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Network environmentalism: Citizen scientists as agents for environmental advocacy

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ABSTRACT

Citizen science – public participation of non-scientists in scientific research – has become an important tool for monitoring and evaluating local and global environmental change. Citizen science projects have been shown to enable large-scale data collection, increase scientific literacy, and monitor environmental quality. However, few studies have examined the individual-level motivations and impacts of citizen science participation. We employ an exploratory multi-method approach (on-line surveys, a focus-group session, informal interviews, and descriptive statements) to evaluate the experiences of citizen scientists volunteering with two conservation organizations based in Bangalore, India. Our findings suggest that citizen science may contribute to increased environmental awareness among the general public. In particular, we identify a three-step process whereby highly motivated individuals, or environmental opinion leaders, seek out citizen science opportunities due to an interest in one or more environmental issues; gain expertise through citizen science participation; and diffuse acquired skills and knowledge to peers through social networks, education of other non-scientist Indian citizens, and/or changes in career or education trajectories. As a result, citizen scientists in India promote environmental principles through an active environmental advocacy network.

1. Introduction

Citizen science, defined as the public participation of non-scientists in scientific research, has become an important research tool for the environmental sciences since the mid-1990s (Bonney et al., 2009b). Extensive review of the citizen science literature illuminates various impacts on research, science education, and participatory public engagement (Bonney et al., 2009a,b; Devictor et al., 2010). Citizen science has the ability to engage non-scientists in large-scale research efforts that produce peer-reviewed publications (Bonney et al., 2009b; Dickinson et al., 2012), expand the scope of scientific knowledge for non-scientist volunteers (Conrad and Hilchey, 2011), and enhance opportunities for environmental science by enabling research "at scales that would be unachievable through professional science alone" (Miller-Rushing et al., 2012, p. 286). Additionally, citizen science may result in "the application of scientific thinking to everyday life" (Price and Lee, 2013, p. 779) and the co-production of knowledge between scientists and citizens (Cooper et al., 2007).

Despite efforts to document the contributions of citizen science to the environmental sciences, questions about what motivates citizen scientists to volunteer and the subsequent impact of this undertaking on the volunteers themselves and on their social networks remain open for analysis (Brossard et al., 2005; Price and Lee, 2013; Toomey and Domroese, 2013). Moreover, despite the growing practice of using citizen science to assess global environmental change, citizen science projects outside North America have received minimal research attention. Exceptions include research on collaborative and participatory science in which communities and researchers work together to generate

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new knowledge (Fortmann, 2008). Lawrence (2010), for example, explores the ways in which local and scientific knowledge interacts through participatory conservation across different regions, including Central America and East Asia. While this article is not intended to provide a comparative overview between citizen science in India and other regions of the world, we contend that it is imperative to understand the full impacts of citizen science in different institutional contexts through detailed case study work.

This paper begins to fill these gaps in the global citizen science literature. We conducted an exploratory study to discern motivations for and impacts of citizen science volunteers working on wildlife conservation projects with the Centre for Wildlife Studies and the Wildlife Conservation Society (CWS-WCS), two organizations based in Bangalore, India. CWS, established in 1984, is a non-profit trust that practices science-based conservation with attention to large mammal ecology and conservation. WCS, an international conservation organization, established its India program in 1988 (information about the partnership between CWS and WCS can be obtained online). Employing data collected from a mixed methods approach (on-line surveys, a focus-group session, informal interviews, and descriptive statements), we suggest that participation in a citizen science project can act as a catalyst for increased environmental engagement and awareness. Specifically, we use survey and interview data to propose a three-step process that explores how citizen scientists utilize expertise gained through participation to become conservation advocates. Our three-step process is adapted from Katz' (1957, p. 61) hypothesis of the two-step flow of communication, which argues that opinion leaders – individuals motivated to address issue-specific concerns by taking concrete action – more readily absorb information related to their particular interests and communicate it to members of their social network in an influential way. We confine our analysis to an examination of the impact of citizen scientists on wildlife conservation in India because CWS-WCS focuses exclusively on these issues; however, our conclusions could be applied to a range of environmental issues in India.

In the proposed three-step process, CWS-WCS citizen scientists first seek volunteer opportunities because they are environmentally conscious individuals motivated to increase their knowledge about wildlife conservation (i.e. environmental opinion leaders). Second, these individuals enhance perceived self-efficacy by obtaining experience and expertise through volunteer work with conservation scientists. Third, they mobilize as environmental advocates, diffusing conservation principles more widely via three social pathways: (1) communicating with co-volunteers, friends, family, and colleagues through social networks, (2) educating other non-scientist Indian citizens based on expertise gained in their volunteer experiences, and (3) adopting career paths that allow them to engage directly with wildlife conservation, specifically through outreach.

We investigate three fundamental questions to explore how citizen scientists may act as both opinion leaders and as social advocates: (1) What factors *motivate* citizen scientists to volunteer?; (2) How does volunteering impact the *individual*?; and (3) What is the *broader* role of citizen scientists for enhancing public awareness of wildlife conservation issues in India? We focus on India because it is underrepresented in the wider literature on citizen science (but see Conrad and Hilchey, 2011), has well-established laws and institutions for conservation and wildlife protection dating back to 1972 (GoI, 1972–2014), and has witnessed the growth of an increasingly active environmental movement (Haynes, 1999; Jasanoff, 1993).

In order to address these questions, the rest of the paper proceeds as follows. We first provide background on the citizen science literature and situate CWS-WCS citizen science projects within the broad field of public participation in scientific research (PPSR). The next section discusses the three-step process – that is, seeking opportunity, expertise, and advocacy. We then turn to our case study, which consists of a series of citizen science projects in India implemented by CWS-WCS. We present our methods and discuss results to examine how the three-step process can help illuminate motivations for volunteering and possible impacts, including diffusion of conservation principles across wider public networks. We conclude by outlining some implications of our findings for broader conservation awareness in India.

2. Citizen science: a review

Citizen engagement has long been recognized in the environmental science and policy literature as a tool for collecting data, advocating for social change and environmental justice, making science more inclusive, and enhancing social-ecological connections (Agrawal, 2001; Conrad and Hilchey, 2011; Fortmann, 2008). Bucket brigades, residential groups recruited to monitor air quality standards, have been celebrated as an important mechanism for community policing (O'Rourke and Macey, 2003). Likewise, Morello-Frosch et al. (2009, p. 1) contend that citizen science plays an important role in "interpreting, disseminating, and leveraging" environmental information to promote community health.

The use of the citizen scientist in research has increased over the last two decades – a trend projected to continue (Bonney et al., 2014). Increased interest in citizen science by the scientific community, nongovernmental organizations (NGOs), and the general public corresponds to growing levels of concern for environmental issues and awareness of human impacts on ecosystems (Bonney et al., 2014; Conrad and Hilchey, 2011; Kinchy and Perry, 2012). Since its emergence and popularization, promoted largely by ornithologists at Cornell University, the process and perception of citizen science has undergone periods of contestation and transformation (Bonney et al., 2009b). Scholars and practitioners have debated what constitutes "citizen science," its goals and objectives, and how to evaluate its contribution to scientific advancement and public engagement (AMNH, 2011; Haywood and Besley, 2014). Some researchers have focused on the benefits of citizen science in performing scientific research, including increasing sample sizes and accessing locations and data sites that professional scientists may be unable to access themselves (Brudney, 1999; Cooper et al., 2007; Danielsen et al., 2014). Others have focused on the ways in which citizen science engages the public in participatory scientific learning and environmental advocacy (Cornwell and Campbell, 2012; Ellis and Waterton, 2004; Shirk et al., 2012). Citizen science has also been utilized to understand global environmental change. For example, Hurlbert and Liang (2012) draw upon citizen science bird observations to document climate change effects while Danielsen et al. (2014) demonstrate the importance of locally-based natural resource monitoring for conservation in developing countries.

Perceived benefits resulting from public participation in scientific research has led to an increase in citizen science projects across numerous disciplines (Dickinson et al., 2012). To promote comparability and encourage broader learning across projects, Cornell University, in cooperation with several other organizations, launched DEVISE (Developing, Validating, and Implementing Situated Evaluation Instruments for Informal Science Education). DEVISE aims to design consistent methods for use across disciplines to measure individual learning outcomes and project-wide impacts (AMNH, 2011, p. 4). However, the design, purpose, and desired outcomes of citizen science programs continue to be shaped largely by the disciplinary norms within which projects are conducted, and remain open to examination and debate. As such, we feel it necessary to define the scope

conditions within which the CWS-WCS citizen science project is based to facilitate understanding of how our conclusions may apply to the wider citizen science dialogue.

Haywood and Besley (2014, p. 93) argue that PPSR has been shaped by two theoretical traditions: "public understanding of science," guided by the goals of science education and literacy, and "public engagement in science," characterized by participatory democratic principles. Bonney et al. (2009a, p.18) further distinguish between three types of citizen science projects: contributory projects, in which volunteers primarily contribute data; collaborative projects, in which volunteers collect data but may also help refine project design, analyze data, or disseminate findings; and co-created projects, in which projects are co-designed by scientists and volunteers. Within the framework laid out in Bonney et al. (2009a), Wiggins and Crowston (2011, p. 5) identify five mutually exclusive and exhaustive types of projects: "action, conservation, investigation, virtual, and education."

CWS-WCS citizen science projects are contributory in nature, but also fall under the category of investigation projects identified by Wiggins and Crowston (2011). These projects emphasize data collection from the physical environment. Volunteers engage in land use mapping, human-wildlife conflict surveys, and transect and occupancy field surveys. In a contributory/investigation project, education is not always an explicit goal, but it is frequently a strongly valued purpose (Wiggins and Crowston, 2011). Accordingly, this analysis engages considerably with the first tradition – public understanding of science – because one overarching goal of CWS-WCS is to promote conservation efforts in India via outreach to non-experts (Haywood and Besley, 2014; Tlili and Dawson, 2010). However, CWS-WCS citizen science work also relates to the second tradition – public engagement in science – because volunteering can lead to greater advocacy, knowledge sharing between different communities, or a greater sense of environmental citizenship.

The CWS-WCS approach to citizen science presumes that an "evidence-based approach" is necessary to address wildlife conservation issues in a biologically megadiverse country with about 1.2 billion people (Karanth and DeFries, 2010, p. 2865). Early conservation initiatives in post-independence India – including enactment of wildlife protection and forestry laws, designation of protected areas, and the launch of Project Tiger and Elephant – emerged with a broader environmental movement that gained momentum by linking advocacy, human rights, and the environment in the early 1970s (Haynes, 1999; Karanth et al., 2008; Rangarajan, 2001). India's larger environmental movement focused on promoting public engagement to cultivate a greater sense of environmental citizenship (defined by Ellis and Waterton, 2004, p. 95). For example, beginning in the 1970s in what became known as the Chipko movement in Uttar Pradesh, women placed themselves between trees and loggers to prevent the felling of trees vital for livelihoods. In the 1980s, a coalition of Indian and international environmental and human rights groups worked together to rescind World Bank support for the Sardar Sarovar dam project, which would have resulted in massive population resettlement (Haynes, 1999).

While India's conservation movement also emerged in the early 1970s, it has focused more on influencing policy and legislation, especially through the expansion of a protected area system (Karanth and DeFries, 2010). Scientists, practitioners, and citizens have worked to increase support for conservation in India by utilizing data on human-wildlife-ecology interactions (Karanth and DeFries, 2010). In this vein, CWS-WCS citizen scientists collect data used to provide scientific evidence supporting continued development of conservation initiatives, advocate for wildlife conservation in a densely populated emerging economy, and inform policy. Both the broader environmental movement and conservation initiatives in India reveal a potentially vibrant environmental civil society that can mobilize to influence environmental issues. The aim of this study is to further understand motivation for and impact of one type of citizen science project in India.

2.1. Three-step process: seeking opportunity, self-efficacy, and advocacy

We draw from Katz' (1957, p. 61) hypothesis of the two-step flow of communication to explore what motivates citizen scientists to volunteer, and their potential impacts. Katz' (1957, p. 77) two-step flow hypothesis emphasizes "interpersonal relations as channels of communication." Katz (1957, p. 61) specifically hypothesizes that "influence stemming from the mass media first reaches 'opinion leaders' who, in turn, pass on what they read and hear to those of their every-day associates for whom they are influential." Opinion leaders have issue-specific interests and the ability to communicate those interests to others in a way that influences beliefs. In our study, we focus on environmental opinion leaders – defined as individuals "who actively choose to seek out information in order to learn more about how their behavioral change may influence both their social and ecological environments" (Dalrymple et al., 2013, p. 1441).

More recent literature examining the relationship between volunteering and motivation support the idea that leaders can act as "belief-managers" (Arbak and Villeval, 2013, p. 637; Gächter and Renner, 2010). In particular, Arbak and Villeval (2013, p. 638) argue that voluntary leadership is "widespread and persistent even though it involves personal costs." Although scholars postulate a number of motivations that might spur volunteerism, Clary et al. (1998) suggest six major factors: career motives, enhancing self-esteem, social motives (norm conformance), protective (escaping negative feelings), understanding or learning, and value (expressing beliefs). Allison et al. (2002) concur but add three: religiosity, team-building, and enjoyment.

To date, most research on contributory citizen science has focused on the idea that volunteers engage in citizen science volunteerism to increase scientific literacy (Miller-Rushing et al., 2012). However, we argue that such a vague motivational mechanism misses an important aspect of citizen science participation – a high level of concern for environmental outcomes. Hart et al. (2011, p. 278) show that environmental values are "...a strong predictor of both concern about how government agencies manage wildlife and the willingness for an individual to formally engage in the management process itself." Additionally, Cornwell and Campbell (2012) demonstrate how high levels of environmental concern – here, concern for conservation of loggerhead sea turtles – translated into greater engagement in conservation policy and practice. These examples suggest that individuals with a high level of concern for a particular issue are (1) more willing to invest individual resources to become familiar with the issue area and (2) more likely to become leaders in that issue through participation in environmental advocacy.

In this study, we suggest that environmental values may be a prominent driver for citizen scientists to seek out volunteer opportunities (step 1 in our three-step process). These individuals – environmental opinion leaders – have a high concern for wildlife conservation issues and willingness to expend personal resources in order to gain expertise. They are more likely than the average citizen to utilize their own time and resources to gain expertise concerning particular issues.

Environmental opinion leaders that participate in citizen science projects increase their expertise about wildlife conservation issues (step 2). Although there is much debate on the concept of "expertise" in the citizen science literature (Carolan, 2006;

Fortmann, 2008; Leach and Fairhead, 2002; Lorimer, 2008), we suggest that citizen science projects offer the means to develop particular forms of expertise when citizen scientists gain issue-specific knowledge through volunteering. Increased expertise can then lead to enhanced levels of perceived self-efficacy as volunteers obtain more experiential knowledge. Self-efficacy is defined as "judgments of how well one can execute courses of action required to deal with prospective situations" (Bandura, 1982, p. 122). Volunteers with higher levels of perceived self-efficacy may feel more empowered to communicate about environmental issues to others (Cornwell and Campbell, 2012; Dalrymple et al., 2013). Bandura (1982, p. 123) provides theoretical support for this pathway, noting "people avoid activities that they believe exceed their coping capabilities, but...undertake and perform assuredly those that they judge themselves capable of managing." Dickinson et al. (2012, p. 292) similarly conclude that participation in citizen science creates learning experiences that generate "ecological knowledge, inquiry, and place-based nature experiences" and reinforces issue-specific expertise.

Opinion leaders that seek out volunteer opportunities and generate expertise in conservation issues may then choose to mobilize as advocates (step 3). Several studies demonstrate an important link between environmental opinion leaders and social advocacy. Dalrymple et al. (2013, p. 1441) show how environmental opinion leaders in their study on aquatic invasive species served as "opinion vectors" that communicated with the public about environmental issues. Similarly, Nisbet and Kotcher (2009, p. 329) argue that people concerned with climate change act as "connective communication tissue" that "alerted their peers to what mattered among political events, social issues, and consumer choices." Beyond drawing attention to a particular issue, environmental opinion leaders also "signal how others should in turn respond or act" (Nisbet and Kotcher, 2009, p. 332).

Dalrymple et al. (2013, p. 1442) argue that environmental opinion leaders can serve in these communication capacities because they possess high levels of perceived "self-efficacy." Ultimately, self-efficacy becomes important vis-à-vis environmental opinion leaders for two reasons. First, the literature indicates that, despite increased access to science and environmental information through a variety of platforms (i.e. internet, media), public concern and knowledge about these issues remains relatively low (Dalrymple et al., 2013; Jones, 2010). Second, recent behavioral studies suggest that social networks and opinion leaders are an important source of novel information. Scholars indicate that people consistently look to others to know how to act in a situation where they are unsure about acceptable behaviors (Cialdini and Goldstein, 2004; Cialdini et al., 1990), and, as a result, opinion leaders become important in communicating ideas about social issues. For example, in their study examining changing perceptions on biodiversity in individuals that participated in a butterfly watch, Cosquer et al. (2012, p. 7) show "that the awareness of biodiversity (here, willingness to participate in the Garden Butterflies Watch) spreads in general social networks (i.e., the media), which are not necessarily connected to nature." Dickinson et al. (2013, p. 563) argue that, in many contexts, we are "influenced not just by immediate friends but by friends of friends of friends," which suggests that human behavior can be "contagious" within social networks. Price and Lee (2013) demonstrate that, in the context of citizen science, social networks and interpersonal communication are powerful instruments in changing attitudes toward science because people tend to change behaviors and opinions based on interactions and feedback from others. As a result, Dickinson et al. (2013, p. 564) argue that citizen science projects can enhance group efficacy and provide a mechanism to channel environmental information within social networks. In the next sections, we outline this three-step process – seeking opportunity, expertise, and advocacy – within CWS-WCS projects in India.

3. Methods

Our exploratory study combines multiple methods – we triangulated data collection by analyzing 115 surveys (July–November 2013), conducting a focus group session and informal interviews with CWS-WCS volunteers in the field (February 2014), and collecting descriptive statements of volunteers over time from three CWS-WCS staff members (April 2014). Combining multiple methods provided an opportunity to gain more insight into perceived motivations and impact. Given the exploratory nature of this study, it was critical to obtain information utilizing multiple methods, as each method added to our understanding and analysis.

Current and former volunteers were asked to participate in an online survey consisting of questions about their individual-level motivations and perceived impacts of volunteering. We used the web-based platform Qualtrics to support and manage the survey (Qualtrics, 2014). An online survey was the most suitable approach for collecting data to address our research questions because volunteers are located throughout India, and e-mail is a more reliable and effective form of communication. CWS-WCS provided contact information for 214 volunteers that volunteered at least once with either organization from 2008 until 2013. Of those contacted, 115 (54%) completed surveys. This represents a convenience sampling technique; thus, our results cannot be considered representative or generalizable. However, our data provide an interesting glimpse of the potential impacts of citizen science projects in India that we consider to be an important contribution to the collection of studies investigating citizen science. Our sample size was small because electronic records containing full contact information for former volunteers were only available from 2008 to 2013; however, its size is similar to other research on citizen science (see Cornwell and Campbell, 2012; Dalrymple et al., 2013).

The survey consisted of 35 questions in 5 sections: motivation for participating in citizen science (e.g., reasons for participating, time spent volunteering, travel costs to participate); perceived impact of citizen science on environmental awareness/attitudes (e.g., level of concern with environmental issues, ranking environmental concerns by issue, whether volunteering has altered concerns); perceived impact of participation in citizen science on behavior (e.g., whether volunteering has changed educational or career pursuits, new skills); citizen science and social networks (volunteering before or after working with CWS-WCS, how well do volunteers know other volunteers); and demographics. Responses were collected in Microsoft Excel to generate descriptive statistics to inform the analysis. Qualitative and open-ended responses were coded and post-coded to summarize the data.

Survey results were supplemented with a focus group session and informal interviews by one of the authors in Rajasthan, India. The author conducted one focus group session in February 2014 with eight citizen science volunteers during their participation in a social science survey examining human-wildlife conflict around protected areas in Rajasthan State. These volunteers are not necessarily representative of the larger survey sample; rather, they provide additional context to the citizen science experience with CWS-WCS. Focus group participants had not taken the survey and were volunteering with CWS-WCS for the first time. The focus group session lasted for 1.25 h and included questions from the online survey. The author also engaged in informal interviews with a subset of the focus group participants, following four CWS-WCS volunteers as they worked in the field the day after the focus group session. Only four participants could be followed because volunteers were evenly divided between two cars, one of which

was traveling to another field site. We used this opportunity to conduct more informal conversations with volunteers.

To address any discrepancies between results concerning volunteer profiles from the surveys, focus group, and informal interviews, we requested that the CWS-WCS staff responsible for managing volunteers provide statements describing volunteers over time. We asked about the motivations for volunteering, occupation, intended career path, the level of their knowledge and expertise concerning environmental conservation, and whether the demographic profile of these individuals has changed over time. Three CWS-WCS staff members contributed descriptive statements.

4. Results

4.1. CWS-WCS citizen scientists

Of the 214 volunteers who received the invitation to participate in the survey, 115 completed it. There were 89 male respondents, 23 female respondents, and 3 did not specify their gender. The age distribution of those surveyed fell into three cohorts pre-defined in the survey: (1) ages 18–29 [55%], (2) ages 30–39 [29%], and (3) ages 40–49 [16%]. Respondents were English-speaking, but generally fluent in two or more other languages. For example, 82% spoke Hindi, 65% spoke Kannada, 24% spoke Tamil, and 23% spoke Marathi.

The majority of respondents (91%) had completed at least 12 years of education, with 60 respondents having completed an undergraduate degree and 41 having completed both an undergraduate and postgraduate degree. The median and mode level of education was an undergraduate degree (Category 4 out of 6 categories, SD 1.08). For reference, the average years of education completed by Indian adults 15 years and older is 5.7 (World Bank, 2010). Monthly household income among CWS-WCS volunteers ranged from less than 25,000 INR (Category 1) or 422 USD (18%) to greater than 100,000 INR (Category 5) or 1690 USD (23%). The median monthly income was 50,000–75,000 INR (Category 3) while the mode was 25,000–50,000 INR (Category 2) (USD 827–1241 and 414–827 respectively) (SD 1.47). The average monthly income in India is 7412 INR or 125 USD (World Bank, 2012), suggesting that CWS-WCS volunteers are relatively wealthy.

4.2. Motivation to volunteer

We measured motivation to volunteer by asking three questions: (1) the primary reason(s) for participating as a volunteer with CWS-WCS, (2) personal time and money expended to volunteer with CWS-WCS and (3) self-reported levels of concern about environmental issues. For the first item, volunteers selected between thirteen options: personal (with opportunity to specify), professional (with opportunity to specify), concern for environment/wildlife (with opportunity to specify), educational opportunity, travel, access to parks, meet new people, learn more about rural India, concern about social justice, opportunity to see wildlife, opportunity to spend time in nature, and other (with opportunity to specify). Survey respondents reported three primary reasons for volunteering: (1) concern for the environment and wildlife conservation (77%), (2) opportunity to spend time in nature (68%), and (3) opportunity to see wildlife (66%).

Open-ended responses from the survey, along with the focus group, interviews, and detailed statements from CWS-WCS staff, provided further insights into participants' motivation to volunteer. Reasons varied, but fell into one of three general categories: first, an inclination to *give back* to society by participating in conservation activities. Survey respondent 36 reported that s/he needed "to contribute something to save our nature." Second, volunteers indicated a desire to learn about nature, wildlife, and wildlife conservation. Survey respondents reported a desire to "[gain a] better understanding of science behind conservation" (respondent 5), "learn more about wildlife from experts" (respondent 9), and "enhance my knowledge regarding wildlife and its conservation" (respondent 31). Third, volunteers sought greater field experience in order to alter education or career trajectories.

We utilized a second measure, "willingness-to-pay," to discern potential personal costs to volunteering. Such models are correlated with motivation in economics (Freeman, 1993); thus, we assume that volunteers willing to invest their own resources (personal time and money) are motivated to act on issues of interest. Arbak and Villeval (2013, p. 655) support this assertion by concluding that volunteer leadership is observed frequently even though "material gains from setting a good example are not always present" and "doing so comes with costs."

CWS-WCS does not ask volunteers to pay to participate in citizen science activities. However, volunteers are expected to pay for travel costs to field sites. Travel costs vary depending on the volunteer's home location and the location of the citizen science project in India. We asked volunteers to estimate time spent volunteering (categorical response: <7 days, 7–15 days, 15–30 days, >30), the number of hours required to travel to CWS-WCS field sites (open response), and whether they were required to take time off from work (yes or no, and how many days). Respondents were also asked the average number of times they have volunteered with CWS-WCS, to directly estimate total out-of-pocket costs to volunteer, and the total amount they would be willing to spend to volunteer for CWS-WCS.

Roughly two-thirds of respondents (64%) traveled from Karnataka (corresponding to cities Bangalore, Belgaum, Chickmagalur, Gundlupet, Koppal, Mangalore, Mudibidri, Raichur, Shimoga, Sirsi, Udupi, Virajpet) and about 17% traveled from the neighboring state of Maharashtra (Dapoli, Lonavala, Mumbai, Nagpur, Pune, Ratnagiri). Volunteers also reported journeying from: Andhra Pradesh (Chittor), Delhi (New Delhi), Goa (Chicalim, Mapusa), Gujarat (Ahmadabad), Odisha (Bhubaneswar), Punjab (Tarntaran), Rajasthan (Jaipur), Tamil Nadu (Chennai, Coimbatore), and West Bengal (Durgapur, Kolkata) (Fig. 1). The majority of respondents (57%) spent 7–15 days (travel + volunteer time) volunteering with CWS-WCS per year. Interestingly, about 13% of respondents volunteered for more than one month. Within the sample, the average respondent traveled 15.27 h to get to CWS-WCS field sites (median 9.88; mode 24; SD 14.3). Of the 115 respondents, 78 (68%) reported that they took time off work to volunteer. These individuals reported taking anywhere from 3 to 30 days of leave, with the average being about 9–10 days per year. Respondents had volunteered with CWS-WCS an average of 3–4 times, but the frequency of volunteering, in some cases over two decades, ranged from 1 to 25 times. These descriptive statistics demonstrate strong motivation to volunteer, especially given that volunteers are willing to take leave from work. This is highlighted by the fact that most volunteers (53%) reported only traveling outside of their home state for any reason every few years.

Survey respondents estimated that average out-of-pocket costs to volunteer were about 3000 INR or 51 USD. The maximum spent was 18,750 INR or 305 USD (median 1875; mode 1000; SD 3656). Yet, participants indicated they would be *willing to pay* an average of 4900 INR or 83 USD to volunteer (maximum 50,000 INR; median 3000 INR; mode 5000 INR; SD 6582), suggesting that the value of the experience exceeds the resources expended to travel to the volunteer site. Five respondents said that there was no limit to the amount of money they would pay to participate with CWS-WCS. In the focus group session, out-of-pocket costs ranged from 500 to 24,000 INR (10–415 USD). Two individuals further stated that

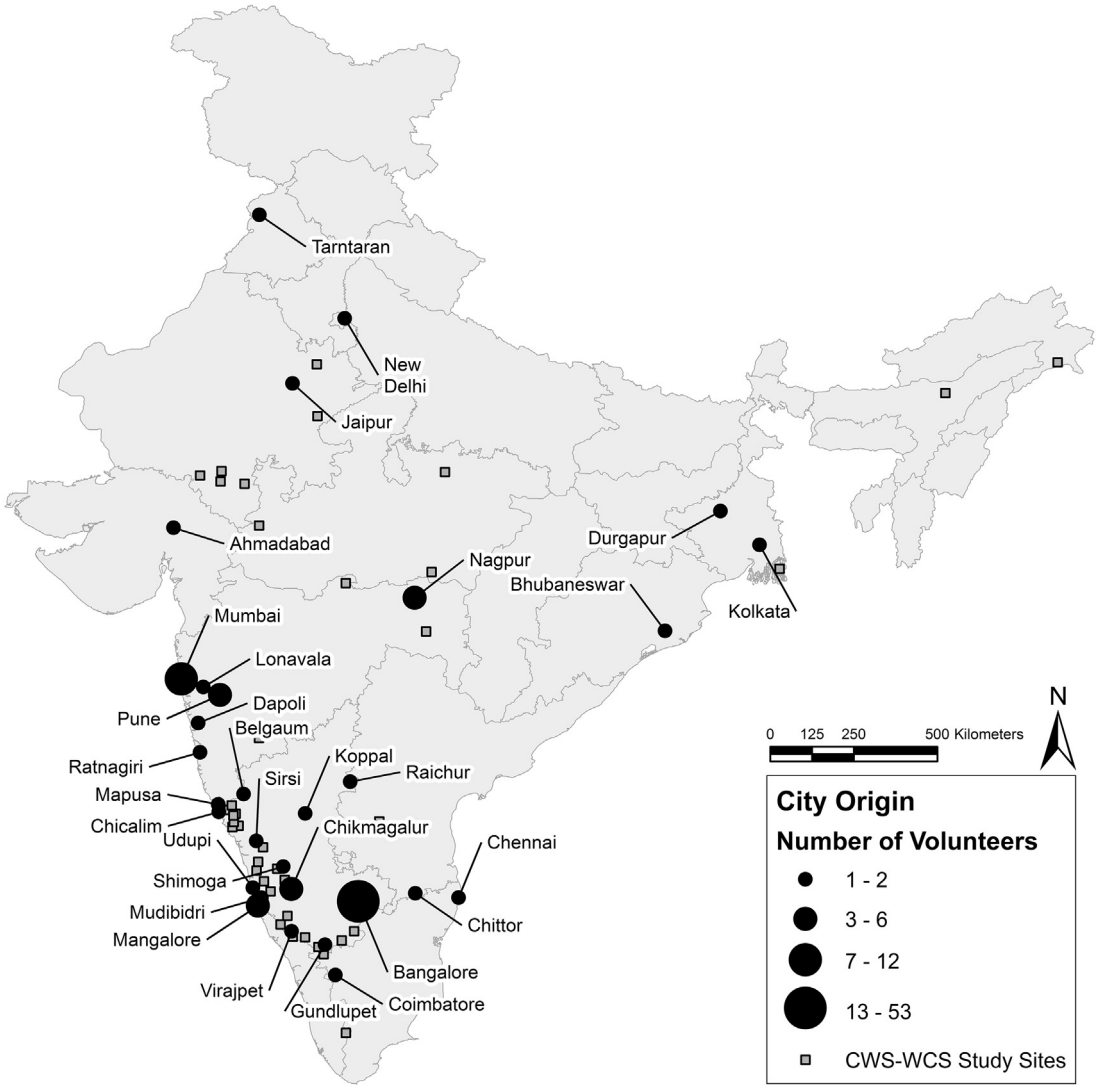

Fig. 1. Map of volunteer origins in India and CWS-WCS citizen science project sites.

expense "was not an issue" because volunteers gained such "invaluable experience" in the field.

Our survey also asked respondents to rank their concerns of environmental issues. We used a Likert scale (1–5 with 1 being not at all concerned and 5 being very concerned) to evaluate levels of concern. Our selection of variables followed Göksen et al. (2002) in a study measuring environmental concern in Turkey, although we modified our variable list to better represent the Indian context. Göksen et al. (2002, p. 619) employ both "concrete environmental problems – those that can be directly experienced – and concern for abstract environmental problems – those that are removed from daily experience and are not salient" to measure environmental concern. Our variable list included: wildlife conservation, air or water pollution, climate change, environmental degradation, food security, forest degradation, land use change, human-wildlife conflict, poaching, rural livelihoods, and tourism (Fig. 2). Volunteers were most concerned about forest degradation (mean 4.78), wildlife conservation (4.77), and poaching (4.71).

4.3. Impact of volunteering

Respondents indicated that volunteering increased concern about wildlife conservation both in India (88%) and in their home state (83%). Additionally, the citizen science experience with CWS-WCS enhanced volunteers' perceived knowledge about environmental issues and wildlife conservation. Increased perceived knowledge was discerned through two questions. First, we asked what new skills did you learn or knowledge did you acquire from volunteering? We presented fourteen options from which volunteers could select as many as applied to them: data collection/entry, scat collection, mammal ID, bird ID, tree ID, conducting social surveys, ecology – plants, ecology – animals, population monitoring, wildlife tracking, camera-trapping, transect design, GPS mapping, or other (open response). We based these options on the activities in which CWS-WCS volunteers are primarily involved. Second, we asked an open-ended question about whether volunteering impacted respondents in ways not yet identified (open response).

The majority of respondents (61%) reported acquiring new skills and knowledge, or advanced scientific literacy. New skills included data collection methods (83%), GPS mapping (62%), wildlife population monitoring and estimation methods (57%), mammal identification (57%), transect design (54%), and conducting social surveys in rural areas (53%). Respondent 54 claimed that the experience had "changed [their] outlook toward survey methodology and data collection [. . .] and that sound science is an effective way for long term conservation." Respondent 93 learned about GPS mapping and passed on the skill to others, "[I] used GPS mapping

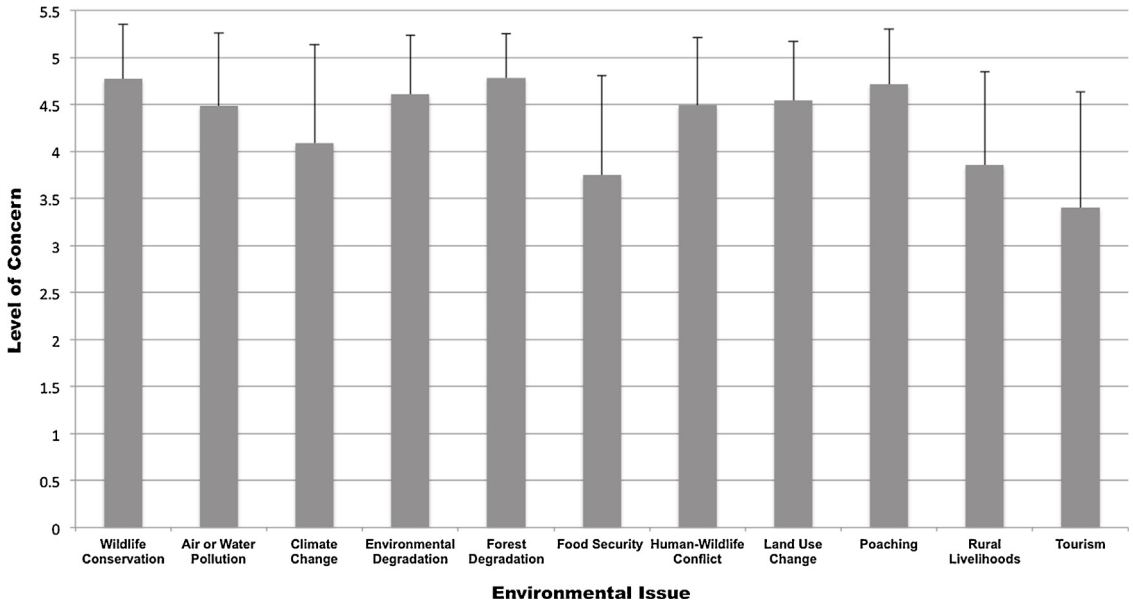

Fig. 2. Self-reported levels of concern for environmental issues in India (n = 115). Respondent value ranged from 1 indicating ("not at all concerned") to 5 (indicating "high concern"). For each issue we provide the mean value and standard deviation.

device for trekking purpose and also taught many people on how to use the GPS device." Respondent 12 noted that "knowledge about the animals behavior and identification has helped me in managing them during trekking or riding in forest area." In response to the second open-ended question, forty-three respondents provided additional information about impacts not yet identified, within which twenty-one volunteers (49%) indicated they perceived improved knowledge, skills, or awareness about nature.

Further, we asked whether respondents applied the skills or knowledge acquired from volunteering to other aspects of their life (those that answered yes were asked to further specify in an open-ended question). 62% of survey respondents noted that they applied their skills and knowledge to other aspects of their lives. Respondent 83 wrote, "As a researcher, all the skills I had learned at CWS help me especially in designing the correct methods to study my research questions." Respondent 88 noted that s/he perceived obtaining "management skills, discipline, details, ground truthing, regular reporting, data compilation ... apply all these skills [to daily life]." Respondent 53 indicated that volunteering "improved the overall quality of my work that I do. I also gained the knowledge to analyze things in many different ways. It helps in planning the things well in advance. It increased my boldness and dareness [confidence]," while respondent 42 noted, "I am applying them [skills] in my personal wildlife watching routines and techniques."

CWS-WCS staff statements confirmed that volunteers acquire "first hand knowledge of the ground realities [of conservation work]. The interaction they have with other experienced volunteers and CWS staff also helps a great deal in their understanding of the issues" (Staff statement 1). This is important for volunteers that "come with the intention to learn and use the knowledge in academics or to pursue their career in the same field [of wildlife conservation]" (Staff statement 3) because having a certain level of field experience is expected or required for higher education and career opportunities, and working with a high-profile organization like CWS-WCS is appealing. Individuals in the focus group recounted gaining more confidence in their ability to operate "in the field" and emphasized that access to scientific expertise, as well as the "ability to learn from professionals," was exceptionally valuable (direct quotes taken from focus group).

Overall, responses from volunteers and staff suggest that participating in citizen science enhances self-efficacy. Respondent 34 remarked, "A huge chunk of my success as a teacher of wildlife and ecology subjects [...] is because of what I learnt from [CWS] and others associated with CWS. CWS has shaped my personality and professional life. Hats off to it!" Respondent 31 wrote, "I got lot of recognition by participating with them, [and now] I am getting a lot of options to work on wildlife conservation." The data suggest that volunteers gained insights, skills, knowledge, awareness, and confidence, all key factors that facilitate increased self-efficacy (Dalrymple et al., 2013). In sum, these results indicate that exposure to environmental issues and scientific skills acquired by participating in citizen science may increase volunteers' confidence and ability to carry out their own projects.

4.4. Advocating for conservation

Social networking serves as a mechanism for both communicating about opportunities to engage in citizen science projects and communicating about volunteering to others: 93% of survey respondents reported that they told friends (97%), colleagues (57%), and family (35%) to volunteer with CWS-WCS. Three survey respondents said that they told "students" [respondents 34 and 105] or "students & youngsters who are interested in wildlife" [respondent 13] to try conservation volunteering. Two others participants wrote that they tell all "nature lovers" [respondent 19] or "people who want to take part in conservation but don't know ways" [respondent 37] to volunteer with CWS-WCS. Respondents also volunteer with other environmental or conservation groups or organizations: according to survey responses, CWS volunteers participate in 82 organizations throughout India. These responses suggest that CWS-WCS is part of a growing network in India for highly motivated individuals to engage in environmental issues, communicate with each other, and alert the wider social network about opportunities.

Such networking appears to be an important diffusion pathway, as about 69% of the survey respondents reported knowing other people that volunteer (besides those encountered through volunteering with CWS-WCS). They also reported knowing a range of 1–5 CWS-WCS volunteers, an average of 3 people. These

people consist mostly of friends (87%), colleagues (24%), family (9%), and a mix of professors, college friends, students, social media connections, and volunteers met in other organizations. Further, 65% of the sample noted that they maintain contact with other volunteers. Of those, 75% indicated they speak by phone, 71% exchange information through social media, 67% keep in contact via email, and 40% engage in personal visits. Thus, there is an exchange of information through these social pathways that keeps a network of people informed and engaged. Respondent 73 commented directly on the volunteer network, noting there was a "nation wide network of dedicated volunteers [...] receiving technical support from CWS."

Respondents also disseminated their knowledge and experiences to the broader public. Eight individuals said that they provided courses and lectures about conservation in India to students, clubs, and community groups: respondent 4 noted s/he worked on "EE [environmental education] programs with schools, camps;" respondent 100 stated "[I] have been conducting nature awareness camps for school children for some time now;" and respondent 32 wrote that the "knowledge I acquired as volunteer I use, display, and provide through seminars to school children of our area." Fourteen volunteers suggested that volunteering helped them engage in general outreach activities: respondent 93 "started educating more and more people in my office by giving presentations on wildlife [conservation] activities;" respondent 77 said that "I and my friends [...] promote wildlife conservation awareness amongst inhabitants of town & villages dotting the periphery of certain Protected Areas;" and respondent 73 noted that s/he was "applying the skills for wildlife protection in my state. Spreading awareness about stray wildlife among people reducing conflict." Additionally, 17 survey respondents (15%) started 15 new environmental organizations to enhance outreach (Table 1).

We asked volunteers whether volunteering with CWS-WCS changed their educational or career pursuits in any way. Fifty respondents (45%) indicated that they had changed their educational pursuits, and 39 (35%) suggested they had changed careers. In terms of educational changes, 22 out of 50 survey respondents indicated they pursued undergraduate or graduate programs in wildlife studies, or undertook additional courses (i.e. online or part-time courses). Seventeen out of 50 respondents suggested that volunteering had changed their awareness of wildlife conservation. Changes in awareness ranged from: increased exposure to new ideas, people, or opportunities (i.e. volunteering "exposed me to some of the brutal truths about human-wildlife conflict" [respondent 61]), to being better informed "about critical wildlife habitats and the need to protect them" (respondent 28), to a greater understanding of research methodology (i.e. volunteering "gave me a better understanding of the strengths and weaknesses of social science research" [respondent 1]). The remaining 11 out of 50 respondents included learning new skills ($n = 3$), making career changes ($n = 3$), or did not respond to the question ($n = 5$).

In terms of career changes, volunteers reported switching from careers in information technology, interior design, or computer science to one in wildlife conservation. Some career changes were comprehensive ($n = 16$): "I have quit the job and full time working on wildlife conservation" [respondent 9]; "left my job" [respondent 82]; "I changed my career from an Interior designer to a full time wildlife conservationist" [respondent 82]. Other respondents made more subtle changes either by incorporating environmental issues into their work or planning for future changes ($n = 23$): "Now I am working as a teacher and I keep trying new modes of experimentation so that my students learn them correctly" [respondent 53]; "I want to work fulltime with an NGO working toward nature and wildlife conservation" [respondent 80]. There were also normative shifts in career perceptions ($n = 6$). For example, respondent 89 suggested that volunteering "made me realize there is more to life than just job security and monetary satisfaction" while respondent 1 noted that volunteering "has perhaps make me wonder a little more about what is important to me."

The qualitative data from the focus group session and the CWS-WCS staff statements indicated that age and income-level were important factors in making academic or career shifts. CWS-WCS staff reported that volunteers are increasingly made up of young individuals seeking to gain experience to prepare for a career in the environmental sciences. A CWS-WCS staffer noted: "the proportion of student-volunteers has dramatically increased over the years" (Staff statement 2). Another statement asserted: "a large part of them [volunteers] are students especially from the forestry college ... most of the students are inclined to make a career in wildlife and use this volunteering opportunity as a learning exercise" (Staff statement 1). All eight focus group respondents were under the age of 30 (seven under the age of 25) and volunteering with CWS-WCS to build their resumes. Two people had a Masters degree in Wildlife Science and were actively applying to PhD programs, while three participants were actively applying to Masters programs.

The qualitative data directed us to further examine whether career and education decisions were related to age and/or income level in the surveys. We used a Fisher's exact test to investigate whether age or income was related to changes in educational or career pursuits. There was not a significant relationship between changes in educational pursuits and age ($p = 0.283$) or income ($p = 0.269$), nor was there a significant relationship between changes in career pursuits and age ($p = 0.289$) or income ($p = 0.642$). A non-significant result is interesting because it indicates independence between the variables (i.e. 45% and 35% of respondents reported changing their educational and career pursuits *in some manner regardless of* age or income level). This differs from qualitative perceptions that volunteers are increasingly student-based, and suggests that volunteering remains an impetus of change for a range of individuals. Conducting larger surveys with control groups across a greater number of citizen science organizations may clarify this discrepancy.

Table 1
Organizations and groups started by citizen scientists after volunteering with CWS-WCS.

Type	Name	Number of people involved
Club	Nature Club	1
Club	Ecology Club	1
Committee	Village Conservation Committee	1
Conservation	Wings of Bangalore	1
Conservation	Forest protection force	1
Education/conservation	Wildlife rescue team	1
Education/conservation	Shimoga Amateur Naturalists (SAN)	1
Foundation/conservation	Kudremukh Wildlife Foundation	2
Foundation/conservation	Tiger Research and Conservation Trust	2
Group	Growing Wild	1
NGO	Wildlife Conservation Action Team Chikmagalur – WildCAT-C	1
NGO/education/advocacy	Biodiversity Conservation Society (Dapoli, Ratnagiri, Maharashtra)	1
Research	Mhadei Research Center	1
Research	Hypnale Research Station	1
Society/association/ conservation	Kenneth Anderson Nature Society	1

Our data tentatively suggest that volunteering with CWS-WCS increased volunteers' perceived self-efficacy, which helped participants apply acquired knowledge and skills to the pursuit of their own environmental agendas through social advocacy. Our data also supports the idea that volunteers diffuse environmental knowledge and opinions primarily through three social pathways: (1) social networks, e.g., interpersonal communication with co-volunteers, friends, family, and colleagues, (2) the education of other non-scientist Indian citizens based on learned skills and experiences as a volunteer, and (3) the adoption of career paths geared toward increasing awareness about wildlife conservation and environmental principles. Information exchange through these social pathways could support the development of a network of people informed about environmental issues in India.

5. Discussion

Based on our data analysis, we find that the reach of citizen science for our case study extends beyond increased scientific literacy. The citizen science project analyzed here presents an opportunity for highly motivated individuals to gain exposure to and experience in conservation. More surprising, it may also provide an unintentional diffusion mechanism to communicate wildlife conservation issues to the general public. We propose a three-step process whereby highly motivated individuals, or environmental opinion leaders: (1) seek citizen science opportunities because they are interested in one or more environmental issues; (2) gain a certain level of expertise through participation in citizen science projects, and (3) pass on their skills and knowledge to other individuals within their social network.

5.1. Stage 1: seeking opportunity

We propose that our survey respondents identified themselves as opinion leaders through their responses to survey questions gauging both their motivations for and the impacts of volunteering. Volunteers signaled that they actively sought out opportunities to engage in conservation issues and could ultimately tap into social networks to advocate for conservation principles. This idea corresponds to Dalrymple et al.'s (2013, p. 1439) finding that opinion leaders "often do not hold formal positions of power" in their social networks "but tend to fill the important role of passing information to their peers and upholding social norms." We believe that characterizing the CWS-WCS volunteers in this analysis as environmental opinion leaders is appropriate for the following reasons: resource investment and environmental concern.

First, respondents demonstrated a commitment to volunteering through their willingness to invest personal resources – time and money – to work with CWS-WCS. Olson (1971) postulates that leaders emerge because they value the collective good more than members of the collectivity, and thus are either willing to incur costs to participate or perceive the ratio of costs to benefits differently than others. Our data demonstrate that volunteers are willing to pay not only the monetary costs of traveling to project sites, but also the opportunity cost incurred by taking time off work to volunteer. Volunteers hail from across India, indicating that travel costs and time needed to volunteer are sometimes substantial, depending on location of the project site.

Second, most respondents reported a uniformly high level of concern for the numerous environmental issues as a motivating factor for participating in citizen science in India (Fig. 2). Bandura (2002, p. 270) argues that "to be an agent is to influence intentionally one's functioning and life circumstances." In our data, we see that CWS-WCS volunteers are motivated to obtain environmental expertise in order to be involved in the field of environmental and wildlife conservation. Specifically, respondents volunteered with CWS-WCS more than once, volunteered with other environmental organizations, made changes in their career or educational trajectories, and disseminated environmental issue-awareness through social networks.

5.2. Stage 2: experience and expertise

Environmental opinion leaders in our study perceived that they increased their skills, knowledge, and confidence through volunteering, a finding supported in the wider literature (Cornwell and Campbell, 2012; Dalrymple et al., 2013; Price and Lee, 2013). We argue that participation in citizen science projects can contribute to specific forms of expertise, allowing individuals to develop higher levels of self-efficacy (Carolan, 2006). As detailed in the Results Section, numerous volunteers linked the skills and knowledge they perceived to have acquired from volunteering to the ability to reach out to others in their networks either informally or formally. At least 15 respondents felt confident enough in their skills and knowledge to start a new conservation organization. Moreover, citizen science in India may constitute an important avenue for access to potential career building and educational opportunities in the field of environmental science. The focus group session and informal interviews confirmed the value of time spent in the field.

5.3. Stage 3: diffusion and advocating for the environment

Volunteers indicated *passing on* environmental awareness and knowledge to others through social networking and outreach activities. Price and Lee (2013, pp. 795–796) claim that one of the most important components of citizen science is "the social component of the project," which is critical for "empowering" citizen scientists and increasing perceptions of self-efficacy. Indeed, survey respondents reported both that they inform others in their social networks of volunteering opportunities and that they keep in touch with other volunteers. Critical to our proposed model is the idea that social networks are important for "disseminating information and ideas, providing access to resources, capabilities and markets, and allowing the combination of different pieces of knowledge..." (Cassi et al., 2008, p. 284).

We identified three possible pathways used by CWS-WCS volunteers for communicating environmental information: (1) communicating with co-volunteers, friends, family, and colleagues through social networks, (2) educating other non-scientist Indian citizens based on volunteer experiences, and (3) adopting career paths geared toward increasing awareness about wildlife conservation. In the first pathway, volunteers act as "connective communication tissue" (Nisbet and Kotcher, 2009, p. 329) that alert their peers to important issues and opportunities. In the second pathway, they enable "communication among heterogeneous actors for building social capital and exchanging knowledge" (Giest and Howlett, 2014, p. 38). In the third pathway, they make or plan to make a commitment to contribute to environmental and wildlife conservation fulltime, serving as opinion leaders that can affect the environmental behavior of others.

6. Conclusions

Our findings tentatively suggest that citizen science could constitute an important mechanism for environmental advocacy in India that promotes conservation principles through social interconnectedness. Other studies have demonstrated that citizen science has great potential for social mobilization because it provides the necessary tools and expertise to engage in complex problem solving (Cooper et al., 2007; Price and Lee, 2013).

Specifically, we argue that the survey participants act as environmental opinion leaders that provide a mechanism for dispersing information about wildlife conservation.

We contend that environmental opinion leaders seek out opportunities to engage in environmental activities. Participation in citizen science projects helps these leaders develop a sense of self-efficacy through the development of new skills, expertise, knowledge, and ultimately through interacting with other opinion leaders. These leaders communicate environmental information within their social networks. This suggests that organizations like CWS-WCS, which primarily utilize volunteers to collect data for scientific research, could have broader impacts for generating awareness about wildlife conservation in India. Rather than engaging in social mobilization, as was commonplace in many earlier forms of environmental activism in India, citizen science has enabled volunteers to advocate through other forms of social networks.

An in-depth analysis of CWS-WCS and their volunteers allowed us to focus on particular mechanisms that help explain *how* citizen science works for CWS-WCS in India and *why* it has certain impacts. While our three-step process – seeking opportunity, expertise, and advocacy – has limited generalizability due to the small sample size and focus on only CWS-WCS, it does suggest that citizen science projects have broader societal impacts, especially for promoting conservation efforts and awareness. We expect citizen science to become an even more important tool for monitoring environmental change and expanding how citizens understand their impacts and consequences, given its increasing acceptance within the scientific community and technological innovations that facilitate public participation (Bonney et al., 2014).

We thus encourage future researchers to focus on the social mechanisms that explain the workings of citizen science and its impacts, ideally across multiple cases and in a variety of contexts. Making comparisons based on the underlying social mechanisms would enable scholars to identify patterns and draw more generalizable conclusions concerning who participates in citizen science, why, and the impacts of this participation for both individual volunteers and the general public.

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