Item number	Title/reference *(academic style) name initials (year) title, publisher, volume, pages*	Name of reviewer
2	Walker, D.W., Smigaj, M. and Tani, M., 2021. The benefits and negative impacts of citizen science applications to water as experienced by participants and communities. *Wiley Interdisciplinary Reviews: Water*, *8*(1), p.e1488.	Žemartas Budrys, Xwhy

Review of findings / main outcomes

The article's focus, interestingly, is not on the impact of CS to science and research but on the participants in CS applications to water. This review aims to raise awareness of outcomes experienced by participants involved in citizen science applications to water, which should enable better project design and management, maximizing benefits and avoiding negative impacts.

There are different levels of involvement by participants and the range of professional scientist supervision varies significantly. It could take shape from co-created projects (scientists and local communities co-create research) to passive participation (data mining). All citizen science typologies are applied within the water sciences.

However, the investigation of the impact on participants in the studies is not prevailing. Most of the studies do not mention any impact on participants, neither positive nor negative. Authors divided the impact to Not mention / potential / actual.

Potential benefits of involvement in citizen science:

- Public engagement;
- Rasing awareness;
- Democratisaion of science;
- Development of mutual trust, confidence, and respect between scientists, authorities, and the public:
- Knowledge gain
- Increased scientific literacy:
- Social learning
- Incorporation of local, traditional, or indigenous knowledge
- Increased social capital
- Empowerment
- Behavior change:
- Improved environment
- Decreased risk or improved health
- Improved livelihoods
- Motivational benefits

Actual benefits of involvement in citizen science:

Some benefits are inferred, so one can anticipate what could be the actual impact, however, this is not done in the study itself. There are studies that observed the benefits, stating that common benefits such as raised awareness, increased scientific literacy and social capital, and consequent behavior change have been observed in their study.

Authors present many various case studies where different benefits have been observed such improved livelihoods or incorporation of indigenous knowledge.

In some studies, authors found an investigation of benefits, i.e. post-project surveys conducted. They found plenty of examples of investigated benefits and offer some case studies where it was done and what kind of benefits have been chosen to be investigated.

Authors also present negative impacts, even though 70% of the reviewed water science papers have no mentioning of negative impacts.

Negative impacts are:

- Over-burdening the public:
- Health and safety issues
- Decreased self-reliance:
- Increased sensitization to hazard:
- Exclusion (what participants are participating)
- Technology (exclusion due to being non-technologically savvy, the poor)
- Decentralizing monitoring and passing burden from authorities to public
- Decentralizing risk and passing burden from authorities to public
- Conflict creation (i.e. owner of a well in Lebanon would not accept citizen science data showing contaminated groundwater)
- Data privacy
- Time consuming or boring, and difficulty of tasks
- Importance of data matching goals of citizens
- Disappointment when no impact
- Erosion of confidence, trust and social capital
- Problems caused by financial incentives

Authors express their concern that there is little effort dedicated to investigating benefits and negative impacts. Thus, they see this as a huge research gap since indicated benefits and negative impacts could have been happening in more CS applications, however, they had been left unnoted. Authors say that measuring the impact on communities is the least what scientists can give back to the communities in their CS projects in order to avoid one way exploitation. Hence, scientists shall strive for creating benefits and being aware of that throughout the project: "Specific recommendations include: selecting appropriate indicators to ensure that desired outcomes are achieved (Jordan et al., 2012), social analysis before and long-after citizen science establish- ment to critically analyze the legacy of projects beyond their funding period (Gharesifard, Wehn, & van der Zaag, 2019), and assessing the timeline of benefit achievement to better inform participants and conducting indepen- dent research of projects to enable reporting of null and negative impacts (Stepenuck & Green, 2015)."

Key references *(academic style) name initials (year) title, publisher, volume, pages*

Gharesifard, M., Wehn, U., & van der Zaag, P. (2019). What influences the establishment and functioning of community-based monitoring initiatives of water and environment? A conceptual framework. *Journal of Hydrology*, 579, 124033. https://doi.org/10.1016/j.jhydrol.2019.124033
Jordan, R., Ballard, H., & Phillips, T. (2012). Key issues and new approaches for evaluating citizen-science learning outcomes. *Frontiers in Ecology and the Environment*, 10(6), 307–309.
Stepenuck, K. F., & Green, L. T. (2015). Individual-and community-level impacts of volunteer environmental monitoring: A synthesis of peer-reviewed literature. *Ecology and Society*, 20(3), 19.

Other useful points

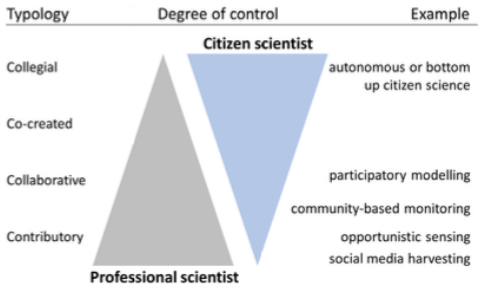

FIGURE 1 The relative degree of control of citizens and professional scientists for different typologies of citizen science. Categorization of a project is subjective; examples such as community-based monitoring and participatory modeling could move up or down the scale. After Shirk et al. (2012)