Is earth stewardship enhanced through citizen science projects and initiatives?

Jordi J. Tablada
May 2018

In what is commonly referred to as the Anthropocene era, human activities are responsible for the deep degradational changes taking place within the earth's vital processes and systems, bringing the ecological resources that humans depend on to the brink of depletion and collapse (Raudsepp-Hearne et al., 2010). In order to address, and hopefully reverse, the negative effects of such changes and its often uncertain consequences, earth stewardship advocates for a transformation in our relationship with the environment from a local to a global scale (Chapin, 2011).

Stewardship, from the combination of the old English words stiġ (hall or house) and weard (watchman or guardian), originally referred to the domestics task of serving food and drink to a hall's or castle's master. New duties and responsibilities were progressively included in the term until it encompassed all tasks and burdens associated to the full management and service of an entire household. The ultimate goal of earth stewardship is to, respectfully and responsibly, manage the wide range of natural resources that humanity needs to thrive and flourish while preserving them for future generations (Chapin, 2011), a key achievement also stated in the United Nations Millennium Development goals (United Nations, 2000). As the old Lakota proverb says: "The frog does not drink up the pond in which he lives".

To accomplish its goal, earth stewardship requires a fully collaborative approach through multiple sources of knowledge and disciplines, ranging from natural and social sciences to indigenous knowledge, in order to understand and improve the complex relationships between humans and the biosphere (Palmer et al., 2005). As suggested by Nobel-prize winning atmospheric chemist Crutzen (2002), earth stewardship needs involvement from all social layers, from the general public to the highest authority entities, to effectively perform a turn on ethics, behaviour and attitudes so as to achieve a higher level of socio-ecological resilience, human and environmental well-being (Chapin, 2011). In the last few decades and as part of that involvement, a new process has gained traction as a way to successfully implicate non-scientists citizens in scientific research (Bonney et al., 2009; McKinley et al., 2017). It is what I refer to as citizen science.

Although its relevance has increased in recent years, citizen science is not a new concept. Humans have been extensively documenting and studying the natural world for centuries. While most of the recorded information is associated with a more "elitist" group of curiosity-driven amateur naturalists and researchers, examples of groups traditionally closer to the lower end of the socio-economic hierarchy exist. There are documented cases of farmers and wine-makers who have been collecting data for decades as a result of practical needs born out of their productive farming and wine-making activities (Miller-Rushing, Primack, & Bonney, 2012).

Using large collections of data, at both spatial and temporal scales, to provide answers to specific research questions is now a common practice in modern scientific research (Biber, 2013; Haywood, 2014). However, science professionals, government agencies and other stakeholders frequently face resource constraints that make monitoring and collecting tasks unfeasible. Citizen science can be a useful tool as the

involvement of members of the public provides a mechanism to monitor and collect the desired data. From monitoring a specific bird species to examining air quality, the range of citizen science projects is becoming wider and wider, and it is now seen as an increasingly relevant tool for environmental science research (Dickinson, Zuckerberg, & Bonter, 2010; Dickinson et al., 2012). Citizen science is relevant to top-down participative initiatives where public members are requested to provide information to an institution or group such as a university or a government agency (Conrad & Hilchey, 2011). In developing countries where professional monitoring services are limited and expensive, or in some cases non-existent, this option offers huge potential in the biodiversity and conservation field (Danielsen, Burgess, & Balmford, 2005).

Although participation is a crucial part of this methodology, the limitations are obvious. Volunteers and participants do not have a saying in the possible results and they are often exclusively limited to the data gathering process, which may lead to participants' frustration if they feel their work is not making a difference (Ellis & Waterton, 2004). Not to mention that nothing prevents the leading agency or organisation to disregard the collected data unless a legal requirement prevents them from doing so. Or even worse, collected data can be misused if placed in the wrong hands, instead of serving conservation and scientific purposes it might be used to help raise career profiles of the professional scientists involved (Ellis & Waterton, 2004).

To overcome these pitfalls, often closely related to community-based monitoring and community-based management (CBM) initiatives, some citizen science projects actively involve the public in studying environmental trends relevant to the decision-making, planning and management of natural resources and ecosystems at a local scale (Conrad & Hilchey, 2011). It is aligned with the fact that in most cases, local populations are the ones most affected by the ecological systems being studied. It is a different approach to top-down projects as, ideally, participants have a say in what the project's outcomes might be. There is evidence suggesting that this type of monitoring-based projects often improves communities resource management strategies and helps to change environmental attitudes and behaviors, leading to a more sustainable resource management (Danielsen et al., 2005; Ballard, Fernandez-Gimenez, & Sturtevant, 2008; McKinley et al., 2017). All of these positive outcomes are in line with the concept of earth stewardship.

In Zábalo, an area in Ecuador near the Peruvian border, the Cofán indians, and their ancestral knowledge, are directly responsible of the increase of local endangered freshwater turtles populations. Economic incentives have been put in place to help them switch their hunting habits to more conservation-friendly activities such as freshwater turtle monitoring and nesting management. Increased awareness, new acquired skills by the involved locals and economical benefits are measured outcomes of this project, as documented by (Townsend, Borman, Yiyoguaje, & Mendua, 2005). Being aware of the benefits of the performed work and having a positive notion of engagement in long-term projects are key components of effective and sustainable citizen participation.

In some situations, community-based and citizen led efforts might arise without the intervention of any government or third-party stakeholder and just as a result of an environmental issue at a local scale. In Martha's Vineyard (United States) intensive coastal water monitoring from concerned community members and grass-roots organisations resulted in a series of pressuring actions that pushed the local authorities to take action. Measures were then put in place, leading to a significant increase in water quality levels, indirectly benefiting the local shellfish industry (Karney, 2000). This demonstrates that when citizens become organised, gather scientific proof and use it to make their case in front of local authorities, the final results are well worth it, both for the community and the environment.

But there are also similar cases such as the well-known Canadian "Chemical Valley" where no action has been taken by authorities despite continued local efforts. Home to the Aamjiwnaang First Nation people, the valley also hosts a large number of petrochemical plants and oil refineries, which makes 40 percent of Canada's total chemical industry. For years, the federal government and provincial authorities have been disregarding the rigorously collected evidence, by local citizens, in a joint effort with the University of Michigan, in regards to the high levels of pollution and toxicity found on their ancestral lands (Wiebe, 2016). This community not only has been subject to a significant cultural and spiritual degradation but to a continuously physical and psychological harm due to the effects of the industrial facilities occupying part of their traditional territory (Wiebe, 2016). Despite the constant corporate agressions and inaction of the government, complicit of these agressions, the Aamjiwnaang people have not been discouraged in their efforts to hold corporate polluters to account in what probably remains as one of the most inspiring and recognised ecological guardianship cases ever recorded. This might be an example of how citizen science and public participatory initiatives are more likely to succeed when the decision-making needs to happen at a local level. In the Aamjiwnaang people's case, the local-based monitoring approach does not seem to persuade the Canadian government nor the transnational petrochemical companies operating in their sacred land. This aligns with Danielsen et al. (2005) thoughts on the lack of effectiveness of local participatory monitoring in higher institutional levels unless the initiative is "embedded within or linked to a national or international scheme that feeds the data up to the levels at which governments, international agencies and multi-national corporations operate" (Danielsen et al., 2005:2527) .

All these different approaches to citizen science and public participation point to what Lakshminarayanan (2007) raised; that the role of citizens and volunteers can not be limited and simply be labeled as "data gatherers" but as real scientists doing science. By putting citizens to the same levels as scientists, environmental science becomes more open, accessible to everyone and can be seriously taken by governmental institutions. Other than increasing participants knowledge through experience, scientists also benefit from this as it builds a bidirectional communication channel, making it easier to get access to local wisdom and know-how (Carolan, 2006; Conrad & Hilchey, 2011). When this access to indigenous and local knowledge is recognised it often comes with a sense of

empowerment as in the previously mentioned example of the Cofán indians in Zábalo, Ecuador.

Overall, benefits to the environment as outcomes of CBM and citizen science initiatives are not particularly well documented (Conrad & Hilchey, 2011). Nor are the relationships and social processes that involved volunteers often experience as part of these initiatives (Haywood, 2014) . This makes difficult to judge the rate of success and failure of such initiatives. Seems like most of the literature around the validity of citizen science focuses on the consistency of gathered data by volunteers and participants (Dickinson et al., 2010; Haywood, 2014) but there is much more to be analysed; a wide set of multidimensional effects on the participants, commonly referred to in the literature as "internal values" (Haywood 2014), that might become positive inputs towards earth stewardship.

By being actively engaged in citizen science initiatives, volunteer participants are generally able to boost their scientific knowledge (Conrad & Hilchey, 2011). As their expertise and environmental and scientific literacy increase, so does their confidence and their abilities to engage in other tasks. Confidence can come from within oneself but is also subject to external factors. Recognising volunteers effort, valuing their work by including them as contributors in publications and making them aware of the positive changes they are being part of, are just some of them (Dickinson et al., 2012; Venkatraman, 2010; Whitelaw, Vaughan, Craig, & Atkinson, 2003). These measures are also known to be effective against lack of interest in the long run (Conrad & Hilchey, 2011), helping initiatives to maintain or increase their pool of volunteers. By improving volunteers skills and literacy, citizen science projects are likely to result in higher standards of scientific methodology and data collection (Bonney, Phillips, Ballard, & Enck, 2016). This will help legitimitate the project outputs in terms of decision-making and ecological impacts.

Volunteering experiences are known to help build social networks as it is a way to meet like-minded people, leading to acquire a certain sense of collectiveness. Through these social connections, participants can share their own experiences and knowledge and at the same time learn from others (Guiney & Oberhauser, 2009). As a result of these social learning processes, some participants may disseminate their acquired knowledge and experience to family members and friends (Cornwell & Campbell, 2012; Johnson et al., 2014) as it is a known trait of human nature to communicate and share one's attitudes and behavior through social networks (Johnson et al., 2014; Price & Lee, 2013). When this knowledge and behavior dissemination is taken to a higher level, literature tends to refer to its human vectors as "opinion leaders" (Johnson et al., 2014:238). These opinion leaders may reach broader audiences than just their close social connections, turning into an important channel of dispersion for environmental issues and becoming a reference for other people (Dickinson, Crain, Reeve, & Schuldt, 2013; Johnson et al., 2014; Stern, 2000).

In the last few years, citizen science projects have been using new technologies and social media networks to increase volunteer communication, participation and

learning (Ambrose-Oji, van, & O'Neil, 2014). The use of websites and blogs is a common and widespread practice as they help heighten the impacts of the projects (Merenlender, Crall, Drill, Prysby, & Ballard, 2016). Some research has been done in the involvement of social media tools in citizen science but not extensively as it is a relatively new field of study. There are examples of citizen projects being subject to an increase in registered members and social interactions, not necessarily among participants only but with external individuals, through shared content (Liberatore, Bowkett, MacLeod, Spurr, & Longnecker, 2018; Shaw, Surry, & Green, 2015). Unfortunately, there seems to be no literature on the particular study of how social media networks help volunteers to reach and influence more audience. Their potential is obvious as they enable opinion leaders to reach a wider audience, exponentially when a piece of content goes "viral", and it is a topic worth well researching.

Other social consequences as a result of being involved in citizen science initiatives are educational moves or career changes among participant citizens. In Bangalore, India, the rate of volunteers changing their educational pathway was as high as 45% after having participated in a wildlife conservation project (Johnson et al., 2014). This can be triggered as a result of a combination of experiences and learnings acquired through the programme, in this particular case a biodiversity conservation effort. Participants acknowledged multiple reasons to justify their changes, from learning new skills to being exposed to some environmental truths that they never thought of before (Johnson et al., 2014). This is powerful proof of the transformative social potential that lies in citizen science. As powerful as not to only encourage educational changes but career moves. In the very same project in Bangalore, India, 35% of the participants suggested they had changed careers after their experience (Johnson et al., 2014). Most of them coming from computer science and information technology backgrounds, which are the kind of jobs requiring to spend long hours in front of a computer and would likely to be based in urban areas. Participants acknowledged a change on their life priorities and recognised that the experience helped them connect with values traditionally not aligned with the consumerism-based world (Johnson et al., 2014).

Associated to this discovering experience there is interesting work in the literature of what is commonly known as "sense of place". This is defined as the learning of a local environment and the awareness that implicitly comes with it (Evans et al., 2005). As a result of being part in a citizen science project in the field, participants may acquire interest in the cultural, spiritual and intrinsic value of an ecosystem, concepts traditionally associated to a sense of place, as Chapin (2011) exposed. This can result in a greater sense of responsibility and affective and appreciative ties towards the local environment. When places are perceived to have significance, evidence suggests they are likely to be more respected and cared for (Haywood, 2014;Podeschi & Howington, 2011).

Developing a sense of place among younger generations is important. Citizen science is a great way to let youth discover their local surroundings and potentially change the perception they might have about them (Ballard, Dixon, & Harris, 2017; Vitone et al., 2016). Allowing students to experience the outdoors seems an appropriate manner to send them on a discovery and learning journey on their own terms. This way

of self-discovering is also represented in the way students can be encouraged to apply critical-thinking to their own findings. By using their own collected results as part of a project, students can then assess, analyse and finally formulate new questions to advance their research, leading to further knowledge gain (Mitchell et al., 2017). These new findings and learning experiences have the potential to lead to pro-environmental behavior (Dickinson et al., 2012) as they come from one's within and are not externally induced.

In places where native and indigenous communities have an unfortunate story of land, culture and identity loss, citizen science initiatives can provide youngsters with ways to reconnect to the land and its spiritual and cultural values. Unlocking lost indigenous knowledge can also be part of this re-discovery process. The very same knowledge needed to help better manage resources and natural ecosystems that in many cases proved to be sustainable, effective and respectful with the land in the past (Snively, Corsiglia, & Cobern, 2001).

Overall, effectively performed citizen science projects, englobe a set of socio-transformative processes that can directly contribute to earth stewardship principles in a positive manner. From an individual level, such as personal growth and learning leading to pro-environmental behavior, to a more collective instance, such as influencing decision-making processes related to natural resources, this essay has tried to cover all of the ways citizen science can contribute to the enhancement of earth stewardship, the reasons why and the associated social relationships behind it.

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