and has led to the **integration of actions on Citizen Science in three Commission documents**: the **Action Plan on nature, people and the economy** (COM(2017) 198 final), the **Actions to Streamline Environmental Reporting** (COM(2017) 312 final), and the ongoing work on **environmental**

[9] https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/citizen-engagement-science-and-policy-making

[10] See also http://ec.europa.eu/environment/action-programme/

[11] Recorded in the EC's Advanced Records System (Ares) on the 27th of April, 2017 (Ref. Ares(2017)2190526).

compliance assurance (and upcoming Communication). In addition, as Citizen Science can play a big role in opening up EU research to citizens, the Citizen Science group is contributing to strengthen citizens' engagement within the context of the **Open Science agenda** and of the **next EU Framework Programme on research and innovation**, also through dedicated funding. The regular work of the group has also attracted interest in the Commission beyond the environmental field, as providing best practices for better **integrating citizens in the whole EU policy cycle**, from policy consultations to compliance assurance.

As part of this collaboration, we developed dedicated demonstrators – **Citizen Science apps** which support EU policies on invasive alien species (in collaboration with JRC Unit D.2) and nature protection (in collaboration with JRC Unit D.6) – and those have been widely acknowledged in the Commission and in the Citizen Science community, including through increasing interest by Member States and positive mentioning by Commissioners. Additional fields and ongoing EU experiences (e.g. on marine litter, birds and pollinators) are also being investigated to derive further lessons.

Our joint outcomes and next steps can be summarized as follows:

Achieved deliverables (2016/2017 - *EC-oriented, understanding and capacities building)*

- **Development, testing and initial running of mobile phone applications** on invasive alien species (after intense testing in the Danube Region – see also Figure 2 - now being integrated in EASIN system)[12] and nature protection (Natura 2000)[13].
- **Validation workshop** on Phase 1 of the group with EC and outside experts, and **final report** (December 2016).
- **Policy brief** on Citizen Science endorsed by EKC DGs and **high level conference** on citizens engagement in science and policy for EC staff (March 2017).
- **Contribution to the Actions to streamline environmental reporting** (SWD(2017) 230 final), Action 8: " Promote the wider use of Citizen Science to complement environmental reporting".
- **Contribution to the Action Plan on nature people and the economy** (COM(2017)19), Priority Action D: "Better communication and outreach, engaging citizens, stakeholders and communities", point 14 (awareness raising, using technologies).
- Contribution to the Draft Communication on EU actions **to improve compliance in the field of environment**, Action 8: "Prepare a guidance document on good practices in the handling of environmental complaints and engagement of citizens at Member State level, including through Citizen Science".
- Position paper on Citizen Science and citizens engagement in next EU research & innovation programme, through informal inter-service group, October 2017.
- Development of an **EU community of practice on the use of Citizen Science for EU policies** (workshops with COST, European Citizen Science Association (ECSA), discussions with Member States about EKC apps, presentations to EEA Management Board and Scientific Committee, participation to Citizen Science group of the Network of European Environmental Protection Agencies (EPA), etc.).

[12] See also: http://digitalearthlab.jrc.ec.europa.eu/app/invasive-alien-species-europe
[13] See also: http://digitalearthlab.jrc.ec.europa.eu/app/mynatura2000

- Contributions to scientific journals and books (see the executive summary for details).

Upcoming deliverables (2018 – *moving into practise with Member States and practitioners*)

- **Repository of best practices** of Citizen Science activities feeding environmental policies, as part of the Citizen Science Data Platform that is hosted by the JRC. This repository will benefit from the DG ENV awarded tender "Study on an Inventory of citizen science activities for environment policies".
- Report on how Citizen Science can **enhance environmental monitoring in protected areas** in Europe (testing of the Natura2000 app with LIFE projects).
- Hands-on experiences of using Citizen Science to **detect and monitor invasive alien species** of union concern (in collaboration with scientific networks and Member State authorities).
- Consideration of **additional demonstrators** (e.g. in the areas of air quality, pollination, or marine litter).

Long term deliverables (up to 2020 – *reflecting on our work and wrapping-up*)

- **Guidelines** to promote the wider use of Citizen Science to complement environmental reporting.
- Full running of the **mobile app** that raises the awareness about Natura2000, including its supporting services as part of the Citizen Science Data Platform.
- **Handover of systems** for using Citizen Science for invasive alien species policy to an appropriate operational environment.
- **Integration of Citizen Science in the EU policy cycle**, beyond environmental policies.

The publication of the apps was further more supported by the Publication Office of the European Union (OP). Relationships with LIFE, the 7th Framework Program (FP7) and Horizon 2020 projects were facilitated by the Executive Agency for Small and Medium-sized Enterprises (EASME).

3.1.2 Citizen Science and Open Science

Citizen Science is one of DG RTD's pillars in the Open Science agenda[14]. It is supported by a dedicated group within the Open Science Policy Platform (OSPP)[15] and an informal inter-service group, which includes the JRC. In 2017, discussions took, for example place in relation to particular focus areas, such as invasive alien species[16], and as part of a dedicated policy round table on Citizen Science and Open Data, which was organised by the Horizon 2020 project Do It Together Science (DITOS)[17] with the participation of DG RTD, DG ENV and DG JRC.

As a result of this work, examples and recommendations for (primarily research) policy were put on table, including not only the re-emphasis on past work such as the socientize 'White Paper on Citizen Science' (asking for capacity building, guidance on data management, going beyond data collection with new forms of participation), but also

[14] https://ec.europa.eu/research/openscience
[15] https://ec.europa.eu/research/openscience/index.cfm?pg=open-science-policy-platform
[16] A.C. Cardoso, K. Tsiamis, E. Gervasini, S. Schade, F. Taucer, T. Adriaens, K. Copas, S. Flevaris, P. Galiay, E. Jennings, M. Josefsson, B. López, J. Magan, E. Marchante, E. Mon-tani, H. Roy, R. von Schomberg, L. See, M. Quintas, Citizen Science and Open Da-ta: a model for Invasive Alien Species in Europe. Research Ideas and Outcomes 3: e14811 (04 Jul 2017), DOI: 10.3897/rio.3.e14811, 2017.
[17] http://togetherscience.eu/

highly interesting new work on evaluation and impact assessment of Citizen Science activities. Especially Austria conducted a detailed analysis and priority setting with the ministry for research, and now launches a new research program emphasizing on Citizen Science.

In the **short term,** it is now important to capitalise on these inputs in order to scope the relevant parts of the next Framework Program for Research (FP9). In the **mid-term**, the EC will have to address a **supporting policy framework** including (i) the **encouragement of Member States** to acknowledge Citizen Science (e.g. but not only, for environmental reporting); (ii) considerations beyond research funding, because **Citizen Science activates are more similar to research infrastructures**, whereas research adds new methods and tools; and (iii) continued support by **leading examples** (such as air quality) but also other topics, such as health care or waste.

As one particular activity, we will collaborate with the Open Science working group of the European Citizen Science Association – ECSA (see also below) in analysing the US-based toolkit for federal agencies to implement Citizen Science[18]. Together, we intend to adopt the **Citizen Science toolkit** to the European context and enriching it with examples of successful usages. Relationships to the **European Open Science Cloud** are still to be defined.

For 2018, it is agreed to follow-up the policy roundtable with another meeting in collaboration with the COST Action on Citizen Science (see also below) in order to define a longer-term roadmap. This event is currently under preparation with our support in order to be held on 1 March 2018.

3.1.3 Citizen Science as a form of stakeholder engagement

Stakeholder engagement is an important facet along the EC policy cycle. The EC's Secretariat General is guiding and coordinating the respective procedures, for example, with the Better Regulation toolbox[19]. Citizens represent one particular stakeholder group. Citizen Science approaches might add to the according parts of the engagement process.

While possibilities have been occasionally assessed so far, experiments have yet to be undertaken. There is a strong support from the EKC to go into this direction, and the JRC Work Program for 2018 has been set up accordingly.

3.2 Collaborations and achievements outside the EC

Whereas many closely related and important activities take place within the EC, ongoing activities outside the Commission are equally required in order to benefit from Citizen Science for EU policy. We succeeded to build a substantial network and carried out or initiated joint actions in a way that resources are shared; different expertise can be combined; and the streamlined outcomes will positively impact to work of each partner that is involved in this joint endeavour.

3.2.1 Citizen Science data modelling and standards

As Citizen Science is (and can only) only coordinated to a limited extent, special care has to be taken in order to make the outcomes of different activities interoperate. This is also a central requirement in order to provide the Citizen Science Data Platform as an enabling framework for any possible application of Citizen Science to EU policy.

Considering furthermore that Citizen Science is not restricted to a particular thematic topic or set of topics, the different existing and emerging communities often follow their specific internal standards, for example, for data provision. The complexity of this scenery has been examined in detail by representatives of ECSA the American Citizen Science Association (CSA) and the Australian Citizen Science Association (ACSA), as part

[18] https://crowdsourcing-toolkit.sites.usa.gov/
[19] https://ec.europa.eu/info/better-regulation-guidelines-and-toolbox_en

a recently published stakeholder analysis[20]. This work was initiated as a follow up action to a meeting on Citizen Science infrastructures and platforms, which was organised by the JRC in Ispra (Italy) in early 2016[21].

Acknowledging this diversity, a collaborative effort has been initiated under the lead of the CSA, its counterparts in Europe and Australia, interested standardization bodies, such as the World Wide Web Consortium (W3C), Open Geospatial Consortium (OGC) and the association on Biodiversity Information Standards (TDWG), and a novel collaboration between the Research Data Alliance (RDA), Committee on Data for Science and Technology (CODATA) and the World Data System (WDS)[22]. This working group, including members of the JRC, coordinates the ongoing standardization activities in respect to project descriptions (metadata), data set metadata, and data modelling and encoding standards. A first report of the work carried out is currently in print[23].

A major contribution from this working group addresses the interconnection of existing and upcoming standards that are relevant to Citizen Science. This activity interconnects a set of global, transdisciplinary data and metadata standards as an evolution of an outcome of the DataOne project[24]: Public Participation in Scientific Research (PPSR) – Core. Ultimately this (meta)model should describe contextualized details about PPSR **projects** (Project Data Model, or PDM), **datasets** (Dataset Data Model, or DDM), and **data** (Observation Data Model, or ODM), see also Figure 4. These standards are united, supported, and underlined by a common framework, the PPSR-Core **common data model** (CDM), which illustrates how information is structured within the Citizen Science domain.

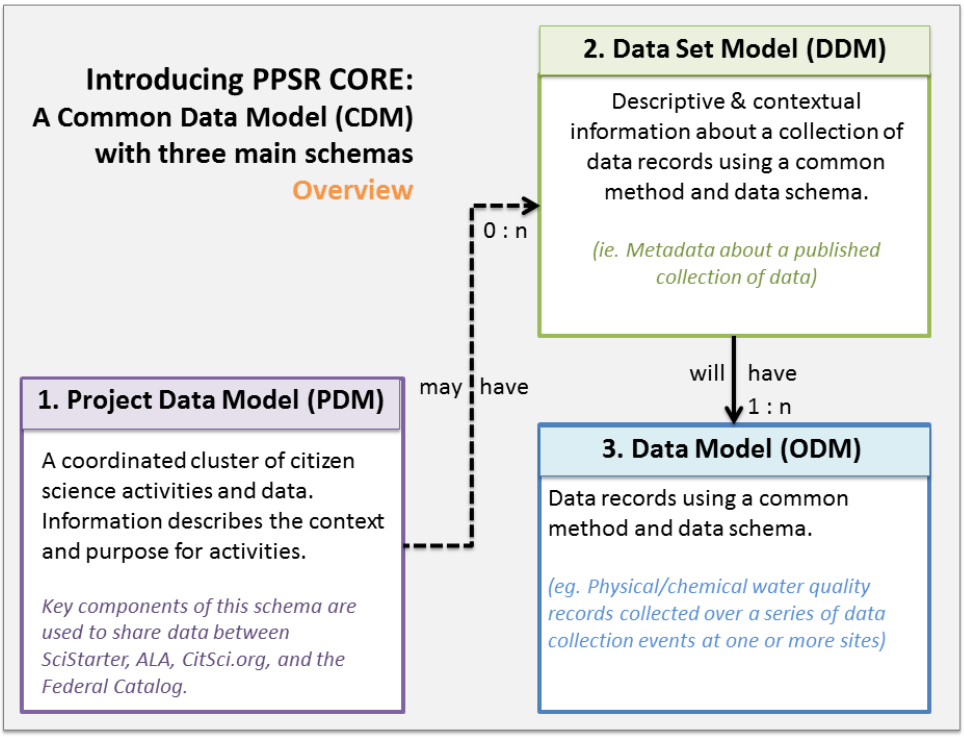

Figure 4: The PPSR-Core data model framework: A common data model with three main schemas (source: see footnote 23)

[20] https://www.wilsoncenter.org/sites/default/files/stakeholder_analysis_0.pdf
[21] https://ec.europa.eu/jrc/en/event/workshop/citizen-science-workshop
[22] http://citizenscience.org/association/about/working-groups/data-and-metadata-working-group/
[23] A. Bowser, P. Brenton, R. Stevenson, G. Newman, S. Schade, L. Bastin, A. Parker and J. Oliver, Citizen Science Association Data & Metadata Working Group: Report from CSA 2017 and Future Outlook, Wilson Centre, in press.
[24] https://www.dataone.org/

At this stage, the PDM is largely agreed, while only central elements of the DDM remain to be defined. Additional items could be identified and the discussion about the exact model is still ongoing. As far as the ODM is concerned, a large proportion is expected to be covered by the OGC, and it's Citizen Science Domain Working Group[25], to which the JRC also participated directly.

In addition to this modelling effort, the working group also provides an opportunity to show case data integration from Citizen Science. Here, we are contributing with our experiences in the domain of the invasive alien species monitoring and the development of the Citizen Science Platform as an enabling framework. More largely, we also, contribute to the analysis of data availability and re-usability from Citizen Science projects. In this way, we will also get an overview about the open issues in data mobilization, which is essential when considering the use of Citizen Science data for policy.

3.2.2 Re-use of Citizen Science apps, platforms and other tools

The heterogeneity and diversity of Citizen Science activities does also pose challenges to the supporting tools, and possible re-use thereof. Related issues directly affect the development of our platform. On the one hand, it remains difficult to understand if a new tool has to be developed or if any existing solution is already available. On the other hand, we see issues in designing new solutions in a way so that potential re-use does not become an obstacle due to, for example, neglecting existing standards, license conditions, or missing flexibility for adaptation. The issue has been investigated in two recent workshops with JRC participation[26] and the common findings have been summarised in a journal publication[27]. Findings specific to biodiversity monitoring led to a scientific publication[28].

At both workshops, working groups were held in the following areas: 1) Interoperability and data standardization; 2) User Interface & Experience Design; 3) Outreach, learning, education, and other rewards of participation. The discussions of the second workshop built on the results of the first workshop. Additional working groups were organized for the second workshop with a focus on 4) Re-use; 5) Sharing of learning; and 6) Tracking participants' contribution across different projects.

The participants suggested, to the Citizen Science community to consider and further discuss the recommendations that resulted of the analysis carried out during these two workshops. This should particularly include the linkage to the ECSA's Ten Principles of Citizen Science[29] in order to add specific guidelines in the context of apps and platforms. The participants also recommend to discuss and consider the building, together with a sustainable maintenance method, of an index for Citizen Science apps and platforms similar to, for example, Scorpus in scientific publishing, with ECSA acting similar to, such as, the European Network of Living Labs (ENoLL), and a cross collaboration of the Australian Citizen Science Association (ACSA), ECSA, and the US-based Citizen Science Association (CSA) for defining criteria for ethics evaluation and certification.

Follow-up actions will be taken in community groups, such as the working groups within ECSA, OGC, and the COST Action on Citizen Science (see also below).

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[25] http://www.opengeospatial.org/projects/groups/citizenscience

[26] U. Sturm, S. Luna, A. Albert, S. Schade, D. Kasperowski (Eds.), Report of the second workshop Defining principles for mobile apps and platforms development in citizen science: Interaction, Interoperability, Innovation, Gothenburg, April 25-27, 2017. Organized by Naturblick from the Museum für Naturkunde Berlin, University of Gothenburg and the European Citizen Science Association (ECSA), 2017.

[27] U. Sturm, S. Schade, L. Ceccaroni, M. Gold, C.M. Kyba, B. Claramunt, M. Haklay, D. Kasperowski, A. Albert, J. Piera, J. Brier, C. Kullenberg and S. Luna, Defining principles for mobile apps and platforms development in citizen science. Research Ideas and Outcomes 3: e21283, https://doi.org/10.3897/rio.3.e21283, 2017

[28] S. Luna, M. Gold, A. Albert, L. Ceccaroni, B. Claramunt, O. Danylo, M. Haklay, R. Kottmann, C. Kyba, J. Piera, A. Radicchi, S. Schade and U. Sturm, Developing mobile applications for environmental and biodiversity citizen science: considerations and recommendations. Multimedia Tools and Applications, in press.

[29] https://ecsa.citizen-science.net/engage-us/10-principles-citizen-science

3.2.3 EPA network, COST Action on Citizen Science and ECSA

In addition to the above-mentioned entities, there is a series of communities and activities that have to be considered for the continuation of our work on Citizen Science. These particularly include:

- The European Network of Environmental Protection Agencies (EPAs), which does not only have an active Interest Group on Citizen Science, but also puts Citizen Science high up on the agenda of their next high-level meeting in April 2018. A closer collaboration would help us to open the discussions with Member States about the potentials and pitfalls of Citizen Science, for example, in order to support the implementation of EU policies and the monitoring thereof. We already established a close connection to the Interest Group, where especially the EKC work is highly appreciated. For 2018, we foresee a closer collaboration in view of the meeting in April, but also in the context of the Actions to Streamline Environmental Reporting. Here, we plan for a collaboration on case studies, lessons learned and recommendations from Member States.
- The different working groups of the COST Action on Citizen Science[30], especially the one dealing with the society, science and policy interface. Here, we see a set of opportunities to benefit from the existing scientific network of experts in order to advance the related dialogues with policy DGs. After becoming part of the COST action (as 'Specific Organisation'), we now (i) consider to co-chair the policy working group, especially in order to get an overview of the existing governmental support to Citizen Science in the different COST countries; (ii) initiated the discussions about a possible training school about Citizen Science and the impacts of digital transformation; and (iii) the JRC (units I.2 and B.6) will host a visiting scientists for one week in order understand engagement mechanisms of Citizen Science for participatory policy. More collaborative actions should follow.
- The Open Science Working Group of ECSA, to which JRC contributes, did not only prepare for a policy brief on Citizen Science and Open Science in collaboration with the Horizon 2020 project DITOS, but also took concrete actions in order to investigate the applicability of the US Citizen Science Toolkit in Europe (see also above). This work will help to develop new insights for possible solutions, and highlight differences between the approaches at the two sides of the Atlantic. It should help us to propose an appropriate framework to promote Citizen Science for European policy.
- The Policy Working Group of ECSA, especially also including their sub-working group on BioBlitzes. They started also (again with DITOS) to organize the BioBlitz community in Europe in order to mobilize data and coordinate data gathering campaigns, for example, along the City Nature Challenge (CNC)[31], which will get international from 2018 onward. The collaboration would help to put our own approaches into wider use and to interconnect relevant Citizen Science activities to European data flows. We contribute to these developments (in collaboration with colleagues of unit JRC.D.2) – especially in respect to data mobilization, interoperability and quality assurance.
- Closely related to the above, the ECOPOTENTIAL project[32] is currently developing a practical guide for the managers of protected sides "How can citizen science enhance environmental monitoring in protected areas in Europe?". The JRC co-hosted the consolidation event with park managers, Citizen Science practitioners and professional scientists on the 21st of November, 2017. We now contribute to

[30] http://www.cost.eu/COST_Actions/ca/CA15212
[31] http://togetherscience.eu/events/city-nature-challenge-2018
[32] http://www.ecopotential-project.eu/

the guide in order to ensure that the approaches of the EKC are considered and to receive direct feedback from the community of potential users.

- The Horizon 2020 project DITOS that does not only support the writing of policy briefs but also organizes hands-on field trips in order to engage stakeholders in real Citizen Science activities. Such trips could also be beneficial for meetings with policy DGs and with Member States in order to improve the joined understanding of the value of Citizen Science for policy. We are now in discussion with the relevant members of the project consortium in order to identify the most suitable collaborations with these kinds of activities. It is most likely that we will co-organise discovery trips back to back with relevant policy-related gatherings, for example, in the context of the EKC work on environmental reporting.
- From December 2017 onward, the Horizon 2020 project WeObserve[33] that is set-up to coordinate Citizens' Observatories in Europe and also helps in the connection to European policy. A collaboration would be beneficial in order to complement from each other's different viewpoints and to jointly develop recommendations. We already established the connection and are looking forward to also collaborate with this project in order to streamline activities on Citizen Science for policy and benefit from each other's capacities.

In addition to these already established and well working collaborations, we will also take action in order to investigate new relationships. This will particularly include possible linkages with the recently announced African Citizen Science Association and the Global Citizen Science Consortium (see also Figure 5).

Figure 5: Announcement of the launch of the African Citizen Science Association and Global Citizen Science Consortium at the United Nation's Environment Assembly (UNEA) on 4th of December , 2017 (source: Twitter)

[33] http://www.iiasa.ac.at/web/home/research/researchPrograms/EcosystemsServicesandManagement/WeObserve.html

3.2.4 Integrative citizen engagement

As previously mentioned, Citizen Science often appears in discussion alongside with terms such as 'citizen engagement', 'public participation', 'social innovation', and 'co-creation'. Acknowledging that definitions differ and the underlying concepts overlap partially, it remains important to stress the uniqueness of Citizen Science as a way to engage people in practical work. Our work concentrates on the development of a mutual understanding between the participants from civil society, research institutions and the public sector by working together on a topic that is of common interest. At the same time, relationships with methods coming from other approaches to public engagement should be further examined in collaboration with the relevant units at the JRC and elsewhere in the EC. The results of these investigaitons might lead to a generalisation of the methodology for using Citizen Science for EU policy into a more universal approach to citizen engagement, and it might influence future versions of the Citizen Science Data Platform.

The 'Smart Citizen approach[34]' (see also Figure 6) provides one possible starting point. Here, different engagement approaches are applied along the investigation of an issue, and they are interconnected by a complete methodological approach. So far, we only began to investigate the possibilities to develop such a methodological approach that then will also have to interconnect with EU policies.

Figure 6: Overview of the 'Smart Citizen Approach' (source, see footnote 37)

[34] L. Henriquez, The Amsterdam Smart Citizen Lab - Towards Community Driven Data Collection, ISBN 978-90-806452-4-0, 2016.

4 The six phases of using Citizen Science for policy

In order to further advance on the use of Citizen Science, to keep structuring the different already ongoing efforts, and to foster practical progress, we saw a strong need to more closely investigate the different phases where Citizen Science and policy have to be connected. Based on our experiences – and inspired from the FP7 project Citclops[35] - we thus define the 'cyclic value chain of Citizen Science' as presented in Figure 7.

In the following, we use this structure to describe the lessons that we learned so far, to highlight benefits and pitfalls, and to propose a way ahead in the development of a robust methodology for using Citizen Science for EU policy. We use examples from our practical experiences - primarily from the collaborative work of the EKC (see also Section3.1.1) – and additional case studies for illustration.

The initial findings presented in this section reflect our current understanding of the topic. They will be basis for future considerations, e.g. when developing the guidelines for using Citizen Science for environmental reporting, but may be topic to updates.

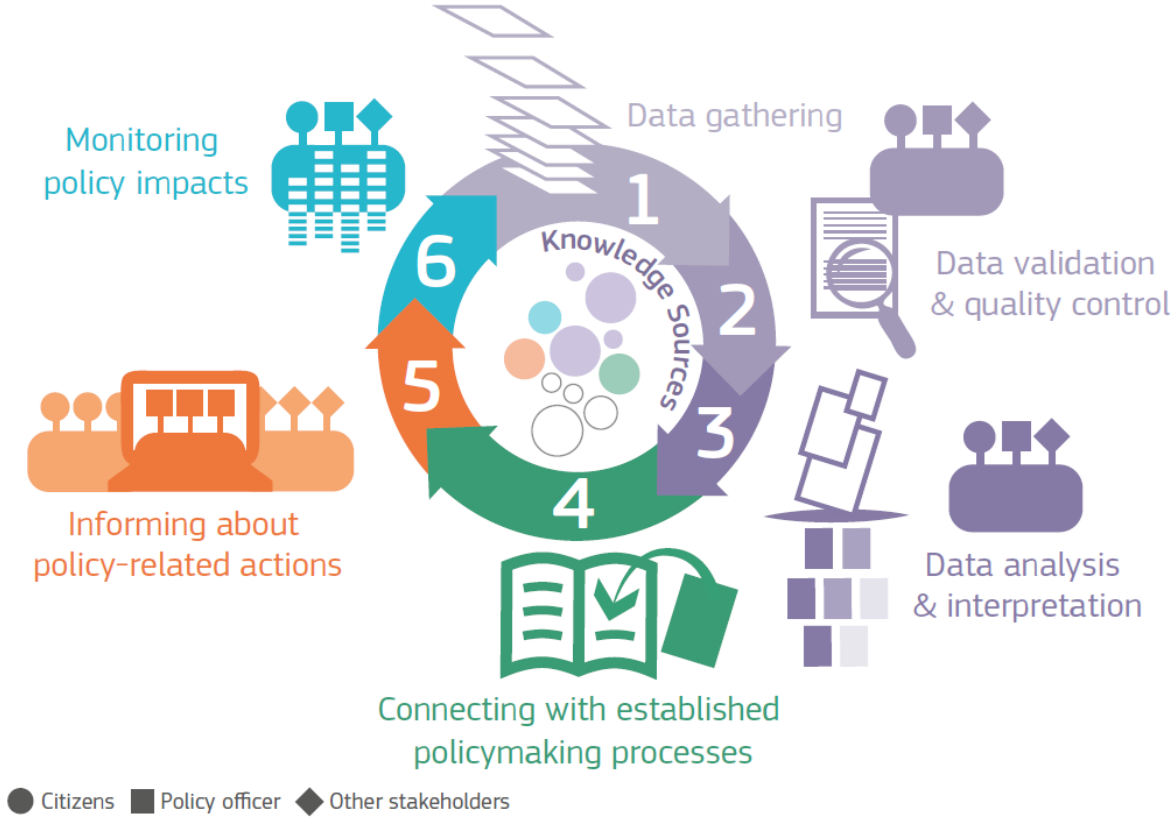

Figure 7: Cyclic value chain of Citizen Science for policy

4.1 Data gathering with Citizen Science

One of the most prominent ways to engage citizen in scientific research is the gathering of new data. This approach is particularly appropriate in cases where data cannot be captured otherwise, for example, due to geographic or temporal resolution as it is the case for the early detection of invasive alien species (see also the Box 1 and Figure 8), or as a proxy in order to optimise resources for collecting the information that is of primary interest - as it is, for example, the case for the Scottish EPA that collects indications of changes in local biodiversity with the help of the anglers community and then carries out detailed surveys in areas of greatest interest[36].

[35] http://cordis.europa.eu/project/rcn/105369_en.html
[36] https://www.environment.gov.scot/get-involved/project-finder/anglers-riverfly-monitoring-initiative/

Data collections may either be carried out from scratch or relevant data from already existing communities can be mobilized. Considering fast delivery and scalability, especially the evolution of digital technologies, including mobile internet, smartphones and Internet of Things (IoT) devices, opens a rich set of possibilities. We already published about according elaborations, especially on the implications for data management[37,38,39].

Box 1 – Data gathering example: Invasive Alien Species App

Amplified by phenomena of globalisation, such as the increased human mobility and the worldwide shipping of goods, we see more and more species outside their native distribution range. Several of these 'aliens' have negative impacts on the new environment, including threats to local biodiversity, agricultural productivity, and human health. Our work addresses these threats, particularly within the European Union (EU), where a relevant legal framework has been established.

Over the past 30 months, the JRC Units B.6 and D.3 developed a mobile phone application, together with the underlying data management and validation infrastructure, which allows users to report about a selected list of invasive alien species. We followed an open and participatory approach that allows more people to share their observations of potential invasive alien species in their surroundings. We put quality assurance and data integration mechanisms into place that allow the uptake of the retrieved information in the related official governmental systems that make it accessible to the relevant policy and research users.

Apart from developing a technical solution and data handling workflow, this work also provides the basis for a more intense dialogues with Citizen Science practitioners in order to the solution into wider use, and with Member States in order to define possible scenarios for using the developed app and information management system in order to facilitate the implementation of EU policy.

More details are available here: http://digitalearthlab.jrc.ec.europa.eu/node/57752

We see the following **benefits** for gathering data with Citizen Science approaches:

- Data gathering with Citizen Scientists can help to reach a wider geographic coverage, to gain more timely information, or to cover a specific topic more deeply, thereby it can provide solutions what would not be reachable in any other way.
- The collected data might directly be used for scientific purposes, or it can be used as a 'proxy' in order to concentrate more detailed gathering on relevant areas.
- Data gathering processes can be supported by technology, such as mobile internet and smartphones, in order to deliver data timely for further processing.
- Data collection is a very concrete and hands-on tasks. It thereby can help to enter into dialogues with citizens.

[37] S. Schade, C. Tsinaraki and E. Roglia, Scientific Data from and for the Citizen. First Monday, Vol.22, August 2017.

[38] L. Bastin, S, Schade and C. Schill, Data – and metadata management for better VGI reusability. In: L. See (ed.). Final book of COST Action IC1203: ENERGIC, 2017.

[39] J. Williams, C. Chapman, D. Leibovici, G. Lois, A. Matheus, A. Oggioni, S. Schade, L. See and P. van Genuchten, Citizen-science data, how should you maximise their impact and sustainability? In: A. Bonn, M. Haklay, S. Hecker, A. Bowser, Z. Makuch and J. Vogel (eds.) Citizen Science – Innovation in Open Science, Society and Policy, UCL Press, in press.

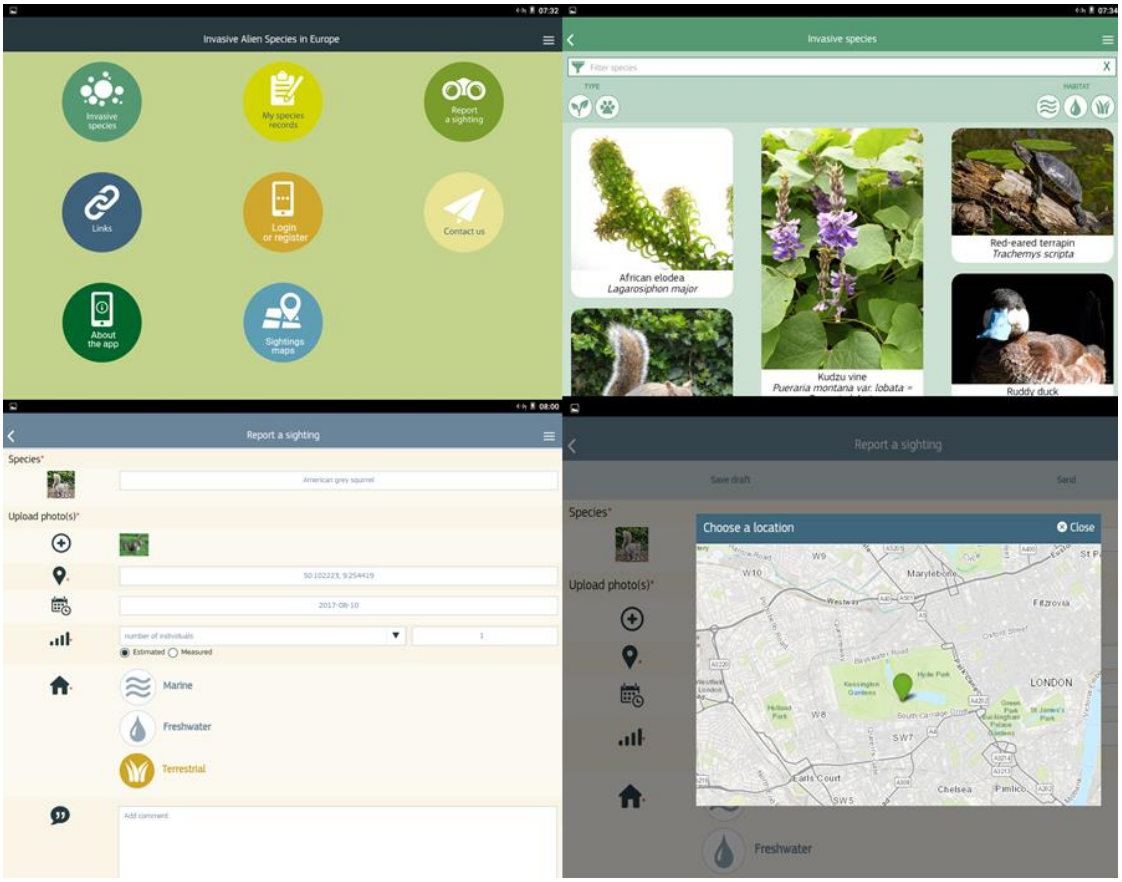

Figure 8: Impressions from the JRC app 'Invasive Alien Species in Europe'

Considering **challenges** for gathering data with Citizen Science approaches, we stress the following:

- Participants have to be motivated to collect the required data, for example, because they have an own interest. It thus cannot be guaranteed that data will be delivered, especially not repeatedly and on a regular basis.
- Sophisticated and restrictive sampling protocols require training and it is not guaranteed that these protocols will be strictly applied. At the same time, and especially in the absence of dedicated sampling protocols, location bias might be introduced because it cannot be assumed that people voluntarily reach difficult terrain, are allowed to access private property, or even distribute equally over space.
- Especially when considering larger territories, in which inhabitants have a different history and culture, it is close to impossible to define harmonised approaches[40]. In addition, language differences have to be acknowledged, i.e. possible apps, promotional material and training have to be offered in a way that the target audience can understand.
- Data use from already existing initiatives may be difficult due to the lack of data access and data modelling standards.
- The quality of the collected data might be challenged by possible users, i.e. quality assurance processes have to be set-up and made clear.

[40] See for example: J. Lisjak , S. Schade and A. Kotsev, Closing Data Gaps with Citizen Science? Findings from the Danube Region. ISPRS Int. J. Geo-Inf. 2017, 6(9), 277; doi:10.3390/ijgi6090277, 2017.

- Data gathering with citizen requires follow-up activities in order to provide feedback to the participants. Whereas this is not a limitation per se, it is a challenge that has to be accounted for in the planning and implementation.
- Technical implications, such as, the use of a smartphone or the appearance of the participants' interactions with required devices, might exclude certain groups of people.
- The data capture may introduce unwanted disruptions, for example, sample collection of species might disrupt the given habitat and thus (especially if massively carried out) counter play the initially good intentions.

4.2 Data validation and quality control with citizen

Citizen Science is also a way in which people can develop expertise and contribute their specific knowledge (see also Box 2 and Figure 9, as well as Box 3 and Figure 10). Accordingly, the involvement of citizen in data validation and quality control should be considered. Possible approaches do not only restrict themselves to the involvement of the crowd (massive amounts of people) in order to ensure quality by repetition and statistical comparison of inputs received. It can also take account of, for example, developed expertise in identifying a specific family of species, or the ability to cross-check facts in a local area. We experienced data validation, for example in the context of our work on invasive alien species[41] and investigated on best practices and recommendations for quality control for Citizen Science[42].

Box 2 – Validation and quality control example: The Land Cover Validation Platform LACO-Wiki

LACO-Wiki is a land cover validation tool developed by the International Institute for Applied Systems Analysis (IIASA). It essentially allows any group of registered users to contribute to the validation of a certain land cover map. The land cover data set that should be validated has to be uploaded by an operator. (S)he is then free to select data sets that can aid in the actual validation process, to define the land cover classification of interest, and provide prepare the validation by selecting the required samples. Once these preparations are completed, so called 'validation sessions' can be launched and shared with selected experts or all registered users (including non-professional experts).

The EEA recommends LACO-Wiki as the supporting tool for the harmonised implementation of the verification procedures for very high resolution (VHR) land cover data - that is delivered from Copernicus (the space program of the European Union). In this wat, it contributes to the delivery of high quality product for the Urban Atlas, Riparian Zones, and Natura2000.

More details are available from: https://laco-wiki.net

[41] K. Tsiamis, E. Gervasini, F. D'Amico, I. Deriu, E. Roglia, S. Schade, M. Craglia and A.C. Cardoso, Citizen Science Application Invasive Alien Species Europe. EUR – Scientific and Technical Research Report JRC105285, Publications Office of the European Union, DOI: 10.2760/043856, 2017.

[42] L. Bastin, S, Schade and P. Mooney, Standards, encodings and tools for assessing fitness-for purpose. In: Bordogna, G. and P. Carrara (eds.). Mobile information Systems leveraging Volunteered Geographic Information for Earth Observation, Springer, 2017.

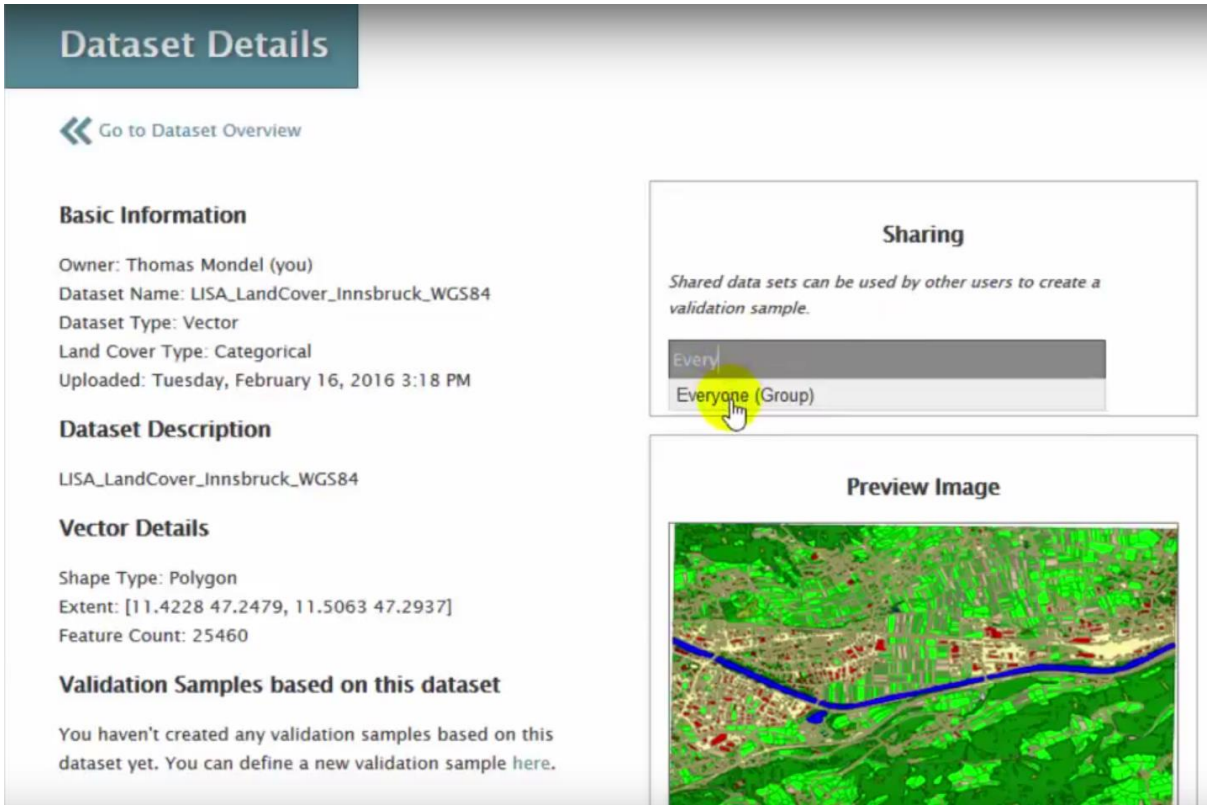

Figure 9: Impression from LACO-Wiki, how to share a validation session with the community (source: YouTube)

Box 3 – Validation and quality control example: biodiversity observations with iSpotNature

As many other tools, iSpotNature provides an opportunity to report about species occurrence information. However, as compared to alternative solutions, this particular instance provides not only a rich set of learning opportunities and sophisticated community support, it also provides an advanced reputation system that allows the participants to develop their reputation overall, and their increasing knowledge about particular animal or plant families. This model is at the same time the fuel or the community-based quality assurance system. As participants build up their reputation on a particular topic, they become valuable contributors to the validation process. This present one of the most advanced approaches of our time in involving citizen directly in data validation.

More details are available from: https://www.ispotnature.org/

Social Points

(3670)

Reputation in groups

Group	Reputation	Observations	Identifications	Received	Given
Other organisms		5	8	4	22
Birds		81	74	370	180
Invertebrates		403	470	696	487
Fish		4	1	2	7
Amphibians and Reptiles		15	18	38	21
Mammals		24	28	79	34
Plants		418	551	1480	860
Fungi and Lichens		99	115	160	142
	totals	**1049**	**1265**	**2829**	**1753**

Figure 10: Impression from iSpotNature, a user's reputation (source: iSpotNature)

We see the following **benefits** for validation and quality control with Citizen Science approaches:

- Large amounts of data might be validated, which would not be possible otherwise.
- This approach helps building communities by acknowledging citizens' expertise and helping each other.
- Participants are offered with the possibility to build experience and learn over time. Which can also help to overcome bottlenecks and missing capacities of professional scientific communities – if long-term support and engagement can be guaranteed.
- The participants trust in the data they provide and may become more interested in related decision making.
- Combined approaches with professional experts or with machine processing are possible in order to benefit from the strength of both options at the same time.

Considering **challenges** for validation and quality control with Citizen Science approaches, we underline the following:

- Not all data can be quality controlled with Citizen Science alone, for example, highly sensitive machinery may be required for particular sensory measurements. In these cases, people should be informed about the specific needs and the approach that is applied. Care has to be taken to which extent data collection is useful. The widely discussed topic of air pollution is a good example. Citizen Science usually deploys relatively low-cost air quality sensors, which deliver results that cannot be compared with accurate professional measurement stations. However, the latter are rare while Citizen Scientists can provide measures at much higher spatial resolution. It is widely discuss how both

approaches could be combined[43]. The JRC (Units C.5 and B.6) developed one possible solution that combines both sufficiently accurate sensors with reasonable costs in an open source solution[44], which is worth to build upon.

- It is not always possible to assess if a required expertise exists and how it can be best build up. More lessons have to be learned on suitable approaches.
- The acknowledgement and value of quality control by citizen is not always recognised and the required scientific and political culture still needs to develop in some areas.
- In some case – especially if it comes to data for policy – legal requirements do not allow for quality control by citizen only.

4.3 Citizen Science data analysis and interpretation

Once data become available – from Citizen Science, form other sources, and combined from multiple providers – new insights still have to be derived from them (see also Box 4 and Figure 11). The required sense making processes are commonly carried out by professional scientists. However, also and especially citizen can be engaged in the analysis and interpretation of data.

Box 4 – Data analysis and interpretation example: analysis of wildlife data from camera traps

Camera CATalogue is a joint project of Zooniverse and Panthera that allows registered users to protect big cats (cheetahs, jaguars, leopards, lions, pumas, snow leopards and tigers) by looking at and identifying photos of wildlife, which have been taken by camera traps. So far, more than 10,000 volunteers helped to spot and classify these kind of wild cats, so that their populations (and changes in population) can be estimated. This new knowledge supports wildlife managers in their daily work to conserve nature.

More details are available from: https://www.zooniverse.org/projects/panthera-research/camera-catalogue/about/research

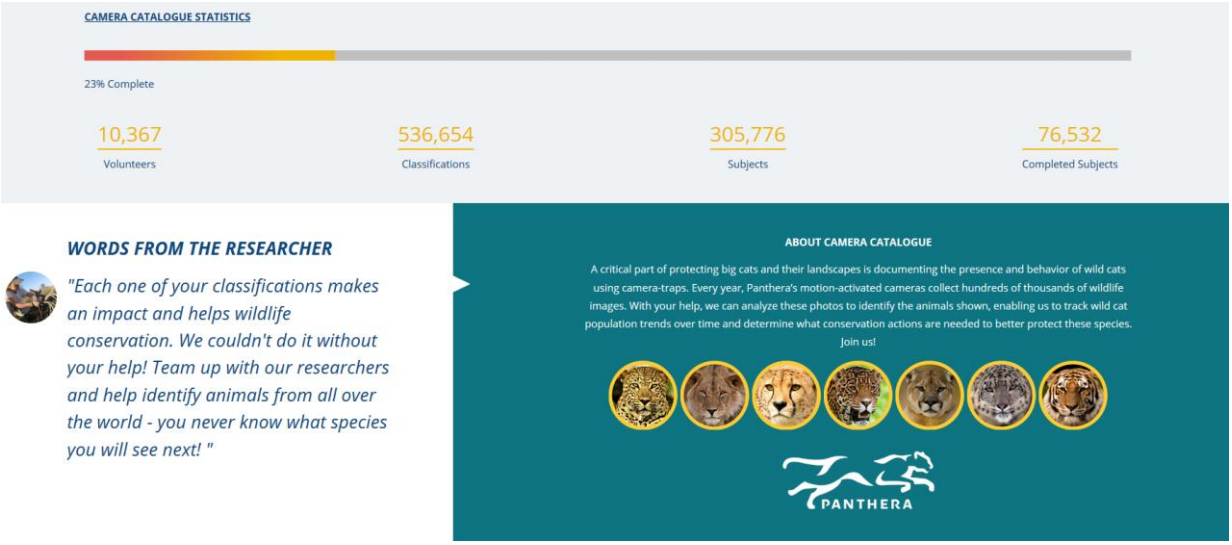

Figure 11: Impressions from Camera CATalogue (source: Zooniverse)

[43] S. Moltchanov, I. Levy, Y. Etzion, U. Lerner, D.M. Broday, and B. Fishbain, On the feasibility of measuring urban air pollution by wireless distributed sensor networks. Sci. Total Environ, 502: 537–547, 2015.

[44] A. Kotsev, S. Schade, M. Craglia, M. Gerboles, L. Spinelle and M. Signorini, Next Generation Air Quality Sensors: Openness and Interoperability for the Internet of Things. Sensors 16(3), 403, doi:10.3390/s16030403, 2016.

We see the following **benefits** for data analysis and interpretation with Citizen Science approaches:

- Again, it becomes possible to complete analysis tasks that would not be possible to carry out otherwise.
- Human reasoning complements and often outperforms any alternative, esp. automated processing by machines.
- Deeper engagement by 'understanding the data'.
- Inclusion of viewpoints that would possibly be ignored by traditional analysis approaches.
- Data analysis can lead to a close engagement between citizen and researchers by debating different interpretations and possible causes.

Considering **challenges** for data analysis and interpretation with Citizen Science approaches, we underline the following:

- It cannot be assumed that any kind of analysis could easily be performed by anyone immediately. Sufficient training needs to be offered.
- It may only be a limited amount of people interested in a particular topic, especially depending on its complexity and time to be invested.
- At least in early stages, outcomes might be biased, for example, by the need to still develop background knowledge to perform a particular analysis task.
- When it comes to interpretation, received inputs may vary. It can become difficult to digest, consider and respond to all inputs received.
- Language issues may have to be considered.

4.4 Connecting Citizen Science with established policy processes

Whereas the three phases mentioned previously are common to many past and ongoing Citizen Science initiatives, we have to particularly consider three additional phases when considering the connection to policy. Most fundamentally, the derived knowledge needs to feed into policy making processes using robust and well-established methodologies (see Boxes 5 and 6 for examples). This phase can be difficult if knowledge flows build over a long time, or easier if new flows have to be set up anyway due to the consideration of a new policy area. We started to elaborate on this topic in a book chapter that is currently in press[45].

Box 5 – Connecting with established policy processes: bird monitoring in Europe

Since 2002, the Pan-European Common Bird Monitoring Scheme (PECBMS) uses common birds as indicators of the general state of biodiversity across Europe. Additional indicators are provided for farmland and forest birds. The bird indices are the only indicator for biodiversity at European scale and with a high temporal resolution (annual) of the monitoring activities relying heavily on trained volunteers. The bird indices are relevant for (i) agricultural policy, in particular to monitor the effects of the financing of rural development measures on farmland and on forests (Common Agricultural Policy - Pillar 1); (ii) monitoring the EU Biodiversity Strategy to 2020; and (iii) sustainable development indicators and sustainable development goals (SDG) indicators for Eurostat's reports.

The development of bird indicators by PECBMS has also triggered the development and use of such indicators at national level. Overview of the national indicators with links to national web sites can be found on: http://www.bipindicators.net/wbi.

[45] J.M. Rubio-Iglesias, S. Nascimento, C. Herbst, E. Montani, R. Owen, S. Schade and L. Shanley, Citizen Science for better policy formulation and im-plementation. In: A. Bonn, M. Haklay, S. Hecker, A. Bowser, Z. Makuch and J. Vogel (eds.) Citizen Science – Innovation in Open Science, Society and Policy, UCL Press, in press.

More details are available from: http://www.ebcc.info/index.php?ID=476

Box 6 - **Connecting with established policymaking processes: a regional citizens' observatory**

Initiated by the FP7 project WeSenseIt (2012-2016), the Alto Adriatico Water Authority (AAWA) created a framework where citizens and authorities cooperate in the field of water and flooding, both during emergencies and during the day-to-day management of resources, via portable sensors, apps and social media streams mining. This approach was successfully tested in the Italian city of Vicenza, demonstrating and validating the concept of Citizens' Observatories: the infrastructure, technology and methodologies developed; the usefulness of the direct transfer of environmental knowledge for policy, industry, research and society; and the possibilities for a comprehensive implementation and application of the innovation.

Thanks to the fruitful experience gained, AAWA adopted the Citizen Observatory as a mitigation measure in the Flood Risk Management Plan throughout the Hydrographic District of the Eastern Alps, in accordance with the European Floods Directive (2007/60/EC).

More details are available from: http://cordis.europa.eu/project/rcn/106532_en.html

We see the following **benefits** for connecting established policymaking processes with Citizen Science approaches:

- Policy making could benefit from the extended evidence base that also considers multiple contributions from citizen and is therefore more complete.
- The scientific contribution to policy is strengthened because it included complementary approaches to collect and analyse evidence.
- Participants get the sense to contribute to 'something bigger'.
- Citizen Science if put into an additional use gets more impact.
- The respective policy gets more attention and is better understood by the citizen that participated in the process so far.
- Policy makers can provide actual proof (evidence) that they have consulted the public and considered public contributions, i.e. that they do not only follow a top-down approach.

Considering **challenges** for connecting established policymaking processes with Citizen Science approaches, we underline the following:

- Policy requirements and Citizen Science offers do not always coincide, for example, in terms of timing).
- Not all data flows can account for citizens' contributions (methodologically, legally or politically).
- Scientific evidence is only one part of the decision making process and expectations from citizen might be too high.
- Especially on the European level, the diverse approaches within Member States may make it difficult to treat all contributions of EU citizen equally.

4.5 Informing Citizen Scientists about policy-related actions

The provision of feedback to Citizen Science participants (and to the public at large) is a well-known and critical aspect to retain and possibly increase engagement. In the Citizen Science for policy context, this especially means information provision about decisions on a particular topic under consideration, and transparent and understandable communication about the use of citizens' (science) contributions. Such information

channels are, for example, requested by DG ENV's Action Plan for nature, people and the economy (COM(2017) 198 final) to which we contributed. Some related thoughts are presented in Box 7 and Figure 12.

Box 7 – Informing about policy-related actions: an inspiring project on air quality monitoring

Policy decision can be traced on the web, for example, by following publications in the Official Journal of the European Union, outcomes of the meetings of the European Parliament, etc. Similar mechanisms are often available at national, regional and local levels. Instead of these direct information and possibly following press releases or reactions on social media platforms, we might ask ourselves if such information channels are sufficient to reach citizen (including those contributing to underlying evidence).

A recent project funded by the European Research Council (ERC) suggests that the required communication and interaction channels are of a very different nature. The Citizen Sense project investigated the relationship between technologies and practices of environmental sensing and citizen engagement, taking the example of air quality measurements. Instead of solely focusing on data collection and related policy actions, it investigated much on the story telling with data – beginning with synthesized descriptions of the issues at hand, data collection taken, creation of the evidence base and highlighting of particular problems at a local level, then deriving required actions.

It is not only the different approach to evidence collection (generating evidence-based stories instead of providing regular and long-term monitoring) but also the continuous engagement of the participants that suggest a confrontation and bi-directional debate about policy-related actions then a simple presentation of decisions.

More information available from: https://citizensense.net

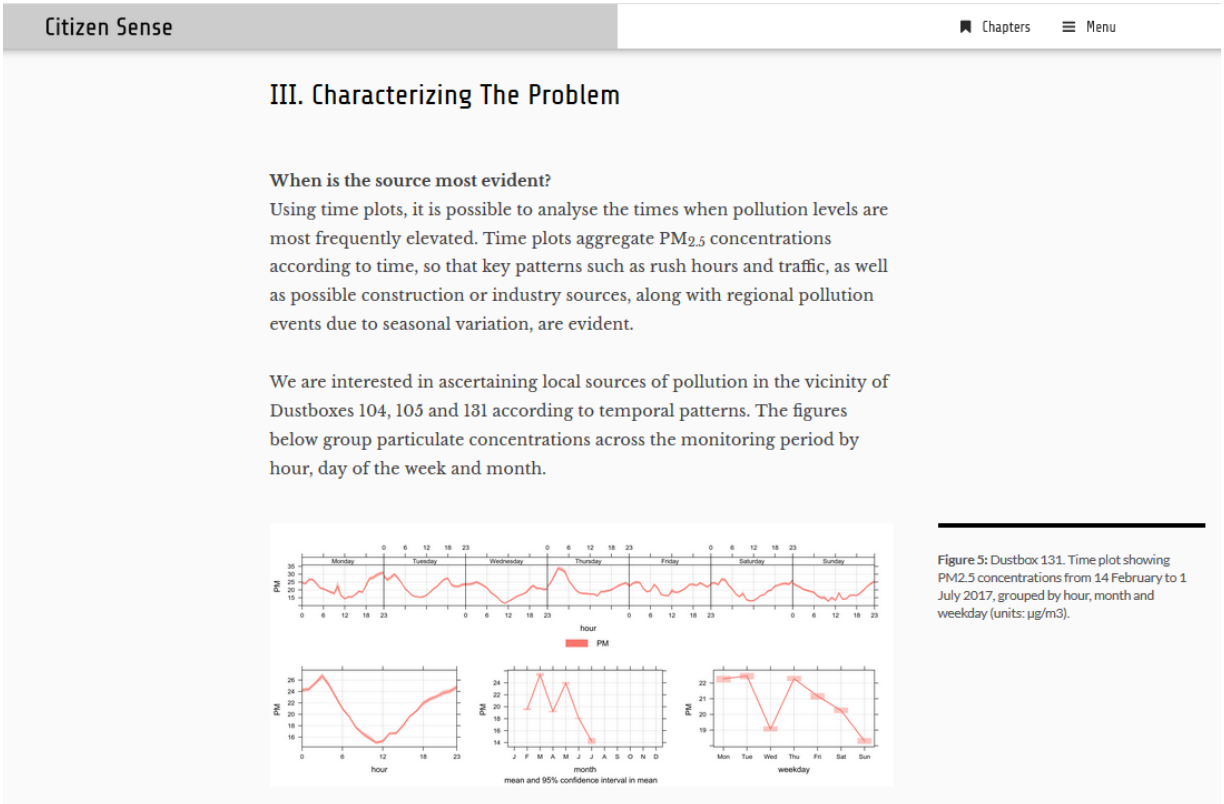

Figure 12: Impressions from 'Citizen Sense' (source: http://datastories-deptford.citizensense.net/deptford-park)

We see the following **benefits** for informing Citizen Scientists about policy-related actions:

- Feedback provision acknowledged contributions and thereby help to motivate and retain participants.
- The need to provide such feedback can also help to trace decision making in general.
- Contributions that would have suggested an alternative solution need to be faced and arguments for deciding otherwise need to be given.
- Beyond the scientific aspect, this may also lead to more active citizenship once it is noted that the voices are heard and contributions count.

Considering **challenges** for informing Citizen Scientists about policy-related actions, we underline the following:

- Citizen Science contributions may happen long before political decisions are made. The temporal gap between initial contributions and according action may be so high that the connection to the citizen is lost.
- The communication channel has to be put into place so that each participant can get informed in the desired way.
- It may be impossible to trace a contribution through the full decision making process.

4.6 Monitoring policy impacts with Citizen Science

Once a policy is already in place, the cycle can be closed by including Citizen Science approaches in the monitoring of policy impacts. Data gathering approaches, for example, can be more closely linked to the intended policy targets and thereby directly contribute to its implementation and later to its evaluation. The use of Citizen Science in monitoring and reporting has been recently requested as part of DG ENV's Actions to Streamline Environmental Reporting (SWD(2017) 230 final). Discussion for the use of Citizen Science for environmental compliance assurance are ongoing, with first results to be expected in early 2018. The box and figure below provide one specific example.

Box 8 – Monitoring policy impacts: flagging environmental complaints with the smart phone

Since a few years, the Irish Environmental Protection Agency (EPA) complements the traditional phone line to flag environmental concerns with a mobile phone app. In 2016, the amounts of complaints flagged with each of the two tools equalled each other, and now the app is on the raise.

Originally developed by a single municipality in the frame of better and more open public service developed this application for its citizens to report on possible issues. Incoming messages are directly fed into the local complaint handling software to that the city can handle them in a uniform way and take action on the collected inputs. The solution was gradually offered to other municipalities, too, and is now widely available and supported by the national EPA. In this way, the approach is promoted nationwide, while collected data is forwarded to the responsible authority for consideration.

For more details see: http://www.epa.ie/enforcement/report/seeit/

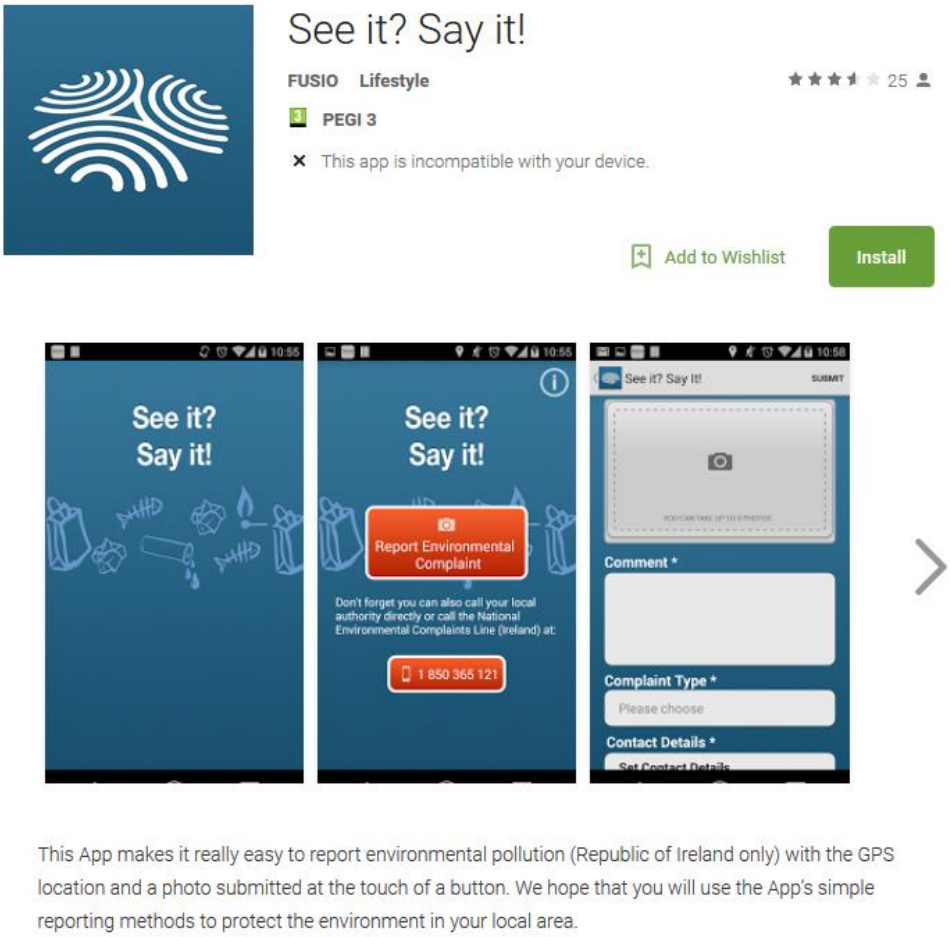

Figure 13: See it? Say it! app on the Play Store (source: Google Play Store)

We see the following **benefits** for monitoring policy impacts with Citizen Science approaches:

- Citizen become the co-owners of the policy.
- This approach enables a much closer and more timely monitoring – at high resolution.
- The policy may be better and faster implemented at local level because of the citizens' interest.
- Citizen can ultimately get more trust in policy because they see it happening and are part of the change.

Considering **challenges** for monitoring policy impacts with Citizen Science approaches, we underline the following:

- The difference between monitoring a phenomena (e.g. air pollution) as compared to monitoring a policy (e.g. on vehicle emissions) may cause confusion for any participant in the process. Some concepts might be too abstract.
- The time that is needed to cause a change might demotivate people.
- Participants might get the feeling to 'police their neighbours' which is not the desired situation. Instead, the aim is to find common solutions and realise them.

4.7 Benefits of the overall approach to Citizen Science for policy

Whereas we visited each of the six phases in the cyclic value chain of Citizen Science above, we also acknowledge a series of benefits in providing an overarching methodology that follows the complete cycle. Most notably, these benefits include:

- Extension of the evidence-base for policy making by contributions from citizen – thereby making the scientific evidence more robust and complete.
- Explicitly acknowledging citizen contributions in a way that is meaningful – instead of a solely sporadic inclusion on only one of the phases.
- Offering to the citizen a portfolio of options by which they can get engaged with science and policy – thereby increasing trust in both research and governments.
- Embracing the cyclic nature of policy making, in the sense that the contributions to the monitoring of impacts and evaluation of policies (phase 6) also can provide inputs to revisions and adoptions of policies (phase 1).
- Only once this overarching approach is properly understood, we will be able to reflect about possible evolutions on the notion of agency and definition of expert knowledge.
- Similarly this understanding will be absolutely essential in order to even start to seriously re-define the power relationships between direct and representative democracy.

4.8 Challenges of the overall approach to Citizen Science for policy

Equally, there are a set of challenges that will make it difficult to implement such a methodology along the complete this value chain for different policy areas. Those challenges include, for example:

- Data mobilization, data utilization and feedback provision can come in many flavours, and it can be expected that solutions are to a large extent depending on the policy under consideration. There is thus a challenge in the possibility to generalize and streamline solutions.
- It requires a well-defined framework together with the accompanying tools in order to follow contributions through the complete cycle (or even several iterations). Especially when building on already established Citizen Science communities (such as Bird Watchers) it is challenging to interconnect the existing methods and tools. In addition, we lack examples on how to carry over the results from monitoring policy impacts into the co-design of new policies, or (more likely) the revision of already existing policies.
- Given that Citizen Science works best on hands-on problems where people can directly contribute, it can be assumed that the easier a setting the more people might contribute. This introduces a risk to focus policies only on the obvious issues by missing some more wicked or hidden issues.

5 Additional relevant policy areas

Before moving on in defining the next steps, two additional policy areas should be mentioned in the wider context of our work. While we did not explicitly made any connection to our work so far, both areas (digital social innovation and digital government) provide connections that might be worth to exploit in the future.

5.1 (Digital) Social Innovation

Social innovation describes new solutions (products, services, models, markets, processes etc.) that simultaneously meet a social need (more effectively than existing solutions) and lead to new or improved capabilities and relationships and better use of assets and resources. In other words, social innovations are both good for society and enhance society's capacity to act.

Digital Social Innovation is defined as the use of digital technology to enable or support social innovation. With the rapid growth of cheap, ubiquitous and powerful tools like the internet, the world-wide-web, social media and smart phone apps, new ways of carrying out social innovation have become possible whilst many existing ways have been strengthened. Often this means the barriers to social innovation in terms of communication, outreach and scaling have been reduced and thresholds lowered. Digital tools can also be transformational and open new perspectives on social innovation, such as the use of so-called Big Data to collect and analyse data of what social needs are being experienced, by which people, in different places, at different times.

(Digital) Social Innovation and Citizens Science share a lot of commonalities; the most outstanding being the open, participatory, co-creative, bottom up approach to address problems of common concern where institutional actors and resources are not enough to tackle the issue with the necessary relevance, quality, or granularity. In this respect, Citizens Science can somehow be considered as one dimension within the complex ecosystem of the Social Innovation phenomena which is climbing higher and higher on the EU agenda for grow and inclusion.

The EC has devoted a dedicated space within Horizon 2020 Research and Innovation Framework Program, respectively within the Responsible Research and Innovation (RII) Chapter as horizontal dimension, and the CAPS (Collective Awareness Platforms) a DG CNECT 15M € initiative focusing initially on Decentralized Data Governance and later on Sustainability and Social Innovation.

The **CAPS initiative** aims at designing and piloting online platforms to create awareness on sustainability problems and putting in place collective solutions. It fosters collaborative solutions based on networks (of people, of ideas, of sensors), enabling new forms of digital social innovation.

CAPS projects are expected to support environmentally aware, grassroots processes and practices enabling citizens to share knowledge, make better informed decisions as consumers, nudge collective environmentally-savvy behavioural changes, and set up more participatory democratic processes.

Concrete examples of emerging areas include:

- **Open Democracy**: enabling citizens' participation in democratic processes by developing and applying new tools (e.g. voting, online consultation).
- **Open Policy Making**: better decision making based on open data.
- **Collaborative Economy**: lending, exchange, swap made to operate at scale
- **Collaborative Making**: developing new ways of manufacturing.
- **Collaborative Consumption**: rethinking consumerism.
- **Environmental Action**: collectively acting to save the planet.
- **New Collaborative approaches** to inclusion, agriculture, health, disaster management.

A recent important output stemming from DSI activities is the DSI manifesto 46 that was endorsed earlier this year at a DSI international Conference in Rimini (IT). The DSI Manifesto aims at fostering civic participation into democratic and social processes, increasing societal resilience and mutual trust as core element of the Digital Society. It provides recommendations for policy makers, to drive the development of the European Digital Single Market to fulfil first and foremost societal and sustainability challenges (rather than short-lived economic interests), with the help and engagement of all citizens.

This manifesto reflects the views of a broad community of innovators, within the context of the CAPS initiative. As such, it is open to incorporating incoming views and opinions from other stakeholders and it does not intend to promote the specific commercial interests of actors of any kind.

The Citizens Science dimension is embedded in these types of activities and stands at demonstrating both, the growing importance of the use of innovative data sources or rather resources, being these information, services, infrastructures or knowledge, and the huge potentialities and social economic benefits that initiatives engaging with public, for scientific, political or social purposes bear in themselves, by their very nature.

5.2 Digital Government

Digital Transformation is taking place at very high pace and globally both, geographically and in all sectors of our society, thereby bringing about important socio-economics effects consequences, challenges and opportunities. Digital Transformation is a dynamic phenomenon bringing together all societal actors in an ever-evolving ecosystem, where each interaction should be seen as an indispensable part of the value chain. All societal stakeholders are equally involved and concerned by Digital Transformation to different levels and extent, being them Public Administrations (local or central), businesses (industry or SMEs), academia and research bodies, citizens and intermediaries (NGOs, charities, para governmental bodies, etc.).

In this context, governments are called to respond rapidly and effectively to the challenges and also opportunities brought about by DT. Turning into Digital Governments Implies: transformation of working methodologies, systems, tools, channels, models, actors, data, information; it requires: ICT enabled solutions (tools, systems, and platforms) based on interoperability, standardisation, accessibility, availability, reusability of data (Open Research Data Policies); it is based on innovative research paradigms, services (beyond innovation 2.0) and business models, relying on dynamic alliances of multiple actors, one-only principle and one-stop shop through multi-channel delivery of services; applies new paradigms, from ownership to sharing of resources, from restricted to openness of data and services, from closed to collaborative, co-creation and co-design of personalised, cross-border, innovative, inclusive citizens cantered solutions; (eGov AP = digitize and enable, connect, engage); creating new trends by swiftly converging towards new/emerging form of innovation: open innovation, reverse PSI, open data, open process, open services, open science, citizens science implying citizens engagement (as a conditio sine qua non).

Digital Government emerging ecosystems imply features that need to apply Citizens Science/Citizens Engagement paradigms. In this context, the EU eGovernment Action Plan 2016-2020 has been a significant step in this Digital Transformation empowered by new data sources and participatory approaches, by acting as a catalyst, 'to coordinate public sector modernisation efforts and resources in the field of eGovernment', by making use of consultation, participatory, co-creative approaches with relevant stakeholders like NGOs, local administrations, citizens representatives, Communities of Practices, but also private sector, academia and research institutions.

[46] https://www.dsimanifesto.eu/manifesto/

The recent Tallinn 2017 Ministerial Declaration47, was signed during the Ministerial Meeting which took place in the framework of the eGovernement Ministerial Conference on the on 6 October 2017. The main message of the declaration is that even though the EU eGovernment Action Plan 2016-202048 has been a significant step in this modernisation, more needs to be done, to ensure its implementation, including to put the end-users – citizens, businesses, public sector employees – truly at the centre of services (user-centricity).

In this context, Citizens Science is relevant, insomuch that it enriches citizens participation with scientific data, combined with citizens knowledge of specific needs, their localities and relevant communities of practices, all working around common governance issues.

[47] https://ec.europa.eu/digital-single-market/en/news/ministerial-declaration-egovernment-tallinn-declaration
[48] https://ec.europa.eu/digital-single-market/en/news/eu-egovernment-action-plan-2016-2020-one-year

6 Conclusions and next steps

Over the past two years, we completed a transition from the consideration of Big Data for policy to a more focussed consideration of Citizen Science, and we now concentrate our efforts in order to establish Citizen Science in Europe as an integral component of public participation in policy. Many rich experiences and first progress could already been made, primarily including advancements in the areas of Environmental Citizen Science, re-use of data and tools, and streamlining of the most relevant activities that are ongoing in Europe and across the globe.

At the same time, we identified six different phases to be considered when using Citizen Science for policy, and prepared a Citizen Science Data Platform as a supporting technical framework. A first assessment of the benefits and challenges underlines the complexity of the topic, but also encourages further actions in order to make EU policies more effective by promoting Citizen Science contributions to the overarching processes and to the distinguished steps within.

Given this status quo, it is now our main objective to build on and leverage from the already existing partnerships in order to address major challenges and to improve the use of Citizen Science for European policy (i) along all the six phases of the cyclic value chain of citizen science; (ii) across the full policy cycle; and (iii) applied to a rich portfolio of policy topics.

In order to advance our work on Citizen Science and to meet this objective, we see a particular need to take the following steps:

- **Develop a robust methodology for data collection, analysis and use of Citizen Science for EU policy** – along identified six phases, and especially including more detailed investigations on engaging Citizen Scientists in data analysis and interpretation, and on the transition between impact measures and policy revisions. This new work area will be considered in the planning for further demonstrators of the value of Citizen Science for (European) policy. This work might be addresses in the context of new experiments and demonstrators, e.g. in areas such as air quality, marine litter or pollinators.
- **Provide a platform as an enabling framework for applying this methodology to different policy areas, including the provision of best practices**. In addition to the continued evolution of the Citizen Science Data Platform from its current state (see also footnote 8), the collection and analysis of best practices will be carried out in collaboration with DG ENV and a recently launched tender to develop and analyse an inventory of best practices for Environmental Citizen Science. The final inventory will be made available by the JRC Citizen Science Data Platform. Impact measure have to be put into place in order to analyse case studies and to identify best practices.
- **Offer guidelines for policy DGs in order to promote the use of Citizen Science for policy in Europe**. We will follow-up on this item by investigating possible adoptions of the US toolkit, together with ECSA. At the same time our work on guidelines in the context of environmental monitoring and possible on compliance assurance will add to this work area.
- **Experiment and evaluate possibilities of overarching methodologies for citizen engagement in science and policy, and their case specifics**. Such works will be undertaken as part of an upcoming new collaboration within the JRC Work Program 2018-2019. Additional investigations will be carried out together with the COST Action on Citizen Science. Here, we consider the Cynefin framework[49] as a possible guide in order to categorise different issues at stake and to identify most appropriate ways of approaching solutions.

[49] https://en.wikipedia.org/wiki/Cynefin_framework

- **Continue to advance interoperability and knowledge sharing between currently disconnected communities of practise.** We will continue our contributions to ongoing standardisation efforts and the promoting of re-usable solutions. Outcomes will be made available as part of the Citizen Science Data Platform into an unique access point for sharing Citizen Science data, knowledge, practices, resources and useful/relevant information. At the same time, the further exploitation into non-environmental policies will be topic to further action. This will include the identification and assessment of work in areas such as cultural heritage, digital social innovation, digital government, etc. Potential new demonstrators will be considered with a view to extend the repository of best practices and to extend and adopt guidelines for using Citizen Science for effective policy.

List of abbreviations and definitions

AAWA	Alto Adriatico Water Authority
ACSA	Australian Citizen Science Association
CAPS	Collective Awareness Platforms for Sustainability and Social Innovation
CDM	Common Data Model
CNC	City Nature Challenge
CODATA	Committee on Data for Science and Technology
CS	Citizen Science
CSA	American Citizen Science Association
DDM	Dataset Data Model
DG	Directorate-General
DG CLIMA	DG Climate Action
DG CNECT	DG for Communications Networks, Content and Technology
DG ENV	DG Environment
DG ESTAT	DG Eurostat
DG RTD	DG Research and Innovation
DITOS	Do It Together Science Project (Horizon 2020)
DSI	Digital Social Innovation
DT	Digital Transformation
EAP	Environmental Action Program
EASIN	European Alien Species Information Network
EASME	Executive Agency for Small and Medium-sized Enterprises
EEA	European Environment Agency
EC	European Commission
EKC	Environmental Knowledge Community
ENoLL	European Network of Living Labs
EPA	Environmental Protection Agencies
ECSA	European Citizen Science Association
ERC	European Research Council
EU	European Union
FP7	7th Framework Program
IIASA	International Institute for Applied Systems Analysis
IoT	Internet of Things
JRC	Joint Research Centre
ODM	Observation Data Model
OGC	Open Geospatial Consortium
OP	Publication Office of the European Union
OSPP	Open Science Policy Platform

PDM	Project Data Model
PECBMS	Pan-European Common Bird Monitoring Scheme
PPSR	Public Participation in Scientific Research
RDA	Research Data Alliance
RII	Responsible Research and Innovation
SDG	Sustainable Development Goals
SME	Small and medium-Size enterprises
TDWG	Association on Biodiversity Information Standards
VHR	Very High Resolution
W3C	World Wide Web Consortium
WDS	World Data System

List of figures

Annexes

Annex 1. Existing policy support to Citizen Science

Document	Anchor
SWD (2017) 230 final: Actions to Streamline Environmental Reporting	A specific action focused on promoting the wider use of citizen science to complement environmental reporting has been included in the Action Plan following the Fitness Check of environmental reporting and regulatory monitoring launched by the Commission in 2015 in the context of the Better Regulation Package. This Action Plan **acknowledges the potential to use other data sources such as citizen science** as a tool to complement reporting or in some cases as an alternative, but it also notes that experience shows this may not be easy and a number of questions have to be resolved. Accordingly, stepwise actions shall be carried out that will lead to the development of guidelines by 2019.
SWD (2017) 139 final: An Action Plan for nature, people and the economy	The action plan seeks to **strengthen the involvement of the public, stakeholders, local authorities and communities** in protecting nature. The Commission together with the Committee of Regions will use all available platforms to raise awareness and promote local involvement and exchanges of knowledge. It will give more recognition to good management practices in Natura 2000 areas and awareness-raising of the Nature Directives through relevant for a, availing of new technologies and outreach activities, strengthening links between natural and cultural heritage. Through the European Solidarity Corps the Commission will **help young people to get directly involved** in conserving nature and gain valuable expertise for their professional life.
Resolution of 13 June 2017 on the assessment of Horizon 2020 implementation in view of its interim evaluation and the Framework Programme 9 proposal (2016/2147(INI))	"… recognises […] the need for the involvement of public and private sector stakeholders and civil society, and the **importance of citizen science** in ensuring that society plays a more active part in defining and addressing the problems and in jointly putting forward the solutions;"
Open Innovation, Open Science, Open to the World - a vision for Europe	In accordance with the political priorities of EU Commissioner for Research, Science and Innovation Carlos Moedas, and as a result of its 2014 public consultation, in 2015 the European Commission identified five lines of potential policy actions to support the development of Open Science in Europe. Citizen science is mentioned under the action "Fostering and creating incentives for Open Science" (i.e. fostering Open Science in education programmes, promoting best practices and increasing the input of knowledge producers into a more Open Science environment - **citizen science**-). The European Commission has established an Open Science Policy Platform in order to propose recommendations for developing Open Science policy through a structured discussion with all relevant actors. Under this umbrella, a Working Group that will discuss citizen science issues in the context of Open Science has been established.
Lamy Report "Investing in the European future we want" (July 2017)	Action 8: Mobilise and involve citizens Citizens should also be actively involved in measuring progress towards the fulfilment of missions, including stirring

	public debate on how to interpret, value and share progress. Whenever possible, citizen science should be encouraged, where citizens become providers and users of data. This will reinforce and give new meaning to the policy of open access to publications and data; this openness should enable citizens and citizen groups to participate in evidence-based policy and decision-making. This could give rise to new types of partnerships, such a "P4P"s or "P4.0s" where "people" are working together with the public and private sector. This could be systemically implemented on European, national and regional levels.
Key findings from the Horizon 2020 interim evaluation	"Stakeholders are less convinced about the role of Horizon 2020 in the resolution of societal challenges than in the achievement of knowledge-related objectives, which seems to call for **better involvement of end-users and communication with citizens** on the contribution that research and innovation can make to tackling societal challenges."
Horizon 2020 2018–2020. Recommendations to the European Commission from the. 'Science With and For Society' Advisory Group	- On citizen influencing the research agenda: *Part of the Horizon 2020 funds should be reserved for projects that involve a stronger citizen/science engagement including broad consultations (going beyond the Commission's minimum standards) where citizens can co-construct future R&D and its design, often involving problem solving at the regional and local level. [...] Encouraging a wider participation of new actors in science stimulated by RRI activities. New actors should include business, social partners and citizens with* ***more focus on the potential opportunities of citizen science in the broad sense of the notion****.* - On the relationship between SwafS and Citizen Science, they ask these questions: *What oversight provisions should be put in place for citizen-initiated health research?* ***How can scientists work with citizen-scientists without exploiting them and how should funding agencies determine the potential of citizen science projects? Citizen science will therefore require relevant monitoring and an attached evaluation model to measure impact.*** *[...] An important policy orientation at Commission level under the Moedas 3O's strategy is the promotion of citizen science.* ***Much more attention is needed regarding meanings, mechanisms, and challenges of citizen science.*** - In relation to Responsible Research and Innovation it says: *Public engagement with science (and technology), including participation of* ***various kinds such as citizen science, is increasingly experimented with****, but could become a 'citizen-participation wash' rather than serious co-construction.* ***Learning-by-doing will be important, including occasional evaluations.*** *Quality assurance of inputs and interactions is important, also for the inputs from scientists into the interactions* - And in the conclusions: *It is in Europe's interest to develop effective science, research and innovation ecosystems across the whole of Europe.* ***Societal engagement in building these ecosystems, as witnessed by the rise of citizen science, will be key to their success***
Competitiveness Council Conclusions	"The Council… b) ACKNOWLEDGES that the Commission has

of 27 May 2016	already taken important measures in Horizon 2020 to connect science and society, as well as to promote open science, and ENCOURAGES the Commission to step up its efforts to **bring science closer to the citizens** and **to involve citizens and civil society more** in the strategic agenda-setting of R&I priorities at EU level, including in Horizon 2020 advisory and expert groups;" (Para 4.b)
A New vision for EU research and innovation	Whenever possible, **citizen science should be encouraged**, where citizens become providers and users of data. This will reinforce and give new meaning to the policy of open access to publications and data; this openness should enable citizens and citizen groups to participate in evidence-based policy and decision-making. This could give rise to new types of partnerships, such a "P4P"s or "P4.0s" where "people" are working together with the public and private sector. This could be systemically implemented on European, national and regional levels.

Annex 2. Additional readings

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