Engaging local communities in restoration projects

Kandal, Hanaa A.; Swart, Jac A. A.; Yacoub, Hoda A.; Gerkema, Menno P.

Published in:
Restoration Ecology

DOI:
10.1111/rec.13598

RESTORATION ECOLOGY
The Journal of the Society for Ecological Restoration

SER SOCIETY FOR ECOLOGICAL RESTORATION

OPINION ARTICLE

THEMATIC SERIES Arid Lands

Engaging local communities in restoration projects: reconsidering the role of traditional knowledge in Wadi Allaqi, Egypt

Hanaa A. Kandal[1,2], Jac. A. A. Swart[1], Hoda A. Yacoub[3], Menno P. Gerkema[1]

Although there may be large differences between scientific and traditional knowledge (TK) traditions, the possible role of TK for natural management and ecological restoration is increasingly recognized and implies the engagement of local people in conservation and restoration projects. This article explores several forms of community engagement: public participation, citizen science, and responsible research and innovation and argues for an integrated approach as they cover different aspects with regard to the engagement of local people in the context of TK. We illustrate our approach with examples from Wadi Allaqi, a remote area in Southern Egypt. It is concluded that both scientists and local people could profit from such an interaction in ecological restoration and conservation, but that effective policy and management strategies are needed to improve and develop mutually fruitful relationships between scientists and local people.

Key words: citizen science, ecological restoration, public participation, responsible research and innovation, traditional knowledge, Wadi Allaqi Egypt

Conceptual Implications

- Citizens science (CS) and responsible research innovation (RRI) approaches may be considered as elaborations of public participation approaches, stressing the active role of citizens and denoting what it means to give laypeople a real voice, respectively.
- CS projects and RRI approaches are especially relevant for restoration projects as they often imply collaboration with laypeople in conducting the research.
- Traditional knowledge may function as a significant source of information for the protection of desert environments and local people and communities need to be involved in ecological restoration, rehabilitation, and conservation.
- Responsible Science and Innovation approaches are helpful to design and organize collaboration with laypeople in restoration and projects in order to benefit the local community.

Introduction

Many restoration projects aim to restore degraded lands, taking into account also cultural and historical values, besides natural values. In Europe, we find, for example, projects that aim to restore traditional agricultural lands including the traditional utilization customs (see, e.g. UNESCO 2004). In such cases, collaboration with citizens and people from other professions is needed.

However, the relationship between the scientific community and non-scientists or laypeople is not self-evident. Scientists are educated in a specific culture and often embrace particular epistemologies and values on how knowledge should be produced and justified (Bohensky et al. 2013). Literature indicates that the distance between scientists and laypeople, which is sometimes called the "science-society divide" (Barnosky et al. 2016), increases as modern science becomes more specialized (Naustdalslid 2011).

In Western countries, the gap between scientific and traditional knowledge (TK) is considered as potentially bridgeable as many people may be, to a certain extent, knowledgeable of scientific principles. In the case of indigenous people, often living in remote areas, the gap is expected to be much wider. Here, TK is usually transmitted and preserved through quite different methods as oral traditions and cultural expressions, such as arts, crafts, and ceremonies, often accumulated over centuries (ICSU 2002).

In spite of the conceptual and methodological distances between scientific and indigenous thinking, TK may be helpful in realizing sustainability goals, (UNESCO n.d.) and it is

Author contributions: JAAS, MPG, HAK conceived and designed the paper; HAK, HAY provided insights based on their fieldwork in Wadi Alaqi; JAAS, MPG, HAY, HAK discussed the ideas of the manuscript; HAK, JAAS, MPG wrote the manuscript.

[1]Wadi Allaqi Biosphere Reserve, Nature Conservation Sector, EEAA, Aswan, Egypt
[2]Address correspondence to J.A.A. Swart, email j.a.a.swart@rug.nl
[3]Integrated Research on Energy, Environment and Society (IREES), Energy and Sustainability Research Institute (ESRIG), University of Groningen, Groningen, The Netherlands

doi: 10.1111/rec.13598

increasingly recognized that successful ecological restoration depends on effective coordination of science and TK (Uprety et al. 2012).

In this framework, we focus in this opinion paper on three different approaches aiming to bridge the gap between scientist and laypeople: public participation (PP) approaches, citizens science (CS), and responsible research and innovation (RRI). PP is a long standing but rather general tradition meant to enhance collaboration between scientists and laypeople who are affected by research projects. Both CS and RRI are relatively new movements and may be considered as elaborations of the concept of PP. CS especially aims to involve laypeople in the scientific research process itself, whereas RRI stresses to take into account the values and interests of people affected by scientific and technological developments. Considering CS and RRI as elaborations of PP implies that there is a certain overlap of the three approaches, such that PP demonstrates that different practices of laypeople involvement can be distinguished, CS acknowledges the possibility of their active participation in the scientific research process itself, and RRI stresses the responsibility of researchers in such scientific and innovation projects by making clear what it means to give laypeople a real voice.

In this opinion paper, we shortly elaborate on these three approaches and subsequently, we illustrate our insights by the case of Wadi Allaqi, an isolated area in southern Egypt, inhabited by Bedouin tribes with their own body of TK, where two of the four authors (HAK, HAY) performed fieldwork for HAK's PhD project (see also the acknowledgement).

Public Participation

This approach aims to take the needs and perspectives of stakeholders through their involvement during the research process and its implementation in society as for example, in environmental assessment, natural resource management policies (Booth & Halseth 2011), and energy research (Jellema & Mulder 2016). Numerous studies show that PP can enhance the role of stakeholders in decision-making (Fraser et al. 2006).

PP may vary in the extent laypeople are involved. Arnstein (1969) applied the metaphor of a ladder in which each rung corresponds to the extent of citizens' involvement in research plans or programs. It ranges from manipulation (of the public) at the lowest rung to complete citizen control of the research at the highest rung.

More recently, Reed et al. (2018) rejected Arnstein's one-dimensional ladder metaphor, which seems to imply that engagement should always aim to be as far up the ladder as possible. Instead, these authors focus much more on the context of participation and distinguish two dimensions: the extent of top-down steering (ranging from bottom-up to top-down) and the extent of deliberation with stakeholders (ranging from consultation to deliberation). According to this approach, engagement through top-down communication may be considered as successful in certain political and socioeconomic contexts, whereas bottom-up, co-productive processes may be successful among other conditions. The authors insist to select the most relevant type of engagement for a given purposes and context.

Citizen Science

CS is a research strategy to engage non-scientists directly in the process of knowledge development (Buytaert et al. 2014). Thus, laypeople may be involved in research design, data collection, subject recruitment, data analysis and interpretation, and even publication (Riesch & Potter 2014).

CS provide a valuable resource for scientists as many projects require a considerable expenditure of time, effort, and labor unattainable by individual researchers or even research teams (Stilgoe 2009; Bonney et al. 2014). Citizens may receive some training or expertise in scientific methods and concepts, eventually, they may receive some payment for their work (Shamoo & Resnik 2015). CS is not only helpful for scientists. On the one hand, it may provide citizens opportunities to learn more about scientific concepts, methods, theories, traditions, and scientific values. On the other hand, researchers may get more responsive to the needs and perspectives of citizens, including disadvantaged or marginalized groups (Ottinger 2010).

Restoration and conservation-related CS initiatives may enhance people's appreciation for nature and for their local environment (Haywood 2014). In retrospective, as many restoration projects have a long history of collaboration with laypeople and taking into account social aspects and visions of nature (Swart et al. 2001, 2018), they may be considered as CS "avant la lettre." As stated above, they may be considered as an elaboration of PP, albeit that the focus is on the scientific production process itself. In CS projects, scientists usually retain their leading role. CS should therefore be placed on the lower rungs of Arnstein's Ladder and according to the approach of Reed et al. (2018) as having a top-down and deliberative position.

Responsible Research and Innovation

This approach aims to extend the body of responsibilities of scientists, technologists, and related decision makers. As a key concept in the Horizon 2020 funding programme, it is considered by the European Union as "an approach that anticipates and assesses potential implications and societal expectations with regard to research and innovation, with the aim to foster the design of inclusive and sustainable research and innovation" (European Commission NY 2021). The RRI perspective is increasingly recognized as it becomes increasingly clear that the assessment of technical risks of innovation projects must include collective future, social, and environmental impacts as well as choices about the goals and social desirability (Owen et al. 2013).

Four dimensions of RRI have been formulated: (1) *Anticipation* for future developments. So it should not only look to the current research project but also on expected consequences in the future; (2) *Inclusiveness* with regard to stakeholders and the public, meaning that these people are actively involved in the research project; (3) *Reflexivity*, stressing that research should consider underlying value systems in the affected community; and (4) *Responsiveness*, meaning that researchers should response to social concerns (Stilgoe et al. 2013).

The RRI approach stresses the responsibility of scientists and implies cooperation or involvement of stakeholders in the

research process to a certain extent. In the context of PP, the four dimensions generate more concrete types of responsibility to which scientists can be held accountable in their scientific or technological work. It also aims to give potentially affected people having a voice in research and innovation projects. Although there is overlap, it may be considered to be located on a higher rung of Arnstein's ladder and as compared to CS and according to the approach of Reed et al. (2018) as having a bottom-up and deliberative position (see also Smallman 2018). As such it may lower power differences between scientist and laypeople as RRI stresses the role of reflexivity, that is, to take seriously into account the values of affected people and communities.

The Wadi Allaqi Case

Given the noted distance between scientific and TK traditions collaboration between scientist and local people is rather precarious, also in restoration and conservation projects, and may be enhanced by these three approaches. As an illustration, we consider some examples of the engagement of local people in research projects in Wadi Allaqi in the south of the Eastern-Desert in Egypt.

The area of Wadi Allaqi remained relatively isolated until the early 1970s. Bedouins living here had a nomadic life and were self-sufficient for their food and most non-food necessities, using their TK of the surrounding vegetation and environment. This life style secured grazing, shading, firewood, charcoal production, and provided building materials and medicines in this remote area with its harsh conditions (Briggs et al. 1999). However, the formation of a huge water reservoir, Lake Nasser, behind the Aswan High Dam in the late 1960s and early 1970s brought substantial changes in the ecology of the local desert ecosystem and accordingly rapidly transformed the society and economy of the Bedouin tribes (Belal et al. 2009).

Nowadays, most Wadi Allaqi Bedouins do not migrate year round anymore and have permanent settlements at the shores of Lake Nasser. Some are still living in tents, others in stone houses in Allaqi Village, a village established by the Egyptian government in the early 2000s. These developments have not only affected their traditional lifestyle but also their TK base (Briggs et al. 1993), which is however actually eroding (Kandal et al. 2016, 2019, 2021).

Involvement of Wadi Allaqi Local Community in Research

The construction of Aswan High Dam can be considered as a huge scientific and technological project with huge social consequences, without any form of engagement of local people or any sense of taking responsibility for them in the sense described above. Nevertheless, in many scientific research projects in Wadi Allaqi local people did play a role. For example, native people assisted researchers during field studies to find their way in this harsh area as they knew the desert's vast area and were able to navigate through it, even in the night using the stars (Belal et al. 2009). Bedouins in Wadi Allaqi also assisted researchers to collect information on various topics such as the presence of birds (Abdel Azeiz & Walmsley 1991) and other animal species (Mikhail 1993; Springuel et al. 1997), medicinal plants (Badri & Hamed 2000), and environmental issues (Briggs et al. 1999; Ahmed 2003). Similarly, geologists doing fieldwork in the Wadi Allaqi desert, often made use of the Bedouin knowledge of soil color and texture as an indicator of the presence of metals. In addition, Wadi Allaqi Bedouins have the knowledge of where to dug relatively shallow wells to depths of several meters (Yacoub 2018). Another example is the provision of information by Wadi Allaqi Bedouins about the locust movements through the desert to the Commission of Controlling the Desert Locust (CCDL), a regional governmental body in Aswan that aims to follow and predict locust outbreaks (personal communication, 2018, the Commission of Controlling the Desert Locust (CCDL), Ministry of Agriculture, Egypt).

Applying Arnstein's ladder of participation (Arnstein 1969) these examples may be mostly qualified as informing. According to the typology by Reed et al. (2018), they should be assessed as top-down and one-way participation. One may consider these examples perhaps as light forms of CS. In terms of the RRI, we see in these examples some inclusiveness based on the involvement of few individuals of the local community, but no anticipation, reflexivity, or responsiveness with regard to the interests of the Bedouins.

The Agropastoralism Project

A more active engagement of Wadi Allaqi Bedouin in scientific research can be seen, however, in the research project "Agropastoralism as strategy for sustainable conservation and livelihood in Wadi Allaqi biosphere reserve, South Eastern Desert, Egypt," performed by the team of Wadi Allaqi Biosphere Reserve (WABR), Egyptian Environmental Affairs Agency (Yacoub 2012). This research project focused on the degradation of pasture land around the shores of Lake Nasser. Nomadic Bedouin tribes had settled there because of the presence of water and initial grazing resources after Lake Nasser was created. This resulted in severe over-grazing by Bedouin herds (Yacoub 2012, 2018). The aim of the project was to investigate if and how agro-pastoralism could function as an alternative livelihood, to prevent further degradation, and to restore the overgrazed pastures. Local people played a key role in this research project. They selected plant species (for their personal use and as food for their animals) and collected the seeds. They were consulted with regard to various agronomic issues, proper timing of activities and decisions on farms locations, and they assisted in practical work, for example, monitoring, fencing, and watering the area, under supervision of the project team.

It appeared that small-scale agriculture, combined with ancestral pastoral practices based on rotation grazing along the shores, could help to recover the rangelands from regular but temporary grazing pressures. It also helped to establish an alternative livelihood, particularly when the appropriate plant species, cultivated trees, and crops are carefully selected (based on the local community needs of tolerance to drought and temperature), and irrigation water from the Lake is secured.

Local people benefited from the project as it turned out that agro-pastoralism can provide Bedouin people with food and fodder for their animals on a sustainable way, while it also ecologically restored the degraded lands. In addition, the Bedouins

community has learned to apply alternative livelihood resources and has become more aware of the environmental challenges in the area (Yacoub 2012, 2018).

This agropastoralism project seems to be located much higher on the Ladder of Arnstein, as it included partnership with local people and is according to the typology by Reed et al. (2018), much more bottom-up organized. It may also be considered as a form of citizen science as the Bedouin people were actively involved in the scientific research process itself. We like to label it as a "two way version" of CS as not only the scientists benefited from the project, but also local people, in contrast to the other examples, described above.

We can also find here the fulfillment of the four RRI principles: The project responded to concerns of environmentalists and Bedouin people about the degradation of the grazing fields and it included local people actively in the preparation and the conduct of the research project. The project team members reflected on the needs and the culture of Bedouins searching for a form of agro-pastoralism that could maintain Bedouins way of life as much as possible and enable them to restore their degraded lands. The project anticipated on future conditions in the context of climate change, making new practices of agriculture possible also under unfavorable conditions.

Towards a Possible Role of TK in Wadi Allaqi

The agropastoralism project described above demonstrates that local knowledge may be helpful for restoration projects applying CS and RRI as elaborations of PP. However, there are many other examples in other parts of the world, for example, Godden and Cowell (2016), Derak et al. (2018), Robinson et al. (2021), in which we may recognize the approach we advocate. Uprety et al. (2012) argued that contributions of TK may provide a strong foundation to ecological restoration. However, other scholars are much more skeptical about the scientific validity of TK and its usefulness beyond the local level. Hence, incorporating TK systems into ecological restoration may still be a great challenge (He et al. 2009). It stresses the need for reflection and research of the role of TK in restoration.

The recognition of the possible value of TK also requires efforts to maintain the current knowledge base of TK as much as possible, not only for cultural but also for ecological reasons. However, that knowledge base is rapidly eroding, not only in Wadi Allaqi (Kandal et al. 2016, 2019) but also in many other parts of the world. Limiting ourselves to the area of Wadi Allaqi, Bedouins should be encouraged to transfer their traditional way of living and their TK to new generations, and also to people outside their community, in schools and universities, as well as in meetings and conferences. Besides their more traditional role in guiding the field trips as well as data provision and monitoring work, they should be involved in setting up, for example, special training programs (Kandal et al. 2021)

Involving indigenous or local people in education and research is not easy as TK is intrinsically linked to other aspects of their culture. Moreover, for example, most inhabitants of Wadi Allaqi appear to be illiterate and often take distance towards strangers. To overcome such distances researchers should especially pay attention to communication and engagement approaches combined with the aim to contribute to their socio-economic position from the local people's perspective with regard to cultural and environmental issues. The four principles of RRI may here function as a guide. To make use of the heritage of TK of Bedouins in Wadi Allaqi and to support its conservation, policy-makers and researchers within governmental and scientific institutions are particularly in charge. Although there is a willingness among the Egyptian government to utilize TK and scientists and many other stakeholders have a positive attitude towards its significance, a real and significant utilization of TK in practice has not taken place because of many obstacles, among a lack of means (Kandal et al. 2021).

In conclusion, this article stresses the need of engaging local people in research restoration and conservation projects as seen in the case of Wadi Allaqi. In ecological projects, local people may be an important resource by providing TK-based insights over large areas and long time periods (Dickinson et al. 2010). However, such projects should also contribute in reverse to the local society and may also enlarge local peoples' commitment to restoration and conservation goals. TK-policy and TK-management should therefore consider major research and implementation challenges (Hyder et al. 2015). In this light, we think that all types of engagement as distinguished by Reed et al. (2018) can play a role, based on understanding of what works, in terms of desired outcomes by both scientists and local people. However, engagement is not only needed in research but also in policy-making (Kandal et al. 2021) to realize targeted conservation measures that meet the requirements of the local community.

Acknowledgments

We wish to express our gratitude to Dr. H. J. van der Windt (University of Groningen) for his valuable comments. This article is based on chapter 6 of the first author's thesis "Desert Related Traditional Knowledge, Policies and Management in Wadi Allaqi, South Eastern Desert, Egypt," University of Groningen (2020). This research was funded by Nuffic (the Dutch Organization for Internationalization in Education: https://www.nuffic.nl/en).

LITERATURE CITED

Abdel Azeiz S, Walmsley J (1991) The birds of Wadi Allaqi-Lake Nasser, Egypt. Allaqi Project Working paper, No.12. University of Glasgow and Faculty of Science, Aswan, Assiut University, Egypt. Assiut University, Egypt: Unit of Environmental Studies and Development (UESD).

Ahmed NH (2003) Pages 116. Environmental knowledge in Wadi Allaqi biosphere Reserve in South Eastern Desert Egypt. MSc Thesis. Mansoura University, Egypt

Arnstein SRJ (1969) A ladder of citizen participation. Journal of the American Institute of Planners 35:216–224. https://doi.org/10.1080/01944366908977225

Badri M, Hamed A (2000) Nutrient value of some plants in an extremely arid environment (Wadi Allaqi biosphere reserve, Egypt). Journal of Arid Environment 44:347–356. https://doi.org/10.1006/jare.1999.0585

Barnosky AD, Ehrlich PR, Hadly EA (2016) Avoiding collapse: grand challenges for science and society to solve by 2050. Elementa: Science of the Anthropocene 4:000094. https://doi.org/10.12952/journal.elementa.000094

Belal A, Briggs J, Sharp J, Springuel I (2009) Pages 184. Bedouins by the Lake: environment, change, and sustainability in southern Egypt. Cairo, Egypt: The American University in Cairo Press

Bohensky EL, Butler JRA, Davies J (2013) Integrating indigenous ecological knowledge and science in natural resource management: perspectives from Australia. Ecology and Society 18:1176–1182. http://dx.doi.org/10.5751/ES-05846-180320

Bonney R, Shirk JL, Phillips TB, Wiggins A, Ballard HL, Miller-Rushing AJ, Parrish JK (2014) Next steps for citizen science. Science 343:1436–1437. https://doi.org/10.1126/science.1251554

Booth A, Halseth G (2011) Why the public thinks natural resources public participation processes fail: a case study of British Columbia communities. Land Use Policy 28:898–906. https://doi.org/10.1016/J.LANDUSEPOL.2011.03.005

Briggs J, Dickinson G, Murphy K, Pulford I, Belal AE, Moalla S, Springuel I, Ghabbour SI, Mekki AM (1993) Sustainable development and resource Management in Marginal Environments: natural resources and their use in the Wadi Allaqi region of Egypt. Applied Geography 13:259–284. https://doi.org/10.1016/0143-6228(93)90004-K

Briggs J, Badri M, Mekki AM (1999) Indigenous knowledges and vegetation use among Bedouin in the Eastern Desert of Egypt. Applied Geography 19:87–103. https://doi.org/10.1016/S0143-6228(98)00037-X

Buytaert W, Zulkafli Z, Grainger S, Acosta L, Alemie TC, Bastiaensen J, et al. (2014) Citizen science in hydrology and water resources: opportunities for knowledge generation, ecosystem service management, and sustainable development. Frontiers in Earth Science 2:26. https://doi.org/10.3389/feart.2014.00026

Derak M, Cortina J, Taiqui L, Aledo A (2018) A proposed framework for participatory forestrestoration in semiarid areas of North Africa. Restoration Ecology 26(S1):S18–S25. https://doi.org/10.1111/rec.12486

Dickinson JL, Zuckerberg B, Bonter DN (2010) Citizen science as an ecological research tool: challenges and benefits. Annual Review of Ecology, Evolution, and Systematics 41:149–172. https://doi.org/10.1146/annurev-ecolsys-102209-144636

European Commission (NY) (2021) Responsible innovation and research. European Commission, New York https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation (assessed 13 Oct 2021)

Fraser EDG, Dougill AJ, Mabee W, Reed MS, McAlpine P (2006) Bottom up and top down: analysis of participatory processes for sustainability indicator identification as a pathway to community empowerment and sustainable environmental management. Journal of Environmental Management 78:114–127. https://doi.org/10.1016/j.jenvman.2005.04.009

Godden L, Cowell S (2016) Conservation planning and indigenous governance in Australia's indigenous protected areas. Restoration Ecology 24:692–697. https://doi.org/10.1111/rec.12394

Haywood BK (2014) A 'sense of place' in public participation in scientific research. Science Education 98:64–83. https://doi.org/10.1002/sce.21087

He J, Zhou Z, Weyerhaeuser H, Xu J (2009) Participatory technology development for incorporating non-timber forest products into forest restoration in Yunnan, Southwest China. Forest Ecology and Management 275:2010–2016. https://doi.org/10.1016/j.foreco.2009.01.041

Hyder K, Townhill B, Anderson LG (2015) Can citizen science contribute to the evidence-base that underpins marine policy? Marine Policy 59:112–120. https://doi.org/10.1016/j.marpol.2015.04.022

International Council for Science (2002) ICSU series on science for sustainable development No. 4: Science. Tradition; Knowledge and Sustainable Development. 24 pp.

Jellema J, Mulder HAJ (2016) Public engagement in energy research. Energies 9:125. https://doi.org/10.3390/en9030125

Kandal HA, Yacoub HA, Gerkema MP, Swart JAA (2016) Vanishing knowledge of plant species in the Wadi Allaqi desert area of Egypt. Human Ecology 44:494–504. https://doi.org/10.1007/s10745-016-9826-9

Kandal HA, Yacoub HA, Gerkema MP, Swart JAA (2019) Traditional knowledge and community resilience in Wadi Allaqi, Egypt. Journal of Arid Environments 171:103987. https://doi.org/10.1016/j.jaridenv.2019.05.015

Kandal HA, Swart JAA, Yacoub HA, Gerkema MP (2021) The role of traditional knowledge policies in Egypt: the case of Wadi Allaqi. Environment, Development and Sustainability 23:11751–11765. https://doi.org/10.1007/s10668-020-01139-5

Mikhail W (1993) Effect of soil structure on soil fauna in a desert Wadi in southern Egypt. Journal of Arid Environments 24:321–331

Naustdalslid J (2011) Climate change—the challenge of translating scientific knowledge into action. International Journal of Sustainable Development and World Ecology 18:243–252. https://doi.org/10.1080/13504509.2011.572303

Ottinger G (2010) Buckets of resistance: standards and the effectiveness of citizen science. Science, Technology, and Human Values 35:244–270. https://doi.org/10.1177/0162243909337121

Owen R, Stilgoe J, Macnaghten P, Gorman M, Fisher E, Guston D (2013) A Framework for Responsible Innovation. Responsible Innovation. Pages 27–50. In: Owen R, Bessant J, Heintz M. (eds) Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society). John Wiley & Sons, Ltd, New York.

Reed MS, Vella S, Challies E, de Vente J, Frewer L, Hohenwallner-Ries D, et al. (2018) A theory of participation: what makes stakeholder and public engagement in environmental management work? Restoration Ecology 26(S1):S7–S17. https://doi.org/10.1111/rec.12541

Riesch H, Potter C (2014) Citizen science as seen by scientists: methodological, ethical, and epistemological dimensions. Public Understanding of Science 23:107–120. https://doi.org/10.1177/0963662513497324

Robinson JM, Gellie N, MacCarthy D, Mills JG, O'Donnell K, Redvers N (2021) Traditional ecological knowledge in restoration ecology: a call to listen deeply, to engage with, and respect indigenous voices. Restoration Ecology 29:e13381. https://doi.org/10.1111/rec.13381

Shamoo AE, Resnik DB (2015) Responsible conduct of research. 3rd ed. Oxford University Press, New York: NY

Springuel I, Sheded MG, Murphy JK (1997) The plant biodiversity of the Wadi Allaqi biosphere reserve (Egypt): impacts on Lake Nasser on a desert Wadi ecosystem. Biodiversity and Conservation 6:1259–1275. https://doi.org/10.1023/B:BIOC.0000034012.93599.c0

Stilgoe J (2009) Citizen scientists: reconnecting science with civil society. Demos ISBN: 139781906693012. http://www.demos.co.uk/files/Citizen_Scientists_-_web.pdf

Stilgoe J, Owen R, Macnaghten P (2013) Developing a framework for responsible innovation

Smallman M (2018) Citizen science and responsible research and innovation. In: Hecker S, Haklay M, Bowser A, Makuch Z, Vogel J, Bonn A (eds) Citizen science: innovation in Open Science, society and policy. UCL Press, London

Swart JAA, van der Windt JH, Keulartz J (2001) Valuation of nature in conservation and restoration. Restoration Ecology 9:230–238. https://doi.org/10.1046/j.1526-100x.2001.009002230.x

Swart JAA, Zevenberg J, Ho P, Cortina J, Reed M, Derak M, Vella S, Zhao H, van der Windt HJ (2018) Involving society in restoration and conservation. Restoration Ecology 26(S1):S3–S6. https://doi.org/10.1111/rec.12709

UNESCO (n.d.) Local and indigenous knowledge systems (LINKS). Available at https://en.unesco.org/links (accessed 14 Oct. 2019).

UNESCO (2004) Combating desertification, traditional knowledge and modern Technology for the Sustainable Management of Dryland ecosystems. UNESCO–MAB Drylands Series No.4. Proceedings of the International Workshop held in Elista, Republic of Kalmykia, Russian Federation 23–27 June 2004. The United Nations Educational, Scientific and Cultural Organization (UNESCO), Paris

Uprety Y, Asselin H, Bergeron Y, Frédérik Doyon F, Boucher J (2012) Contribution of traditional knowledge to ecological restoration: practices and applications. Écoscience 19:225–237. https://doi.org/10.2980/19-3-3530

Yacoub H (2012) Agropastoralism as strategy for sustainable conservation and livelihood in Wadi Allaqi biosphere reserve, south Eastern Desert. Egypt, The Rufford Small Grants Foundation, London

Yacoub H (2018) Knowledge and community resilience in rangelands recovery: the case of Wadi Allaqi biosphere reserve, south Eastern Desert, Egypt. Restoration Ecology 26(S1):S37–S43. https://doi.org/10.1111/rec.12667

Coordinating Editor: Matthias Gross

Received: 28 July, 2021; First decision: 1 September, 2021; Revised: 22 October, 2021; Accepted: 28 October, 2021