Chapter 2

More Than Just Networking for Citizen Science:
Examining Core Roles of Practitioner Organizations

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ABSTRACT

Citizen science activity is growing rapidly around the world and diversifies into new disciplines with recent advances in technology. This expansion is accompanied by the formation of associations and networks dedicated to citizen science practitioners, which aim at supporting citizen science as a research approach. This chapter examines how four such organizations in the United States, Europe, Australia, and China have begun to take shape, and are working with citizen science communities and stakeholders in respective regions and globally. Challenges and future plans of these groups are also discussed. This chapter identifies three core roles of citizen science practitioner organization: 1) establishing communities of practitioners, 2) building expertise through sharing of existing and developing new knowledge, and 3) representing community interests. By focusing on this hitherto neglected phenomenon, the authors aim to stimulate further research, discussion and critical reflection on these central agents in the emerging citizen science landscape.

INTRODUCTION

Citizen science projects are scientific research projects that rely on public participation (Bonney, Ballard, et al., 2009). Citizens have a long history of participation in diverse scientific investigation activities stretching back to the foundation of learned societies, natural history museums, and universities (e.g., Dickinson, Zuckerberg, & Bonter, 2010; Mahr, 2014). Today, such projects exist all

over the world, and advances in computing and mobile communication technologies have allowed projects to expand in geographic scale and diversity (Sullivan et al., 2014; Dickinson et al., 2012). Bias and sampling errors that once plagued citizen science data can now be avoided by implementing rigorous design strategies (e.g., Bonney, Cooper, et al., 2009; Tinati et al., 2015), and by analyzing data with improved statistical models (e.g., Bird et al., 2013). Projects vary greatly in focus, activities performed, geographic scope and other factors (Kullenberg & Kasperovski, 2016; Shirk et al., 2012). Despite this heterogeneity, some trends in terms of types of activities and key actors have been identified in recent studies.

Haklay (2015), for instance, distinguishes the following levels of engagement and types of activity: Passive Sensing, Volunteer Computing, Volunteer Thinking, Environmental and Ecological Observations, Participatory Sensing and Civic/Community Science. This typology is coherent with a classification developed by the Socientize consortium in the White Paper on Citizen Science for Europe (Serrano Sanz, Holocher-Ertl, Kieslinger, Sanz Garcia, & Silva, 2014), which includes Data Collection, Analysis Tasks, Serious Games, Participatory Experiments, Grassroots Activities, Collective Intelligence and Pooling of Resources as prototypical citizen science activities. Other participatory approaches that overlap with citizen science in terms of methodologies and normative claims are the Do-It-Yourself (DIY) movement (Nascimento, Guimarães Pereira, & Ghezzi, 2014) and the maker scene (Walter-Herrmann & Büching, 2013).

With regard to prominent topic areas of citizen science projects, Kullenberg and Kasperovski (2016) categorized citizen science into three main clusters in a recent bibliometric study. The biggest cluster is in the natural sciences covering research on biology and often deals with environmental issues, such as nature conservation (e.g. flora and fauna monitoring projects) or urban living quality (e.g. water monitoring), and curiosity of natural phenomena (e.g. identifying astronomical anomalies or ways in which proteins fold). The second cluster is geographic information research and comprises approaches such as geographic information systems that include public participation (e.g., Sieber & Haklay, 2015). The third cluster includes research in social sciences and epidemiology, where a range of methods that involve citizen contributions to research is found, for instance participatory health research (e.g., Wright, Gardner, Roche, Unger, & Ainlay, 2010), participatory action research (Nielsen & Nielsen, 2006), and transdisciplinary research (Jahn, Bergmann, & Keil, 2012). Discussions of these approaches, however, appear to be rather limited to the respective social science subdomains and are not well linked to more general debates in citizen science (Crain, Cooper, & Dickinson, 2014). Digital humanities are another popular field for citizen science projects (Kullenberg & Kasperovski, 2016), which includes research in genealogy, history (e.g. Zooniverse project Ancient Lives, Williams et al., 2014), and linguistics (Newman, 2014). One might thus argue that citizen science constitutes a widespread phenomenon, which finds application in a number of topic areas and scientific disciplines, while it appears as a rather fragmented field of research practices with various subdomains developing distinctive yet overlapping methodologies and discussions in the respective research communities.

Although citizen science has gained substantial momentum regarding diversity, reliability, and recognition, several challenges remain. For example, the European Union identified funding, education and training, evaluation, and technology access, as well as data policy, dissemination, and support as key challenges that must be carefully taken into account when working towards the improvement of citizen science throughout the region (Serrano Sanz et al., 2014). Additional challenges include mechanisms for assuring policy impact for relevant citizen science studies, as well as data management, data sharing, data visualization, and professional development (Haklay, 2015). These and similar obstacles are not unique to Europe or the United States, but instead are common and universally experienced across associations around the world.

Simultaneously, citizen science facilitators, managers, and volunteers have begun to converge to evaluate topics considered important for the improvement of scientific rigor, inclusiveness, impact, and reputation of citizen science in various parts of the globe. Topics addressed by these practitioners

included promoting best practices, understanding common challenges, developing communications, sharing resources, and synergies that could result from collaborations. Numerous independent practitioner associations and networks have emerged, which seek to advance citizen science. Four such groups include the Citizen Science Association (CSA; based in the United States), the European Citizen Science Association (ECSA), the Australian Citizen Science Association (ACSA), the Chinese Citizen Science Network (CCSN) (Table 1) as well as groups that are forming in other regions of the world.

This chapter is dedicated to exploring the strategic role of citizen science practitioner organizations in addressing the above mentioned challenges and advancing in the field of citizen science. The four organizations in the U.S., Europe, Australia, and China are compared as case studies to review how practitioner organizations have developed and are working to strengthen citizen science regionally and globally. The first section reviews the development history and central characteristics of each organization, such as aims, activities, and structure. The second section describes current and planned activities of the organizations regarding 1) environmental monitoring, 2) publication, communication, and data infrastructures, 3) best practice and capacity building, and 4) linking citizen science to policy making and cooperative activities. The last section analyzes the roles that practitioner organizations play to strengthen the citizen science field, discusses challenges that associations and networks are facing, and concludes by outlining future steps.

Such reflections on the development of citizen science associations and networks help address the often neglected aspects of networking, professionalization, and institutionalization of rapidly growing fields such as citizen science. Therefore, this chapter provides valuable insights for better understanding the recent global boom of citizen science, while remaining sensitive to regional specificities and contexts. In addition, the developments covered in this chapter also lay the groundwork for actors in other regions of the world to strengthen cooperation and further establishing citizen science.

OVERVIEW OF CITIZEN SCIENCE ASSOCIATIONS AND NETWORK

This section gives an overview of the four citizen science organizations in the U.S., Europe, Australia, and China, which are currently active in collaborative dialogue across the world.

Citizen Science Association

The Citizen Science Association (CSA) is a non-profit association supported by volunteers, membership, and a voluntary member-elected board of directors based in the United States with the aim of supporting all forms of citizen science globally (Table 1). Initial efforts began in 2007 when the Cornell Lab of Ornithology (CLO) hosted an invitational workshop. This event brought 50 practitioners together to discuss best practices and launch the website entitled CitizenScience.org (Table 1) to host tools and guidelines for project design. Evaluation of the workshop and website revealed that project leaders seek not only resources on best practices, but also the opportunity for dynamic engagement with these materials and peers, suggesting a need for continued and improved online resources. Field building continued in 2011 with a second invitational workshop, coorganized by the CLO and the American Museum of Natural History, entitled "Engaging and Learning for Conservation". Participants expressed strong desires to learn about what other practitioners were doing and share insights, suggesting that organizers create ways to encourage continued engagement (Heimlich, 2012). A third conference in Portland, Oregon in 2012, sponsored by the Bechtel Foundation and led by the CLO and the Schoodic Institute, was the first citizen science conference open to general attendance by anyone; it brought 300 practitioners together. Conference evaluation revealed that many practitioners feel disconnected from peers, need access to resources and best practices, and believe that their own insights and innovations are unrecognized and underappreciated (Benz et al., 2013; Heimlich, 2012). Discussions identified next steps, including developing online

tools; providing more opportunities for professional development; starting a new open-access journal; and connecting people with tools for data management and data visualization (Benz et al., 2013). Finally, a milestone occurred at this third conference when participants endorsed the establishment of a global citizen science association. The CSA was formed by a steering committee in February 2014 and launched more formally with the election of its twelve-member board of directors in February 2015.

European Citizen Science Association

The European Citizen Science Association (ECSA) also started out as a loose network of stakeholders, mainly museums and research institutes, with experience in carrying out citizen science activities in the field of environmental monitoring. The idea to consolidate the informal and sporadic exchange as well as to involve like-minded individuals affiliated with institutions and projects from all over Europe was conceived in the United Kingdom (UK) and carried forward by the Open Air Laboratories network (Stack & Donkin, 2013). In 2012, preparatory meetings for forming a pan-European network were held in London and Copenhagen involving citizen science project managers and other stakeholders from the UK, Italy and Germany. In 2014, a non-profit association was registered under German law. The ECSA aims to strengthen and advance the citizen science movement through communication, exchange and co-operation, capacity building and research (ECSA, 2015e). According to its strategy, ECSA has adopted a comprehensive definition of the term "citizen science", covering a wide spectrum of participatory research formats and all scientific disciplines (ECSA, 2015e). The organization is active on the regional (European) level with its main target group being organizations and individuals who conceptualize and implement citizen science initiatives, which are referred to as practitioners or practitioner organizations.

Australian Citizen Science Association

In 2013, Earthwatch Institute Australia released a discussion paper detailing the benefits of establishing a national association for the citizen scientist community following in the footsteps of the recently developed associations in the United States and Europe (Earthwatch Institute Australia, 2013a; 2013b). This paper led to the development of an initial meeting and workshop in May 2014 hosted by the Queensland Museum and supported by CSIRO, Inspiring Australia, University of Tasmania, University of Technology, Sydney, New South Wales Government, and University of South Australia. Over 90 individuals attended the meeting and voted to establish a national citizen science association for Australia. Volunteers immediately began developing a framework for the group now known as the Australian Citizen Science Association (ACSA). Since then, volunteers have continued advocating for citizen science and developing the association. For example, members of ACSA developed communications, determined a host institution, developed a governance structure, and drafted a 3-year Strategic Plan (Table 1). Additionally, ACSA members organized the first Australian citizen science conference in July 2015. The 198 delegates that attended the conference in Canberra were from across Australia as well as from Europe, the U.S., and Southeast Asia. The event started with a welcoming address from Australia's Chief Scientist demonstrating national support for citizen science, which included the announcement of an Occasional Paper (Pecl, Gillies, Sbrocchi, & Roetman, 2015). Delegates were also invited to attend the first Annual General Meeting of ACSA, where a new seven-member Management Committee was elected. Since the conference, the Management Committee has continued furthering development of ACSA, though actions such as establishing Working Groups to advance goals of the Strategic Plan and enabling citizen science networking. The goals outlined in the ACSA Strategic Plan aim to encourage participation, build partnerships, and facilitate a community that is guided by best practices in citizen science, as well as to ensure impacts of citizen science are realized, and to establish ACSA as a trusted and reputable hub.

Chinese Citizen Science Network

The Chinese Citizen Science Network (CCSN) was set up informally in November 2013 by six ecologists with different backgrounds (Table 1). Since the history of citizen science is relatively short in China, it is important to consider development of citizen science in other countries. Such a review reveals the great potential and benefits citizen science may have if implemented more widely throughout China, whether promoted by science, non-governmental organization (NGO), and government stakeholders (Zhang et al., 2013). In China, there are currently approximately 8,000 environmental NGOs. However, collaborations among NGOs, citizens and professionals are rarely seen, leading to poor quality and inadequate representation on collected data by citizens. Currently, the six CCSN members are planning on initiating several small citizen science projects related to biodiversity monitoring by collaborating with scientists and citizens, hoping that these projects could become successful examples for the development of CCSN.

MAJOR ACTIVITIES OF THE ASSOCIATIONS

This section illustrates major areas of work of CSA, ECSA, ACSA and CCSN: (1) activities in the context of environmental monitoring as one of the most significant areas of citizen science practice around the world, (2) infrastructure and communication services provided by the associations as means of support and further development of the respective communities of practice, (3) examples of best practice collections and standards representing milestones in the work of the associations, (4) policy related work of the associations, and (5) cooperation between associations.

Table 1. A structure and status overview of the associations and network as of May 2016

	CSA	ECSA	ACSA	CCSN
Website	citizenscienceassociation.org and citizenscience.org	ecsa.citizen-science.net	citizenscience.org.au	citizenscience.cn
Registered office	Incorporated as a non-profit in Connecticut, USA; hosted by Schoodic Institute, Winter Harbor, Maine, United States of America	Incorporated as a non-profit association in Germany; secretariat hosted by Museum für Naturkunde, Berlin, Germany	The incorporation process is in progress; hosted by Australian Museum, Sydney, Australia	Unincorporated; hosted by Institute of Botany, Chinese Academy of Sciences, Beijing, China
Geographic scale	Global with an emphasis on North America	Europe (core area), members from abroad welcome	Australia	Mainland China
Membership & Outreach Numbers	3500+ individual members (mostly US); no membership fees to date; social media currently include over 1,740 twitter followers.	99 members across 24 countries (mostly EU); organizations and individuals, which pay membership fees; larger network of supporters, newsletter (about 800 subscriptions), Facebook (about 200), Instagram (how many?).	No formal membership structure to date; ACSA and Australian citizen science updates are currently sent through an email list (over 500 subscribers) and social media, including Facebook (1,500), Twitter (1,700), as well as LinkedIn (160) and Google+ (80).	CCSN is still on the stage of infancy consisting of eight core members.
Mission	To advance citizen science through communication, coordination, and education.	Connecting citizens and science through fostering active participation.	To advance citizen science through sharing of knowledge, collaboration, capacity building and advocacy for citizen science.	No mission formally approved as yet.
Vision	A world where people understand, value, and participate in science.	In 2020, citizens in Europe are valued and empowered as key actors in advancing knowledge and innovation and thus supporting a sustainable development of our world.	A community that supports, informs, and develops citizen science.	No vision formally approved as yet.
Objectives	1. Establish a global community of practice for citizen science. 2. Advance the field of citizen science through innovation and collaboration. 3. Promote the value and impact of citizen science. 4. Provide access to tools and resources that further best practice. 5. Support communication and professional development services. 6. Foster diversity and inclusion within the field.	ECSA developed a strategy with three key areas of work each comprising specific actions: 1. Promoting sustainability through citizen science. 2. Building a Think Tank for citizen science. 3. Developing participatory methods for cooperation, empowerment and impact.	1. Encourage broad and meaningful **participation** in citizen science 2. through facilitating inclusive and collaborative **partnerships** 3. and a community of best **practice**, knowledge and tools, 4. to ensure the value and **impact** of citizen science and its outputs are realized 5. enabled by ACSA as an effective, trusted and well recognized organization and hub for citizen science in Australia.	No objectives formally approved as yet.

Networking and Exchange for Environmental Monitoring

A large proportion of citizen science projects around the world focus on investigating aspects of natural world, with many projects being underway for decades (e.g., see reviews for the UK: Silvertown, 2009 and for the U.S.: Miller-Rushing, Primack, & Bonney, 2012; Mahr, 2014). For example, among the oldest continuous datasets are phenological records kept by farmers and agricultural organizations documenting the timing of events, such as sowing, harvests, and pest outbreaks (Hopkins 1918). Early programs such as the North American Breeding Bird Survey, the U.S. National Weather Service's Cooperative Observer Program, North American Bird Phenology Program, and lilac monitoring programs have generated large-scale datasets of biological and physical data that could not have been collected otherwise (Miller-Rushing et al., 2012). Other projects that have arisen at a regional, state, and even local level, including programs that monitor water quality, plant, and/or wildlife (Miller-Rushing et al., 2012), have also generated data not possible to collect without the support of volunteer citizen scientists. Many states, for instance, have long relied on volunteers to monitor water quality, fish populations, or other recreational uses of rivers and lakes (Nerbonne & Nelson, 2008) and programs such as Save Our Streams that tackle local problems have been in existence for a long time (Firehock & West, 1995). Similarly, in Europe, environmental monitoring has a longstanding history of public participation and is of great contemporary importance to traditional science (Science Communication Unit, 2013). Given this deep historical expertise in environmental monitoring, citizen science associations and the Chinese network are working together to facilitating broad-scale and community-based networking for project managers and citizen scientists in this domain. These new connections and collaborations are now enabling the citizen science community to exchange information, methods, and research outcomes, improve projects, and develop new initiatives following best practices.

For example, several initiatives are underway in the United States (U.S.) to improve networking and information exchange. The CSA is working with the Federal Community of Practice on Crowdsourcing and Citizen Science – a group formed within the U.S. government - to develop data-sharing protocols and standards and link federal directories of projects with other directories such as SciStarter (www.scistarter.com). The CSA has also formed a Professional Development (PD) working group that is working with the U.S. National Park Service (NPS) to plan professional development workshops at these centers across the US. These initiatives mark a new direction for citizen science in the U.S. with a focus on PD, data sharing, and project interoperability.

Similarly, a majority of ECSA's founding members have expertise in environmental monitoring so there is a strong focus within the association for related citizen science activities. Related to the objective of promoting sustainability through citizen science (ECSA, 2015a), ECSA aspires to implement joint sustainability-focused citizen science projects between organizations across Europe. The ECSA also advocates for the relevance of citizen science as an approach for environmental policy with national governments and agencies as well as at the European level. For example, ECSA organizes presentations and workshops, publishes policy papers (ECSA, 2015b, 2015c, 2015d) and has been invited to collaborate with the citizen science task force of the European Environmental Agencies (EPAs) in order to develop better environmental governance.

Much like other regions, many citizen science projects in Australia engage participants with nature monitoring. As with all efforts, ACSA is working to promote citizen science that contributes to evaluating environmental health and patterns. In Australia, such projects may engage citizen scientists to share observations of animals, plants, and habitat with researchers, make identifications from images and acoustic data, or supply specimens from nature. These projects are often supported by museums, universities, governmental agencies, organizations, community groups, and individuals. Citizen science initiatives occur at national, state, local, and community levels as well. Members of ACSA are currently working to identify all projects being done across the nation, and as projects are found, information is shared with the community primarily through ACSA social media (Table 1) and shortly to an ACSA-specific project finder. The ACSA members are also looking to better understand

where and how data are collected, stored, aggregated, and used in a citizen science context. This includes considering various information management platforms, standards, and applications that enable citizen scientist to engage, communicate, and contribute around the data they are collecting and sharing. One national biodiversity data repository, which is commonly used by researchers, government, natural resource managers, and citizen science managers alike, is the Atlas of Living Australia (ALA, Belbin & Williams, 2016). Data that are entered into the ALA are then incorporated to the Global Biodiversity Information Facility (GBIF), a global open data infrastructure (Samy et al., 2013). The ALA supports citizen science, as well as other research through providing web services and tools to support the mobilization, discoverability, and validation of citizen science data into the national biodiversity dataset. In addition, the ALA also released a citizen science project finder and biodiversity data collection tool BioCollect that supports citizen science projects undertaking structured surveys (e.g. flora and fauna surveys), as wells as activity-based interventions (e.g. revegetation, site restoration, and seed collection). The ACSA and ALA associates exchange information regularly.

The Australian Citizen Science Association also respond to many inquiries regarding development of projects, organizing workshops, improving citizen science outcomes, and connecting with other initiatives. As ACSA has been under development, members have been facilitating global collaborations. Additionally, ACSA members have driven the development of The Australian Guide to Running a BioBlitz, recruiting guide co-authors who are involved in citizen science and biodiversity data collection across the nation (Hepburn et al., 2015). A bioblitz is an event, usually within a day, designed for scientists and members of the public to intensively collect information on all forms of biodiversity (e.g. plants, animals, fungi, microbes, etc.) found within a pre-determined area (Robinson, Tweddle, Postles, West, & Sewell, 2013). These events are effective for engaging communities with the environmental sciences (Roger & Klistorner, 2016). As ACSA matures, the association aims to connect those groups and individuals currently conducting environmental monitoring to share ideas on a broad scale, and invite those new to citizen science to help make environmental discoveries.

Several citizen science projects in China also monitor the environment. One ongoing project is Chinese Field Herbarium (CFH, http://www.cfh.ac.cn/default-en.html), which was initialed in 2008 and is serving as a web platform for biological field observations and data management. One core CCSN member, Dr. Bin Chen, plays a key role in the CFH project. Currently, the CFH has deposited more than 6,569,000 photos from over 12,000 citizen scientists, with over 1,450,000 of the photos being geo-referenced. The number of citizen scientists and photos continues to increase daily. Another ongoing effort of CCSN is to develop a mobile application for plant phenology monitoring, which is a collaborative effort with researchers from Germany and United States. Meanwhile, CCSN promotes citizen science by organizing sessions in national conferences on conservation biology and ecoinformatics.

Publication, Communication and Data Infrastructures

Beyond the field of environmental monitoring, the broader citizen science community wants best practices resources, greater project diversity, and inclusiveness in the field, as well as recognition for contributions, and want to help build the field (Heimlich, 2012; Crall, 2013). The associations aim to respond to these needs by providing platforms that enable knowledge and tool sharing, as well as providing opportunities for networking and exchange of experiences. Major plans and achievements are described below:

- **Open-access Journal:** The CSA established a globally focused, peer-reviewed, open-access journal entitled "Citizen Science: Theory and Practice" (http://theoryandpractice.citizenscienceassociation.org) published by Ubiquity Press to meet the needs the citizen science community. Previously, high quality research related to citizen science may never be published because an appropriate journal did not exist. Papers that did get published are dispersed across restricted-access publications in diverse fields, making them difficult to find. The citizen science journal offers a consolidated home for peer-reviewed research papers, case studies, opinions, book reviews, and other manuscripts on topics aimed at improving the theory, methods, and practice of citizen science. The current editorial board includes members from mainly CSA, as well as ECSA, ASCA, and other affiliates from around the world.

- **Data and metadata standardization:** To meet the information needs of the citizen science community and ensure that websites, the journal, and workshops are as transformative and far reaching as possible, an innovative cyberinfrastructure (CI) will be developed by CSA in cooperation with other associations. This CI, along with accompanying work to engage the community in its use, has the aim to streamline information discovery, accessibility, and reuse, which will improve efficiency, reduce redundancy, and actively engage dispersed expertise. Currently, practitioners are burdened with updating project details and other information in multiple locations. The CI will make it easy for practitioners to keep information they may have posted on many websites up to date in a single place and simultaneously share and synchronize information across websites. The cyberinfrastructure will be powered by a citizen science-specific data exchange protocol. This protocol will seamlessly share, exchange, and synchronize core information (as metadata) applicable to citizen science projects globally. The CI will consist of integrated databases describing people, projects, best practices, publications, workshops, and outcomes along with information, visualizations, and metadata - all within an open-source framework that can be extended by developers and members of the citizen science community. The associations will develop the CI as a service-based architecture with related Application Programming Interfaces (APIs). The CSA has already developed and piloted a prototype of the data exchange protocol to connect existing project databases at CitizenScience.org, SciStarter, CitSci.org (http://citsci.org/), ALA and BioCollect, which provides a proof-of-concept for this approach. ECSA and ACSA are engaged in the respective CSA working group to contribute relevant knowledge on developments from other regions and give inputs on the worldwide applicability of standards. In addition to the exchange of citizen science project metadata, CSA, ECSA, ACSA, and other organizations around the globe are working towards the development of standards for citizen science metadata that would enable the exchange of observation and measurement data and results of analyses (Bowser et al., 2016; Joint Research Center, 2016).

- **Communication:** CSA, ECSA and ACSA each have independent email lists, where subscribers may post project updates, job post, events, surveys, or discussion topics. Both CSA and ECSA also share one-way association updates with members via electronic newsletters. All associations offer webpages, albeit with different levels of service and interactivity (Table 1).

- In the US, the web platform of the CSA, CitizenScience.org, is recognized as the go-to location for finding information and guidance on citizen science project design and management (Thompson, 2010). A need exists for more dynamic content and improved opportunities for users to share expertise and to interact around pressing questions and innovative ideas (Crall, 2013). The CSA aims to invigorate CitizenScience.org with fresh content that invites multiple contributors, and fulfills the needs of practitioners from diverse disciplines and project types. This website includes high-quality references and resources, such as the Citizen Science Toolkit, data management guide, and evaluation guide. Important goals are to create more dynamic content through writing blog posts and inviting guest bloggers; interviewing practitioners to develop case stories of projects and profiles of people in the field; and scheduling forum discussions and coordinating with guest moderators. Content will also include book reviews, summaries of journal articles, materials for media, newsletters, conference reports, job postings, and a calendar of events. The focus will be on content that synthesizes, assesses, or reviews resources and recommends best practices with a new emphasis on bringing attention to ideas, projects, and people who have something new to offer citizen science practitioners – as well as those on the margins of the community such as data managers, resource managers, public health professionals, and media personnel.

The ECSA website, which at present mainly presents the work of the association, is in a progressive update process with the aim of building a state of the art interactive platform for practitioners and stakeholders that shall contain a database of publications, best practice resources, and tools, as well as offer collaborative online working space and training opportunities. It is also planned to make a repository of citizen science initiatives in Europe available to the public with concise project descriptions in English linking to the individual projects in their native languages, as well as to national aggregator sites in order to provide an easily accessible information hub at the European level. The association also joined social media (Instagram and Twitter) in 2015 (Table 1).

Communication methods for the ACSA community currently consist of a basic website, an email list, and social media (Table 1). Future plans also include developing a citizen science project finder, similar in concept to the ALA biodiversity project finder and the global SciStarter project finder, but focusing on all citizen science affiliated with Australia. Discovery of projects fosters project participation, resource sharing, and collaboration, which can then promote project innovations and sustainability, as well as reduce redundancy in future project development.

The CCSN members are eager to explore the potential of using mobile applications for environmental monitoring in China (Zhang & Huang, 2015), along with training workshops and courses for both citizens and scientists, as done by the U.S.-based National Ecological Observation Network (http://citizenscienceacademy.org/online-courses) providing online professional development resources.

Best Practice and Capacity Building

The CSA, ECSA, and ACSA associations have agreed to foster the exchange of ideas and promote best practices. Similarly, these associations aspire to develop principles, standards, key indicators, and evaluation tools to reflect the value of citizen science to both engage the public and inform the scientific community.

For example, the CSA aims to promote the value and impact of citizen science by developing metrics of success and impact for citizen science programs and developing a data exchange standard for sharing such metrics. Specifically, the CSA has been developing a rubric of impacts and outcomes that include publications, white papers, use of data for decision making, presentations, and use of data in policy development, to name a few. The ECSA plans to collaboratively develop methods and standards for research and engagement to improve cooperation between professional researchers and

citizens across different scientific disciplines (ECSA, 2015e). The ECSA working group on "Sharing Best Practice and Building Capacity" has recently published a list of ten principles that account for strong citizen science projects (ECSA, 2015a). Those guidelines have been elaborated through consultation of citizen science projects across Europe and validated by the community in several rounds of discussion (e.g. Robinson, 2014). Additionally, ECSA aspires to work with groups related to the citizen science field, such as science shops, Do-it-Yourself researchers, and grassroots movements, to learn from their respective methodologies, such as Transdisciplinary Research or Action Research, and channel good practice back into the citizen science community. The goals of ACSA are very closely aligned with the best practice and impact plans of the CSA. The Australian Guide to Running a BioBlitz, is an example of how ACSA members are working to promote citizen science (Hepburn et al., 2015).

Linking Citizen Science to Policy

Citizen science is increasingly recognized by decision makers and included in policies in regions such as the United States, Europe, and Australia. This section provides a few examples of how initiatives in these respective regions currently address citizen science.

Across Europe, the European Union (EU) primarily recognizes the importance of citizen science through both environmental and research policy fields. The potential of citizen science for environmental policy making is mainly linked to data collection for monitoring and stewardship purposes. Benefits related to environmental education, participatory governance, and environmental justice are also noted but considered more difficult to assess (Science Communication Unit, 2013). Regarding research policy, the European Commission, which proposes and implements EU legislation, recognizes citizen science as an important trend that may be leveraged for two current EU policy and funding initiatives. The first initiative is the Open Science agenda (European Commission, 2016), which addresses the transformation of research through advances in information and communication technologies (ICTs) Citizen science is promoted here as a participatory element of research along with Open Access, e-infrastructure development and other measures (European Commission, 2013a). The second initiative is the Responsible Research and Innovation agenda (European Commission, n.d.), which is intended to support public engagement in research and innovation in order to better align outcomes of research and innovation processes with societal expectations and needs, such as grand societal challenges in health, environment, and energy, etc. (European Commission, 2012). The heightened attention from decision makers at EU level manifests in the sponsoring of projects for research, technology development, and public engagement. Prominent examples include the five Citizens' Observatory projects that develop earth observation technology for citizen participation in environmental stewardship (Citizens' Observatory, n.d.),as well as the Socientize project that conducted several citizen science activities (Socientize, n.d.), and coordinated the creation of the White Paper on Citizen Science for Europe (Serrano Sanz et al., 2014).

Several European countries have implemented national legislation with reference to citizen science (Haklay, 2015). The Scottish Environmental Protection Agency, for instance, commissioned a decision framework for choosing a citizen science approach in biodiversity and environmental monitoring (Pocock, Chapman, Sheppard, & Roy, 2014). Similarly, the German Federal Ministry of Education and Research (BMBF) supported citizen science by sponsoring the development of a German citizen science web platform (www.buergerschaffenwissen.de) as well as a set of capacity building measures. Both initiatives are designed to build a national network of citizen science initiatives via a project finder, stakeholder roundtables, and the development of a citizen science strategy for Germany, as well as guidelines to implement citizen science projects for practitioners. Related initiatives, such as scoping projects, landscape studies, platform development and public communication campaigns, are also underway in several additional countries.

As a stakeholder in European research and environment policy, ECSA regularly advocates for citizen science at European and country-specific events, such as the EU Green Weeks in Brussels, at EU consultations, and conferences relating to research, environmental policy, and/or citizen science. The ECSA also develops policy papers showcasing how citizen science can improve the link between science and society. The aim is to raise awareness for citizen science and provide expertise to decision makers in order to contribute to the proliferation of citizen science methodologies and to better link all levels of European governance.

In the U.S., the federal government has established several cross-agency working groups, including the Federal Community of Practice on Crowdsourcing and Citizen Science and the U.S. Geological Survey sponsored Community for Data Integration (CDI) citizen science working group. The Federal Community of Practice on Crowdsourcing and Citizen Science recently released a Toolkit (https://crowdsourcing-toolkit.sites.usa.gov/). In addition, the Wilson Center Commons Lab is working to address associated legal and regulatory considerations for citizen science (Gellman, 2015), as well as assist in the creation of a federal directory of citizen science projects in collaboration with the U.S. General Services Administration (https://www.citizenscience.gov/) (Wilson Center, n.d.). In addition, legislation is being proposed to more tightly couple citizen science with policy. For example, the White House Assistant to the President for Science and Technology, and Director of the Office of Science and Technology Policy, recently released a memo encouraging the use of citizen science and crowdsourcing across all federal agencies (Holdren, 2013).

Members of ACSA are beginning to explore how citizen science is supported through current policies, and where potential exists to influence future policy development, including through the Australian Government's National Science and Innovation Agenda. On a national level, the Australian Government also listed citizen science as a key objective to engage citizens with science, technology, engineering and mathematics in 2013 (Office of the Chief Scientist, 2013), and endorsed citizen science while welcoming conference attendees at the 2015 Australian citizen science conference (Pecl, Gillies, Sbrocchi, & Roetman, 2015). The Atlas of Living Australia (ALA) supports a wide array of biodiversity research, including citizen science, and this national data repository that went live in 2010 is funded through the National Collaborative Research Infrastructure Strategy (NCRIS). The Great Barrier Reef Marine Park Authority is a federal agency which implements community reef monitoring through Eye on the Reef and Reef Guardian programs, to gain large scale measures of marine health (Great Barrier Reef Marine Park Authority, n.d.). Agency support for citizen science on a State or Territory level varies. NSW agencies support several initiatives, e.g. water quality or sport fish tagging (NSW Department of Primary Industries, n.d.), with the New South Wales Office of Environment and Heritage (NSW OEH) recently releasing a citizen science position statement (NSW OEH, 2015a) and strategy (NSW OEH, 2015b). The ACSA members aim to highlight the success of citizen science projects promoted under such policies, to further advocate for continued and expanded support of citizen science.

Collaboration between the Associations and Network

As demonstrated above, the similarity of objectives and tasks addressed by the associations and network have given rise to numerous collaborative activities between the respective boards, committees, and working groups. In addition to sharing knowledge on how to build successful organizations and how to position in the respective local contexts, the cooperation of the three associations has been formalized in a Memorandum of Understanding (European Citizen Science Association, Citizen Science Association, & Australian Citizen Science Association, 2015). This landmark document maps out three key areas in which the associations will work together to strengthen citizen science on a global level:

1. promote scholarship of citizen science via the journal Citizen Science: Theory and Practice,
2. organize joint conferences to directly link practitioners with each other, and
3. collaborate on building digital infrastructure, as well as share online resources, such as tools and best practices.

Cooperation between the associations has a range of aims that were discussed extensively in a recent article for the above-mentioned journal (Storksdieck et al., 2016). In summary, objectives include fostering global collaborations between citizen science practitioners, facilitators, and volunteers from different regions and disciplines, as well as scaling regional activities up to the global level and addressing global challenges. This will eventually contribute to development of new citizen science projects and perhaps improvement of existing ones, as well as support mutual learning and understanding across the world. A fundamentally important aspect to this work is to preserve concerns for local regional specificities. Sharing knowledge and pooling resources can increase the efficiency and impacts of each organization's work, which permits leveraging each other's efforts for building capacity in citizen science. Additionally, such collaborations can increase credibility with the scientific community and the general public, as well as help to establish associations as interlocutors in global fora, such as the United Nations, in which citizen science can make important contributions.[i]

CONCLUSION

Analyzing the associations in United States, Europe, and Australia, as well as the network in China, one finds four organizations with similar goals and comparable activities underway, though to varying degrees and targeting different geographic scopes. It is obvious from the histories of these organizations that each one is in a different stage in establishing as an organization and it would be misleading to assume a singular trajectory of association development. This section presents initial observations and interpretations as a basis for further study.

Structurally, CSA, ECSA, and ACSA show considerable similarities with formal arrangements in place to govern membership and decision-making within the organization, which allow them to operate in the long run and recruit interest and future members within respective regions and beyond. In contrast, the CCSN is organized more loosely as a network without formal structures and only limited reach. With regards to the scientific disciplines that the associations and network are targeting, one can distinguish between disciplinary-focused and generalist organizations. CCSN mainly aims to work with practitioners from biodiversity and environmental sciences, while CSA, ECSA, and ACSA actively recruit and engage with citizen science groups from other disciplines, such as the social sciences and the humanities. On the geographical scale of membership, CCSN, CSA and ACSA have a national scope, while ECSA operates at the European level. A feature shared by all organizations is having a research institute as hosting organization – the Schoodic Institute for CSA, the Museum für Naturkunde Berlin for ECSA, the Australian Museum for ACSA, and the Institute of Botany of the Chinese Academy of Science for CCSN. One might hypothesize that such a linkage to an established academic institution constitutes an important source of reputation, which helps to establish credibility for citizen science. The fact that all host institutions are situated in the natural sciences and more specifically in the field of biodiversity and environmental sciences underscores both to the long tradition of public participation in research and to the current relevance of citizen science in those fields. Evaluating the specific nature of each of those host institutions – natural history museums in Europe and Australia, the partnership with the national parks network in the US, and the Academy of Science in China – promises insights on how the global trend of citizen science manifests in different research systems.

Regarding the content of activity programs, similar needs spurred the creation of each association and continue to shape the portfolio of activities each group undertakes. CCSN shows analogous motivations for further association building. The authors have identified the following key activities as common concerns across groups: 1) networking and exchange for environmental monitoring, 2) providing publication, communication, and data infrastructures, 3) developing of best practice resources and implementing capacity building activities, 4) establishing links to policy making, and 5) strengthening joint activities among them. Through these measures, each of the associations and the

network reviewed herein are strategically positioned to address the challenges mentioned in the introduction as facilitators of citizen science, whether they are working directly with citizen scientists, and/or practitioners and their organizations. In what follows, the authors will show that the examples of association activities provided above are not only an important element of the contemporary expansion of citizen science, but can be interpreted as a contribution to the professionalization of citizen science and reflect the challenges these organizations are facing.

Roles of Citizen Science Practitioner Organizations

Recently, it has been argued that citizen science associations contribute to the professionalization of the field (Haklay, 2015; Storksdieck et al., 2016). This argument is mainly supported by referring to potential benefits that such organizations can and aim to realize to support the field. Storksdieck et al. (2016) identify various such aspired benefits that can be summarized as:

- Linking practitioners, promoting mutual learning and creating synergies between citizen science projects in order to avoid duplication of efforts and increase the quality of citizen science;
- Fostering inter- and transdisciplinary collaborations to stimulate innovation and increase the impact of research along with contributing to a greater responsiveness to societal demands;
- Addressing common challenges of practitioners and offering generic services, such as outreach, education and professional development, to the practitioner community;
- Working with practitioners to develop common norms and standards for the conduct, evaluation, validation and reflection of citizen science;
- Engaging with stakeholders in research, policy making, civil society, and business, to promote collaboration, make citizen science known and increase its credibility as approach for research and innovation.

Further research is needed to judge the claim of an increasing professionalization in citizen science by systematically exploring manifestations and mechanisms of professionalization along with critical reflections on the consequences of such developments. As a starting point for such endeavors, this chapter has attempted to mobilize material to underpin the assumed benefits of citizen science practitioner organizations by reviewing mayor current and planned activities of CSA, ECSA, ACSA, and CCSN. As a result of this analysis, the authors have identified three core roles of citizen science practitioner organizations that can serve as a conceptual framework for further exploring citizen science associations and professionalization:

1. Establishing communities of citizen science practitioners;
2. Building expertise through sharing of existing and developing new knowledge on the practice of citizen science; and
3. Representing community interests.

Establishing citizen science communities: This first role has an internal focus on members of the community and refers to the provision of infrastructure and services to enable networking activities. In many regions of the world, practitioners, advocates, and participants of citizen science are geographically distant from one another, and without established channels for communication that allow for exchange of ideas, resources, and knowledge. There is often a similar lack of communication across disciplines. The associations and network work to offer infrastructures and services for organizations and individuals involved in citizen science to share information and foster collaborations. General elements like websites, email lists, newsletters, and social media activities are means to support the exchange of information, provide guidance on citizen science project management, and facilitate discussion around pressing questions and innovative ideas. Community specific resources like cyberinfrastructure and metadata, including citizen science-specific data exchange protocols and apps, are meant to streamline information discovery, accessibility, and reuse

and thus to improve efficiency and reduce redundancy. The creation of a scientific journal dedicated to citizen science has the goal of improving the theory, methods, and practice in the field and thus to establish a proper community of peers, as well as to anchor citizen science more profoundly in academic research. In addition, the institutionalization of loose networks into formalized associations allows for the development of strategies, provides accountability, and enables the persistence of the knowledge generated over time.

Building expertise through sharing of existing and developing new knowledge on the practice of citizen science: This second role addresses the shared purpose holding the community together, which is related to knowledge. Associations are hubs for the citizen science community to collect and promote best practice examples from projects to stimulate learning and refine methodologies. This is being achieved through professional development (e.g. conferences, workshops, and training events), online tools, and resources (e.g. publications and guidelines), which are anticipated to improve quality and overall impact of citizen science. Examples include CSA's development of metrics of success and impact for citizen science programs, as well as methods and standards for research, engagement, and communication like ECSA's "Ten Principles of Citizen Science" (ECSA, 2015a) and ACSA's best practice "BioBlitz guide" (Hepburn et al., 2015).

Representing community interests: This third role of practitioner organizations covers externally-focused tasks that link the community of practitioners to other stakeholders. Associations work with relevant groups outside citizen science including decision makers, research organizations, funders, industry, other civil society groups, media, and the general public to advocate for citizen science. They provide systematic information on developments in the field, represent the community in relevant discussions and negotiation processes, and offer a contact point helping to heighten awareness of citizen science and facilitating collaboration. The examples from the policy related work of the associations show that this advocacy work may take many forms, such as ACSA's role promoting success of citizen science projects run by local, state, and federal agencies, as well as non-profit, university, industry, and other organizations like the Atlas of Living Australia. Similarly, ECSA aspires to become a think tank for citizen science in European research and environment policy to provide expertise on citizen science to decision makers, and to improve links between European and national levels of governance.

The conceptual framework of three core roles of practitioner organizations also serve to illustrate how they address the challenges for citizen science that have been discussed above. Citizen science practitioner organizations build knowledge-based networks of peers facilitating access to expertise and resources to those involved in citizen science and represent community interests with stakeholders, such as policy makers and civil society. The discussion of activities of the associations in the contexts of environmental monitoring served to give an example of how these analytical roles manifest in a specific case, and how they are intertwined with each other. Finally, the discussion of the joint initiatives of the associations has shown how those activities can be scaled up to the global level and leveraged to reinforce each other.

Challenges for Citizen Science Practitioner Organizations

All the four associations and the network have gained visibility since beginning, and contribute to the acceptance of citizen science beyond the citizen science community by providing networking opportunities, information about existing projects, best practice guidelines, and other support. This increasing activity is linked to rising expectations of what the associations may deliver with regards to specific programs, resources, capacity building, and convenience power. Important challenges that have to be addressed in order to realize the potential of the citizen science associations and network include securing funding for the core business of organizations and for programmatic activities, as well as fostering inclusiveness in organization structures and a plurality of methodologies.

Funding: A key challenge for all associations is fundraising to support communication activities, secretariat staff , the implementation of specific capacity building programs, the development (and maintenance) of infrastructure, such as dynamic websites and data exchange protocols, and research to better understand who is doing what, where, and why in citizen science regionally and globally. At present, all associations and the network discussed cover a significant share of their operational costs through in-kind contributions of their membership, whether through the administrational support of their headquarters, hosting of infrastructure, or voluntary contributions in working groups or at conferences.

The three typical sources of funding for similar organizations include membership fees, grants, and donations. Membership fees represent the most stable and independent way of funding. However in the early period of establishing an organization there is a trade-off between extending the organization's reach and raising fees. Of the organizations discussed in this chapter, the ECSA is the only association that has had a paid membership structure in place from its inception. Both CSA and ACSA are considering membership fees at a later stage of development.

A second important source of funding for citizen science is (research) grants, which could be particularly suited to pay for programmatic activities, i.e. joint thematic citizen science activities, or other finite projects. Grant funding has been acquired, for example, by ACSA from the Australian Government program Inspiring Australia as funding to support the setup of the association. The first CSA conference was initiated when a grant was awarded, and several sponsors then also helped cover remaining costs, making the event possible. The ECSA has received a grant for the first international conference and to date forms part of two Coordination and Support Actions under Horizon 2020 funding. One general concern in this regard is that citizen science has yet to become an established approach to research that is considered valid to the point of being fully integrated into research funding schemes in its own right (e.g. Germany: Pettibone, Ziegler, Bonn, & Vohland, 2015). Currently, citizen science is usually funded through accompanying streams, such as public engagement activities in the EU or science education programs in the US, which represent only a fraction of research budgets.[ii] In the case of ECSA, one central motivation behind establishing the organization was to be able to bid for EU funding and thus to function as an accelerator for small citizen science projects to find partners through the ECSA network (in order to take part in a usual EU project, one needs consortium partners from at least three EU countries). Research project funding, however, can only cover the costs of maintaining an organizational infrastructure, including administrative personnel to a certain extend and does not ensure sustainability. This concern is likely to be augmented for regional associations, as cross border or international NGO funding appears to be even more scarce. In addition, managing such funding opportunities can also represent a challenge for the young organizations in terms of governance and the development of procedures for how to deal with competing interests within the associations.

Finally, a third source of funding is through donations and sponsorships, which could also provide a way to ensure continuity of basic organizational structure through the fluctuation of project funding. All of the associations have received some initial funding through such means. Given that each funding strategy has benefits and drawbacks, associations would likely benefit from having a diverse funding portfolio, not relying on any one particular source of income.

Inclusiveness and plurality: Citizen science associations and networks are developing to represent and advocate for the citizen science community as a whole. Citizen science combines research and civic engagement, and the community is interdisciplinary, also including stakeholders from a wide variety of backgrounds, cultures, positions, organizations, and experiences. Associations and networks must overcome a number of challenges to ensure inclusiveness.

Already the use of the term "citizen science" can be challenging, and deserves consideration by associations and networks. While public participation in research has been occurring for centuries in many parts of the world, the term and current definition "citizen science" is relatively new, having

been formed at the Cornell Lab of Ornithology (Bonney, Ballard, et al. 2009) in the United States (Pettibone, 2015). The contested nature of the term is evident at least at two levels, the linguistic one as well as the semantic one. The tension on the linguistic level is most apparent in non-English speaking countries where local terms and activities exist and the introduction of the English term is often debated and felt as unnecessary anglicization (Pettibone, 2015). On the semantic level, we find different interpretations of which approaches and activities count as citizen science and which ones don't. Great Britain offers the example of an English speaking country, in which "citizen science" has not been universally adopted for a full spectrum of participatory research activities. The term can be deemed unnecessary for long-standing activities involving volunteer domain experts (e.g. Pocock, Roy, Preston, & Roy, 2015), but is more frequently applied to engaging research activities open to the general public and so including people with low levels of expertise (M. Pocock & L. Robinson, personal communication, April 29, 2015). Apprehensions about adoption of the North American term can be encountered in Australia, though acceptance is growing rapidly. Across non-English speaking countries where "citizen science" has been translated into local languages, there are many different interpretations of what the term means[iii]. More systematic research is needed to explore variations on the use of the term across the world, as well as to identify common denominators. For citizen science associations and networks the task is to promote multilingualism and to reach out to groups using other terminologies when investigating what citizen science is underway, so that a broad spectrum of participatory research activities can be equally represented and valued.

Apart from terminology, another inclusiveness challenge associations and networks grapple with is deciding on how to determine which approaches are included under the umbrella of citizen science, such as when evaluating membership applications. Factors such as participant engagement, activities, methods, academic disciplines, and outcomes may be considered when evaluating citizen science (for typologies see: Shirk et al., 2012; Haklay, 2015). While each organization has its own history in this respect, all of them have common roots in ecology, which has the potential to influence priories and activities of the associations. For instance, ECSA has a strong bias towards organizational members (usually research institutes) with environmental or biodiversity focus. Only recently, have groups practicing other approaches, such as cyberscience or participatory health research, been reached. Also the CCSN is currently focused on the advancement of citizen science in environmental protection and biodiversity monitoring. In the United States and Australia there are many projects focused on environmental monitoring. To address this imbalance, ECSA, CSA, and ACSA have adopted policies to actively reach out and offer services to a broad scope of projects, including all scientific disciplines and all approaches to citizen science design and implementation.

Another fundamental challenge of associations and networks is to bring citizen science to the mainstream culture, while not streamlining it in such a way that excludes other approaches to participatory knowledge generation that may be less common today. It is also necessary to critically reflect on the Western model of science and innovation, and reach out to those operating under different models to ensure all groups are represented rather than marginalized and excluded. Organizations advocating for citizen science are encouraged to develop inclusive conceptual frameworks and dialogue activities across different approaches to participatory knowledge generation, including for instance traditional knowledge, participatory action research, and transdisciplinary research. Inclusive organizations also require inclusive governance structures that encourage members to take an active part in the decisions and future of the associations and networks, as well as mechanisms that ensure transparency and accountability.

The Road Ahead

The discussion of the aims of the organizations presented in this chapter along with their activities in progress have shed light on their role as facilitators and their future potential. Associations and networks can function to professionalize citizen science and address gaps of knowledge to facilitate citizen science becoming an established approach for research and civic engagement. Substantial

challenges remain to be addressed in order to be successful in supporting and advancing citizen science around the world.

Essential steps for the coming years will be to implement plans to ensure that ambitious visions of nurturing prosperous and diverse communities of practice are put into action. The associations and network will continue progressing with actions such as organizational and professional development activities. Members will continue synthesizing distributed knowledge into guidelines and standards, and developing cyberinfrastructure and associated tools, and implementing joint citizen science projects supported. The organizations will continue working to become trusted facilitators for the citizen science community by carefully engaging with a variety of different stakeholders whom hold different interests in citizen science as one of the most exciting movements in our globalizing techno-scientific civilizations. Extending and deepening the cooperation between the existing organizations, and engaging with newly developed and emerging groups, is a key ingredient to advocate for the global citizen science communities. Practitioner organizations must use resources with efficiency while working to advocate for citizen science as a reliable field of research and to maximize impact of citizen science and articulate the voices of citizens on global matters of concern. Citizen science organizations must remain sensitive to differences across stakeholder groups, respecting customs, languages, and differences of opinion, whether considering a local, state, national, or broader scale.

There is a growing body of literature on the results, methodologies and epistemologies of citizen science approaches, though few papers are published regarding citizen science networking. This chapter is one of the first overviews of citizen science associations and networks, focusing on the formation, roles, and challenges of such organizations. The aim of this chapter was to stimulate further research and discussion about citizen science communities and their networking efforts around the globe, by providing reflections on the composition and roles of the CSA, ECSA, ACSA and CCSN. Professionalization, regional specificities, and diversity have emerged as topics deserving further study in order to gain a more nuanced understanding of central agents in the emerging field and to contribute to their success.

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KEY TERMS AND DEFINITIONS

Citizen Science: Citizen science describes the involvement of ordinary citizens in scientific research processes. Although currently the majority of participants contribute to data collection in the environmental area, approaches to integrate citizens in the whole research process from developing research questions and methodologies up to interpreting and communicating results improves. In addition, research projects initiated by citizens and performed with or without institutional backing are also described as citizen science.

Practitioner: A person that is mainly involved in the organization of citizen science projects, usually as project and/or volunteer manager. As opposed to volunteers or participants, the term practitioner is used to highlight a coordinating role in designing project methodologies, managing as well as representing citizen science initiatives.

Citizen Science Association: An incorporated organization with the aim of supporting citizen science in any given geography. The term is usually used to refer to an umbrella organization that is not limited to a specific methodology, e.g. participatory computing, or discipline, such as environmental sciences, but promoting the full spectrum of citizen science activities.

Participatory Research: This term may be seen as meta-category for research conducted with the participation of members of the public. It is used mainly in the scientific meta-discourse about the impacts and preconditions of citizen science. The concept of participation increasingly becomes a topic of research, from reflections about its rhetoric potential up to the implicit power relations.

Crowdsourcing: Crowdsourcing means that the "crowd", i.e. a high number of persons that can be anonymous, contribute data, objects, pattern recognition capacities or anything else to a task or project, such as solving a scientific question. For crowdsourcing approaches data quality is mainly assured via statistics of high numbers.

Participatory Action Research: One form of participatory research following the idea that researchers and stakeholders collaboratively develop and carry out a research project from the start to the end, for example in public health. Regarding the research design this approach shows similarities to transdisciplinary research or co-design, but the scientific communities which carry out such forms of participatory research differ: participatory action research is a term developed in social sciences, while co-design or citizen science represent terminologies used in the natural sciences. In addition, methodological and epistemological characteristics of these approaches differ.

Do-it-yourself (DIY) science: This terminology is rooted in the hacker and maker community and has a bias to hands-on applied research, such as building sensors or developing new means of transport. A specific case is do-it-yourself biology, also called biohacking or garage biology, which more specifically addresses (molecular) biologists performing experiments outside institutional laboratories.

Community monitoring: Community monitoring describes projects mainly in the field of environmental research, which are initiated by local communities and normally have also a political intention, such as reducing environmental pollution and/or conserving biodiversity.

ENDNOTES

[i] A recent example is the Eye on Earth Summit 2015 in Abu Dhabi, which recognized the importance of citizen science data as supporting information for environmental decision making in general and for reporting against the Sustainable Development Goals in particular (Eye on Earth, 2015).

[ii] For the European Union, for example, citizen science is seen as a science communication or public engagement measure both of which are covered by the „Science with and for Society" Programme in Horizon 2020, the EU Framework Programme for Research and Innovation, which receives 0,6% of the total budget (European Commission, 2013b).

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iii In Germany, for example, there are debates on the hegemony of the expression citizen science. Some projects, such as the butterfly monitoring of the Helmholtz Center for Environmental Research (UFZ), or the bird monitoring by the umbrella organization of German ornithologists (DDA e.V.), consider themselves as citizen science projects. Others, such as the loss of night project of the Leibniz Institute of Freshwater Ecology and Inland Fisheries (IGB) or the mosquito atlas of Leibniz Center for Agricultural Landscape Research (ZALF), are also seen as crowd sourcing. Still other groups that usually operate independently from research institutions, such as the DIYbio community, hackers or makers, would rather not assign themselves to being part of the citizen science community. Moreover, in other disciplinary contexts different terminologies for comparable approaches may have already been established. For instance in the social sciences, participatory action research, transdisciplinary research, and so-called Mode 2 research or co-production and co-design are other expressions for participatory research formats.