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Citizen Science for Conservation: Towards a Cleaner, Greener China

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Abstract

Citizen science (CS) is the practice in which amateurs without formal scientific training collect data to contribute to the scientific observations available to scientists and decision makers (Bonney et al., 2009). Citizen science is increasingly utilized for environmental protection and conservation as well as related purposes such as education, access to nature, access to justice, inclusion, civics and equality or other 'social goods' (Mor Barak, 2020; Makuch & Aczel, 2020). Several eco-citizen science projects are developing in China (Chen et al., 2020; Hsu, Yeo, & Weinfurter, 2020), though little research has evaluated their effectiveness in facilitating environmental protection or advancing social goods. This paper aims to identify the role and potential benefits of environmental citizen science in China to promote environmental and social objectives within the context of what has been called "authoritarian environmentalism" (Beeson, 2018).

Through semi-structured interviews and a review of the limited available literature, we identify three key areas in which citizen science could potentially benefit environmental protection and promote social good in China: (1) fostering education to inform society and encourage environmental advocacy; (2) facilitating effective environmental governance through monitoring and litigation; and (3) improving data collection for biodiversity and conservation research.

Introduction

China currently contends with well-documented environmental problems, ranging from pollution and contamination, to biodiversity and habitat loss that adversely affect the health of the Chinese population (Lu et al., 2015; Wang et al., 2021; Xiong & Xu, 2021; Zhang et al., 2021), and negatively impact the national economy with direct annual economic losses of over 64 billion CNY (Bao et al., 2017). Pollution threatens to introduce social instability to China as environmental protests have increased (Steinhardt & Wu, 2016). Environmental concerns have led to the formation of several environmental non-governmental organizations (NGOs) (Tang & Zhan, 2008).

Historically, Chinese environmental policy has been characterized by weak policy implementation and delivery (Ran, 2013), although according to Wunderlich (2017), the Chinese administration is more recently attempting to address these issues through, for example, developments conducted under the government's slogan of "building an ecological civilization" (Hansen et al., 2018). Significantly, China's 12th Five Year Plan 2010-2015 included climate change and sustainability goals (Seligsohn & Hsu, 2011)—aims further catalyzed when President Xi Jinping came to power in 2012 (Kostka & Zhang, 2018; Geall & Ely, 2018). A call for an *Ecological Civilization* was first included in the 13th Five Year Plan 2016-2020 (Geall & Ely, 2018). Revisions to China's 2014 Environmental Protection Law (in effect since 1 January 2015) gave local government officials greater power and responsibility to hold polluters accountable for violating pollution limits and *crucially* provides for greater citizen participation in environmental protection (China Dialogue, 2014; Ker & Logan, 2014). Government legislation such as the 2014 "Guidance Opinion on Promoting Public Participation in Environmental Protection" and the 2015 "Measures for Public Participation in Environmental Protection" aim to ensure that the public has access to "information to hold polluters accountable" (Hsu, Weinfurter, & Yan, 2017). Further, Article 53, Chapter V on Information Disclosure and Public Participation of the 2014 Environmental Protection Law is explicit on the role of citizens in environmental protection:

> "*Citizens, legal persons and other organizations shall have the right to obtain environmental information, participate and supervise the activities of environment protection in accordance with the law. The competent environmental protection administrations of the people's governments at various levels and other departments with environmental supervision responsibilities shall disclose environmental information pursuant to the law, improve public participation procedures, and facilitate citizens, legal persons and other organizations to participate in, and supervise, environmental protection work*" (Environmental Protection Law of the People's Republic of China, Article 53 Chapter 5, 2014).

This official position on public participation in environmental protection, combined with the rise of information and communications technology (ICT), has possibly helped to facilitate citizen science development in China. For example, the government set up the "Urban Black and Odorous Water Information Platform" (Hsu, Yeo & Weinfurter, 2020; Hsu, Weinfurter et al. 2020) to allow the public to participate in the "Black and Smelly Waters" (黑臭河 – "*hei chou he*") citizen science monitoring program, started in February 2016, discussed below. The increasing use of social media and personal electronic devices has enhanced the drive of *Third Wave* (emphasizing the importance of economics, externalities, and markets-based approaches) environmental management approaches in China, as citizens and experts together can capitalise on China's progress in the technology arena and use this capacity to monitor environmental change and influence compliance levels and decision-making (Hsu, Yan, & Cheng 2017; Kostka & Zhang, 2018). However, some observers contend this growth in technology for environmental protection purposes might also result in increased politicization of the environment and control over discourses, particularly through internet-based platforms and groups (Goron & Bolsover, 2020). (An examination of censorship is outside the scope of this paper.)

One policy tool increasingly used globally to contribute to environmental protection is citizen science, defined broadly as non-scientifically trained individuals engaged in "collecting, categorizing, transcribing, or analyzing scientific data" (Bonney et al., 2014). Citizen science can help to address environmental challenges by facilitating data collection and engaging the public (McKinley et al., 2017). In China, citizen monitoring has been shown to reduce pollution by supporting governmental oversight and promoting corrective action (Buntaine et al., 2021). For this reason, an increasing number of international government regulatory agencies are developing and supporting citizen science projects (Haklay, 2015). Environmental NGOs and community groups have also adopted the use of citizen science--often in the pursuit of environmental justice, defined as equitable access to resources and accountability regarding uneven distribution of environmental hazards (Taylor, 2014).

Citizen science is a new and developing field in China. At present, there are a small number of citizen science projects attempting to tackle key environmental issues, such as pollution and resource conservation (Zhang et al., 2013). To date, there is limited research on the impacts and effectiveness of these projects, and therefore understanding of the status of citizen science within China is incomplete.

Environmental Issues and Policy in China

Chinese environmental policy follows a model of *authoritarian environmentalism*, defined as a "public policy model that concentrates authority in a few executive agencies manned by capable and uncorrupt elites seeking to improve environmental outcomes" (Gilley, 2012, p. 288; Beeson, 2010; Lo, 2020). However, while the central government formulates policy, implementation is decentralized among local governments (Tang et al., 2019; Tang et al, 2021; Zhang, Zhang & Liang, 2017; Zhang & Li, 2020).

China suffers from multiple severe environmental issues. Most recent data places China 120th of 180 nations on the Environmental Performance Index (EPI) that provides rankings based on "24 performance indicators across ten issue categories covering environmental health and ecosystem vitality" (Yale University, 2019).

Many of these issues relate to China's rapid development over the last 50 years, characterized by a "pollute first, clean up after" model, in which economic growth and industrialization are prioritized over environmental protection (Azadi & Witlox, 2011). Thus, many environmental issues, such as air and water pollution, are attributable to industrial sources (Miao et al., 2015). Between 1992 and 2012 China experienced an average annual urban growth rate of 8.74%, compared to the global average of 3.2% (He et al., 2014). This rapid urbanization has been associated with large-scale environmental damage and in particular, high levels of urban pollution (Wang et al., 2018).

In the 2019 EPI, China ranked 167th of 180 nations for environmental health, and 177th for air quality (Yale University, 2019). Additionally, soil pollution, largely caused by industrial and mining developments as well as rapid agricultural expansion (Li et al., 2014), has been described as “one of the most wide and serious in the world” (Duan et al., 2016, 303).

China also faces significant issues related to land-use change and habitat loss across many habitat types. In 2014, desertified land accounted for more than 1.7 million km^2 of total land area in China, affecting over 400 million people and leading to annual economic losses of over 64 billion RMB (Bao, et al., 2017; Xu et al., 2019). China also suffers from rapid biodiversity loss with an estimated 15-20% of wild higher plants endangered and 233 vertebrate species facing extinction (UNCBD, 2019; Volis, 2018).

Ecological Civilization

The idea of an ecological civilization—based on the goal of environmental and social reform within a society—was first introduced by Ye Qianji in 1987 at China’s National Conference on Eco-agriculture but became more prominent after being presented in 2007 at the Chinese Communist Party’s 17th Congress (Marinelli, 2018). In 2015, the release of “Opinions of the Central Committee of the Communist Party of China and the State Council on Further Promoting the Development of Ecological Civilization” effectively wrote the concept of “ecological civilisation” into China’s constitution as a framework for environmental policy formulation and delivery (Hansen et al., 2018). Importantly, this marks the first time that China included environmental objectives in a Five-Year plan.

Typically, China’s environmental monitoring network has been patchy and thus environmental data has been incomplete (Hsu, Weinfurter, & Yan, 2017). In order to improve environmental policy and achieve “ecological civilization”, the Chinese administration aims to expand the environmental monitoring network, using ‘big data’ to construct a wide-scale environmental data platform (Zhang et al., 2019; Jia & Xu, 2020). Moreover, this push for ecological civilization has led to the rise of *authoritarian environmentalism* or a centralized model of environmental policy with concentration of power within technocratic “eco-elites” (Gilley, 2012; Lo, 2020).

Methodology

As citizen science, and other informal science, is a new field in China, even with the inclusion of grey literature in our analysis, there are still information gaps in both citizen science and environmental data. To supplement and extend findings from the literature review, five anonymized semi-structured expert interviews were conducted in 2019. Interviewees were identified through our contacts with China Dialogue, an independent organization committed to fostering a common understanding of China’s most pressing environmental challenges. We then used snowball sampling to contact other interviewees. Four of the interviewees were senior officials in Chinese NGOs with experience on citizen science projects. The fifth was a researcher who had worked on citizen science projects both within and outside China. Our approach followed the methodology of Maguire and Delahunt, (2017), with coded interview data organized by themes. We recognize the limitations of drawing conclusions based on interviews conducted with five subjects and suggest that this data be used to highlight areas requiring further study.

Citizen Science in China

When asked about the current state and potential benefits and impediments to the use of citizen science in China, interviewee 1 (2019) reported that the concept of citizen science is relatively unknown in China. Interestingly, interviewee 2 (2019) highlighted that many alternative terms can describe the practice of citizen science, such as "volunteer work" or "public participation". It is therefore likely that the number of citizen science projects is under-reported, making it difficult for international citizen science associations to understand the extent to which citizen science is practiced in China, meaning that many citizen science projects lack the support and funding those associations could provide.

With government support, it is likely that the use of citizen science as a mechanism for environmental protection would develop further. However, the term "citizen science" does not appear in any official documents (Interviewee 2, 2019). While there likely will be significant increase in the practice of citizen science, it will probably be characterized as "public participation".

Contribution of Citizen Science to Environmental Protection

Thematic analysis of the interview data organized the benefits of citizen science within three overarching themes: society, governance and science. The first theme, *society*, refers to how improved scientific and environmental education in communities might contribute to better environmental decision-making and improved social well-being. *Governance* describes how citizen science might improve environmental governance—nationally and locally. Finally, *science* illustrates how citizen science might benefit science and research by providing a source of data. Themes, with the benefits and challenges associated with each, are illustrated below.

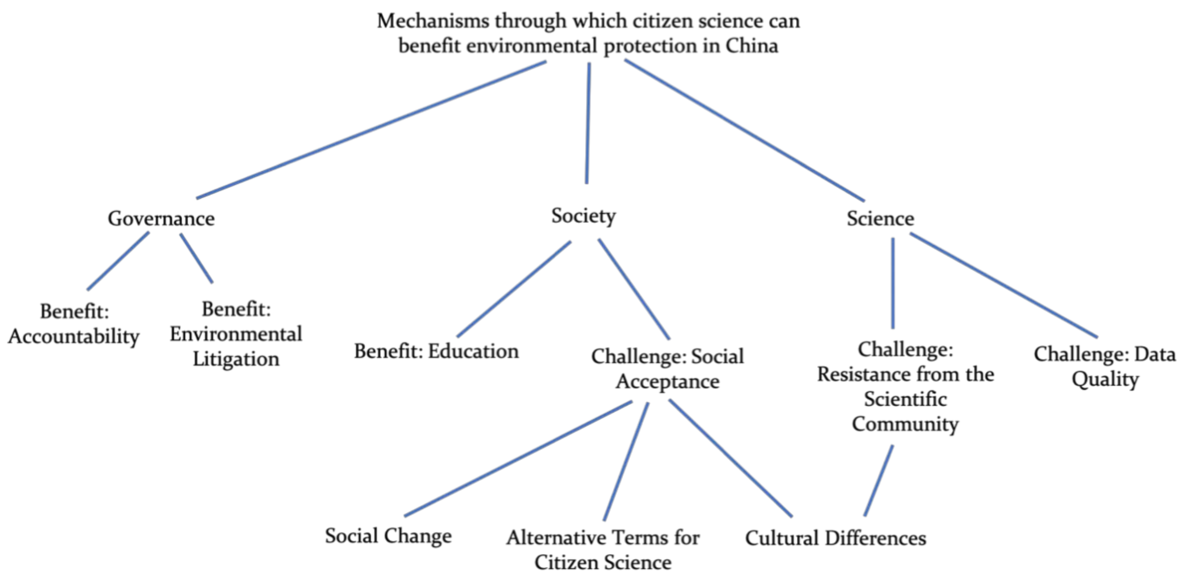

Figure 1. Themes identified in relation to the mechanisms through which citizen science can benefit environmental protection in China – authors' own.

Theme	Benefits	Projects
Society	Science Education	MyH2O Waterschool China
	Environmental Education	
Governance	State-led Monitoring	Foul and Smelly Rivers Campaign
	Community-based Monitoring	Green Hunan Observation and Action Network
	Environmental Litigation	n/a
Science	Informing Research	China Coastal Waterbird Census The Bird Report China Nature Watch

Table 1 – Mechanisms through which citizen science can benefit environmental protection in China

Benefits to Chinese Society

Research highlights how science education promotes "critical thinking, problem solving, engaged learning and knowledge retention" (Bradforth et al., 2015). Typically delivered within formalized school and university environments, informal science education can occur in environments such as museums, zoos and online (CAISE, 2019; Wals et al., 2014). Increased science education has many benefits for environmental protection, as it allows for greater technical understanding of environmental challenges and potential for technical solutions (Wals et al., 2014).

In 2016, the Chinese government pledged to increase the national rate of scientific literacy from the current 6.2%, to 10% by 2020 (China Daily, 2017). To this end, many schemes have been implemented, including construction of hundreds of science and technology museums, inauguration of the National Science Popularization Day and Sci-tech (S&T) Week, and construction of more than 200 million distinctive activities across the country (Gao et al., 2016).

We contend that citizen science has a role to play in fulfilling China's pledge to increase scientific literacy. Currently, there are few citizen science projects and even fewer with explicit educational goals. One example is MyH2O[1]—an NGO that runs training programs to teach university students the skills to conduct water quality assessments in rural areas (Ren, 2017). Although the primary goal of this training is to collect data on water quality, the project also has a major educational component as it recruits university students and trains them to conduct water quality testing (Interviewee 3, 2019).

According to Interviewee 3 (2019), this training can supplement the education of university students, many of whom are science and engineering majors, by increasing their knowledge of both technical monitoring as well as ecosystem functioning. Similarly, students may be taught concepts not covered in their university courses, such as ecosystem dynamics (Interviewee 3, 2019).

Another citizen science effort with a clear educational focus is Waterschool China[2], managed by the NGO Shanshui Conservation Center. The main goal of the project is to help "restore the ecological integrity of the rivers in China", through participatory education and action for sustainable water management for schools and communities of key watersheds in rural China (Shangri-la Institute for Sustainable Communities, 2019).

Crucially, the Waterschool China initiative includes several governmental education bodies as partners on the project, including the National Centre for School Curriculum and Textbook Development, as well as the Ministry of Education of China (Shangri-la Institute for Sustainable Communities, 2019). This support arguably demonstrates a formal recognition of the educational value of citizen science projects.

Interviewee 3 (2019) described how schools are increasingly encouraging pupils to engage in "outdoor" scientific learning and suggested that citizen science could be used to facilitate this learning. In fact, the Chinese Ministry of Science and Technology had previously expressed interest in public science as a mechanism for science education (Interviewee 3, 2019). If government support is further extended to other educational citizen science projects, this might represent a significant mechanism for improving the provision of scientific literacy.

The Chinese government is also keen to promote environmental education within schools (Li, 2018). This is partly in response to the prevalence of "nature-deficit

[1] MyH2O Water Information Network, http://myh2o.org (accessed 13.03.2020)
[2] Waterschool China, http://waterschool.cn/news-events/water-education/

disorder" (Interviewee 3, 2019). Initially defined and categorized by Louv (2009), nature deficit disorder (NDD) occurs as children primarily in developed nations are increasingly less exposed to the natural environment. In China, this phenomenon is particularly pronounced in urban environments, due to the heavy demands of the Chinese education system, which often leads to children spending many hours indoors engaged in studying or schoolwork (Zhu, et al., 2019). This lack of exposure to nature and external environments has been associated with poor physical wellbeing for children and adolescents in China (Zhu et al., 2019).

Although environmental concern has increased in recent years, involvement in pro-environmental behaviors still remains relatively low (Tang & Zhan, 2008). In fact, in China, the public is often unwilling to become directly involved in environmental protection measures (Interviewee 1, 2019; Interviewee 4, 2019). This often results from the common belief that environmental protection is solely the responsibility of the government (Interviewee 4, 2019).

Several studies demonstrate how citizen science facilitates positive attitudes, particularly with respect to environmental education (Kelemen-Finan et al., 2018). Individuals who have participated in citizen science projects often became advocates for environmental action and shared knowledge within their social networks, as shown by Johnson et al. (2014). Interviewee 3 (2019) confirmed these findings, reporting that participants in citizen science projects often developed a greater appreciation of ecosystem processes.

Environmental education is increasingly being incorporated into Chinese curricula (Li, 2018). Therefore, given the government's general support for citizen participation in science, as demonstrated through the official partnership with Waterschool China, there is potential for citizen science to provide environmental education within the formal Chinese curriculum.

Benefits to Governance

Environmental Monitoring

One of the ways in which citizen science might support environmental policy formulation and governance in China is through environmental monitoring, defined as a "tool to assess environmental conditions and trends" that can help to "develop information for reporting to national policymakers... and the public" (UNECE, 2017). Community-based monitoring (CBM) involves "volunteers, either non-experts or trained scientists, engaging... collecting, analyzing, and using data", and as such is often classified as a form of citizen science (Carlson & Cohen, 2018; Conrad & Hilchey, 2011).

Effective environmental monitoring, and the collection of reliable environmental data, is crucial for delivering successful environmental policy (Hsu, Yan & Cheng, 2017). However, historically, the Chinese environmental monitoring system has been both ineffective and inaccurate, and consequently, the data collected through this system is of low quality (Hsu, Yan & Cheng, 2017). China has also traditionally regarded data collected by the environmental monitoring network as a state secret, preventing citizens and NGOs from gaining access (Hsu, Yan & Cheng, 2017).

However, because of the mandate for 'ecological civilization', the Chinese government is attempting to improve both environmental monitoring and the transparency of the data collected (Hsu, Weinfurter & Yan, 2017; Jia & Xu, 2020; Zhang et al., 2019). To develop the environmental monitoring network, in 2016 the Ministry for Environmental Protection approved the "Scheme for Building an Ecological Environment Monitoring Network" (Hsu, Weinfurter & Yan, 2017; Ministry of Environmental Protection, 2016a; Ministry of Environmental Protection, 2016b). This program aims to improve large-scale environmental data collection by 2021 using "big data" (Hsu, Weinfurter & Yan, 2017). Given that citizen science brings a cost-effective and democratic method to collect large datasets, it may represent a vital "big data" mechanism.

In 2015, the Chinese government initiated the 'Foul and Filthy'/'Black and Smelly Waters' (黑臭河 – "*hei chou he"*) rivers campaign. This campaign, conducted by the Ministry of the Environment (MEP) and the Ministry of Housing and Urban-Rural Development (MOHURD), used citizen science to identify and map heavily polluted rivers, by allowing citizens to report rivers on WeChat (a Chinese social media platform) (Hsu, Yeo & Weinfurter, 2020; (MOHURD, 2015; MOHURD, 2016; Phillips, 2016). This project has been incredibly effective as in 2016 citizens recorded pollution in more than 1,300 locations (Phillips, 2016). Early results from a study on China's use of information communication technologies to engage with citizens indicate the approach may improve the ability of governing bodies to enact top-down policies as well as increase civic participation, leading to improvement in water quality data (Hsu, Yeo & Weinfurter, 2020). Following this success, several regional governments have also partnered with local NGOs using volunteers to monitor water pollution (Jia, 2019).

Because recent legislation has promoted the use of "public participation" within environmental protection, there is clear potential for further incorporation of citizen science within environmental monitoring networks (Hsu, Weinfurter & Yan, 2017).

Community-Based Monitoring

Given the extent of pollution in China, as well as the control of information by the central government, there is a need for the public to tackle pollution themselves or to work with the authorities toward this aim (Buntaine et al., 2021). In referring to citizens' awareness of pollution and desire for environmental protection in China, Flatø (2020, p. 50) asserts that "international scholarship indicates that broad-based popular agreement helps push forward reform policies and secure the capacity of a given system to formulate and implement policies". There is a persuasive argument here that engagement in citizen science and data gathering might help catalyze these efforts.

If designed properly, community-based monitoring (CBM) can provide results comparable to those from professional monitoring initiatives (Danielsen & Balmford, 2005). Consequently, CBM initiatives are increasingly employed to overcome limitations in official government-led monitoring, particularly pollution monitoring (Carlson & Cohen, 2018; Danielsen & Balmford, 2005). In fact, CBM can play a large role in holding polluting organizations accountable by catalyzing pollution prevention and mitigation strategies (Whitelaw et al., 2003).

The majority of community-based monitoring initiatives in China have been led by NGOs (Freese, 2018), although an NGO is a comparatively new phenomenon in China (Hsu, 2010). The NGO Green Hunan used citizen science to postpone operation of a dam on the Xiang River (Woodrow Wilson International Center for Scholars, 2016). In this project, volunteers collected data to demonstrate that sewage from upstream cities was present in the river, and therefore violated provisions of the dam's required Environmental Impact Assessment (EIA) (Woodrow Wilson International Center for Scholars, 2016). This information allowed Green Hunan to launch a campaign that resulted in postponement of dam operations to allow river cleanup by the Hunan Environmental Protection Bureau (Woodrow Wilson International Center for Scholars, 2016).

Chinese NGOs have also created networks to provide long-term community-based monitoring (Hsu, Weinfurter & Yan, 2017). The Xiang River Monitoring Network project led by the NGO Green Hunan uses volunteers to monitor and report pollution on the Xiang River in Hunan, and by identifying and recording pollution, has "served as an effective early warning system for local Environmental Protection Bureaus" (Tyson & Logan, 2016). This is particularly important given the high level of heavy metal pollution present within the Xiang River (Han et al., 2014; Wang et al., 2011).

Further, in 2012, Green Hunan compiled information from their monitoring in the "Report of the Current Situation of the Ecological Environment in the Xiang River Watershed" (Yan, 2012). Importantly, this report provided a more accurate picture of the state of pollution compared to official government narratives (Yan, 2012).

Projects such as these have helped to hold local governments accountable and encourage them to stop polluting activities (Yan, 2012). Therefore, in the absence of action by the Chinese government, CBM initiatives are crucial in identifying polluters.

The Black and Smelly Rivers Project (discussed above) offers a good example of how a citizen science project was made simple and accessible to the layperson. This project used straightforward sensorial indicators (sight and smell) uploaded via the use of a mobile phone app by the participant, with a choice of three clear gradations. In getting buy-in from a public previously unfamiliar with methods of environmental data collection, this was a sensible approach that allowed potentially inclusive participation. The citizen-acquired data aligned with official observations, where data existed, and contributed to data where there were gaps; the result was an efficient response by local authorities to remediating polluted water bodies (Hsu, Yeo & Weinfurter, 2020; Hsu, Weinfurter et al. 2020).

Environmental Litigation

In July 2015, the Supreme People's Procuratorate (the national agency responsible for public prosecutions in China) implemented public interest litigation for environmental protection (Zhang & Mayer, 2017), meaning that NGOs may now bring lawsuits against polluters. While this initially only covered selected regions, it has subsequently expanded to cover the entirety of China (Lubman, 2017). There is interesting potential here for the use of citizen-collected data and reporting.

In the Chinese legal system, the plaintiff is required to provide evidence for a case, commonly the opinion of someone with specialized expertise (ICLG, 2019). The party appointing the expert is expected to pay the fees of the expert, often a significant expense (Shouzhi, 2021). Even if the expert is appointed by the court, the plaintiff is still expected to pay the costs based upon their proportion of liability (Shouzhi, 2021). Citizen science has the ability to collect large datasets for relatively low costs and may therefore represent a cheaper way for NGOs to present data in legal actions (Interviewee 2, 2019).

When asked if they thought that citizen science data could be used as legal evidence within China, interviewees were split. While some were confident that citizen science data could pass the legal requirements to be used as evidence, others cited issues with data quality (Interviewee 1, 2019; Interviewee 2, 2019; Interviewee 3, 2019). It is difficult to assess whether citizen science data could be used as legal evidence as both citizen science and environmental litigation in China are new and developing institutions. In the few cases of environmental litigation brought to date in China, the use of citizen science as legal evidence has not been attempted. Given the strict requirements for legal evidence to be validated, NGOs are advised to follow a well-defined and developed plan to ensure the quality of data collected through citizen science, as defined in a manual produced by Harvard Law School (Emmett Environmental Law & Policy Clinic, 2019).

Science and Biodiversity

This section explores the role of citizen science in informing conservation and biodiversity research within China. Conservation policy has failed to significantly reduce the problem of large-scale biodiversity loss within China (UNCBD, 2019). One of the key issues is a lack of accurate data for many species, particularly that related to species distributions (Shan Shui Conservation Center, 2015). Given that effective conservation relies on having accurate and representative datasets, conservation practices in China are likely constrained by the poor quality of biodiversity data (Hermoso et al., 2013; Conrad & Hilchey, 2011).

A primary benefit of citizen science projects is the ability to inform academic research through the collection of data (Dickinson et al., 2010). In particular, citizen science has been shown to be more cost-effective and time-efficient compared with traditional research methods. This generation of large data sets is particularly important for fields in which funding may be scarce, such as ecology or conservation (Bakker et al., 2010).

Therefore, within these fields, citizen science is increasingly used to help inform conservation practice and policy (Conrad & Hilchey, 2011). In China, citizen science projects have helped to collect and improve the quality of biodiversity data.

Biodiversity

Amateur bird watching is an important source of data collection in many citizen science projects (Alexandrino et al., 2019). Within China, the growth of bird watching as a hobby has provided an opportunity for the development of a number of citizen science projects (Ma et al., 2013). The China Coastal Waterbird Census uses volunteers in the China Coastal Waterbird Network to conduct monthly surveys of water birds across 12 permanent sites along the Eastern Coast of China (Fowlie, 2013). The data collected from these surveys is then uploaded and compiled into reports that are publicly available online (Bai et al., 2015). A review of reports produced by the China Coastal Waterbird Census project identified poor management within many protected sites, such as a failure to control invasive species (Bai et al., 2015). Further, the data has helped to identify gaps in wetland conservation policy within the areas surveyed, as it has been used to identify priority areas for migrating birds; alarmingly, it has been found that many of these priority areas are located outside of officially protected areas (Xia et al., 2017).

Another citizen science project that utilizes bird watchers is the Bird Report. Unlike the China Coastal Waterbird census, which focuses on eastern coastal areas, the data from the Bird Report covers the entirety of the People's Republic of China (Hu et al., 2017). Crucially, the data from this project has also been used to inform important biodiversity research. Li et al. (2013) used data from the 2003-2007 editions of the Bird Report to construct a database of distribution for 80% of bird species in China, which was later updated by Dai et al. (2019) to cover all bird species in China. These studies demonstrated that 61% of species had appearances outside of previously known distribution ranges (Dai et al., 2019) and revealed gaps in the Chinese conservation system, as less than 2% of the identified hotspot areas were within national nature reserves (Hu et al., 2017). By highlighting hotspots for bird conservation, NGOs can engage in more focused conservation action by directing resources to these areas (Beijing Energy Network, 2017).

Challenges to Implementation of Citizen Science in China

Social Acceptance

Citizen science, however, is currently not widely accepted by the public in China (Interviewee 1, 2019). Similarly, to other countries, the vast majority of people involved in citizen science projects in China are those already interested in environmental protection (Turrini et al., 2018). Typically, these individuals are disproportionately middle-class, highly educated, in leadership positions and based in larger cities (Chen et al., 2011). However, for citizen science to have a significant impact on environmental protection, a broader section of society needs to be engaged.

Alternative Terms for Citizen Science

When translated into Chinese literally, citizen science is known as '公民科学' (pronounced “gongmin kexue”), but due to the general lack of acceptance, this direct translation is rarely used (Interviewee 2, 2019; Interviewee 3, 2019; Interviewee 4, 2019). Many alternatives are used to denote the term as we have seen, including “volunteer work” (志愿者) or “public science” (公众科学) (Interviewee 2, 2019).

However, even these alternative terms may not always be employed. Often, projects undertaken by NGOs may not be given any label at all, even though they incorporate elements of citizen science. For example, the 2017 annual report for the Chinese environmental NGO Green Camel Bell lists four projects they had orchestrated: the “Protection of Source Water in Gansu”, “Loess Plateau Rehabilitation Project”, “Maqu Grassland Conservation Project” and “Chinese Giant Salamander Conservation Project” (Green Camel Bell, 2017). All four projects involved the collection of data by volunteers and could therefore be described as ‘citizen science’; however, the terms “citizen science”, “public science” or “volunteer work” are not used within the document (Green Camel Bell, 2017).

Consequently, Chinese citizen science projects are both underreported and relatively unknown outside of China. For instance, no Chinese citizen science projects are included on the Wikipedia list of citizen science projects (Wikipedia, 2019). Similarly, SciStarter, a searchable online database of over 3000 global citizen science projects, lists no citizen science projects in China (SciStarter, n.d.). It is likely that citizen science projects in China are often isolated from the global citizen science community, cutting off a potential source of support and capacity building.

Cultural Impediments

As a result of its Western origins, people in China may consider “citizen science” as a fundamentally Western concept (Interviewee 2, 2019)[3]. Certainly, the modern concept of science is rooted in Western traditions of rationalism and analytical thinking (Interviewee 5, 2019). As such, there may be cultural difficulties when translating the concept into a Chinese context (Interviewee 2, 2019).

Unlike Western Culture, which emphasizes individualism and analytical thinking, Chinese culture promotes interdependence and holistic thinking (Talhelm et al., 2014). This emphasis on collectivism presents an issue for citizen science, as the term “citizen” in China carries connotations of individualism (Interviewee 2, 2019). Consequently, the term may be unpopular, particularly among older generations (Interviewee 2, 2019). According to interviewee 2, the term “public” is preferable to “citizen”, thus “public science” is preferable to “citizen science”, as “public” carries connotations of collectivism (Interviewee 2, 2019).

[3] Interview subjects were anonymized at their request to preserve their privacy.

Other cultural values in China can also interfere with the transmission of citizen science. A central principle of Confucianism, and hence traditional Chinese culture and society, is the recognition of one's place within a social hierarchy (Tsou, 1998). This emphasis on social hierarchy and collectivism means that individuals often act from respect of the social order (Hwang, 1987). Within China, academics and scientists are currently among the most respected professionals (Tsou, 1998). Indeed, many scientists may view themselves as "elite" (Interviewee 2, 2019). As such, these scientists may not be willing to embrace members of the public in scientific activities (Interview 3, 2019). Interviewee 4 who remarked that scientists often believed that "we are the science" summarized this viewpoint (Interviewee 4, 2019). In addition, as humility and a recognition of one's place are important elements of Chinese culture (Hwang, 1987), a desire to stay humble may influence the perception of data quality for citizen science practitioners.

Resistance from the Scientific Community

In China, citizen science projects and initiatives appear to be primarily driven by the NGO sector rather than academia (Freese, 2018). In other countries, citizen science projects are often led by or conducted in partnership with academic institutions. Examples include the eBird[4] program led by Cornell University or the Open Air Laboratories (OPAL)[5] program led by Imperial College London (Davies et al., 2011; Sullivan et al., 2014). Significant input from professional scientists and an academic community provides benefits to citizen science projects, including the ability to include scientific training and capacity building, as well as professional laboratory facilities/expertise and data analysis (Savan et al., 2003).

Within China, environmental NGOs face difficulties in finding reliable scientific organizations as partners in citizen science projects. Scientists often fail to see the benefit of working on such projects, given that they often have limited time and resources (Freese, 2018). Many existing partnerships between NGO-driven citizen science projects and academia are based on personal relationships (Freese, 2018) known as 'guanxi' (关), which are an integral part of Chinese culture (Xin & Pearce, 1996). However, given their personal nature these relationships are not widely transferable, meaning few partnerships exist between the NGO sector and the scientific community.

Perceptions of Data Quality

In China, the perception that citizen science data is of low quality is common within the scientific community, meaning that scientists are often unwilling to work with citizen science projects (Interview 2, 2019). Interestingly, this view is also shared by those within the NGO community (Interviewee 1, 2019; Interviewee 3, 2019). Interviewee 3 stated that data produced from citizen science projects could only be used as a

[4] eBird, https://ebird.org/home
[5] OPAL, https://www.opalexplorenature.org/imperial-college

"reference" and that the public should rely on official data (Interviewee 2, 2019). This lack of faith in data quality is likely to further alienate the scientific community.

Projects such as the Bird Report and the China Coastal Waterbird Census have helped to identify gaps within current conservation policy (Dai et al., 2019; Xia et al., 2017). However, these positive impacts may be limited by resistance from the scientific community towards the use of citizen science (Freese, 2018).

Conclusion

We argue here that citizen science can benefit Chinese environmental policy, but challenges need to be overcome, particularly those posed by traditional cultural values.

Alongside environmental NGOs, the government increasingly supports the use of citizen science—although not officially identified as such—under the umbrella of *public participation*. Government departments have collaborated with and supported specific NGO initiatives involving volunteer-collected scientific data. These developments have occurred under recent legislation that has promoted the use of public participation in environmental governance and policy. It is likely that citizen science or public participation fits within the context of Chinese authoritarian environmentalism – specifically it may represent a mechanism for participation within "consultative authoritarianism." As such, citizen science may help the central government collect environmental data in order to enforce environmental policy, while simultaneously reducing social discontent resulting from environmental challenges in China.

The combination of changing social attitudes and government support for public participation may perhaps result in increased use of citizen science for environmental protection within China. Arguably, while this may improve the provision of environmental policy, it does so under a strengthened model of consultative authoritarianism, and hence authoritarian environmentalism.

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Anonymized Interview 2. Interview conducted by D. Cao, July 22, 2019

Anonymized Interview 3. Interview conducted by D. Cao, July 23, 2019

Anonymized Interview 4. Interview conducted by D. Cao, July 12, 2019

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