PROMOTING CITIZEN SCIENCE - AN EMERGING CONCEPT WITH MULTIDISCIPLINARY FOCUS ON ENVIRONMENTAL ISSUES IN THE INDIAN HIMALAYAN REGION

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ABSTRACT

The participation of the general public in the research design, data collection and interpretation process together with scientists is often referred to as Citizen Science. While citizen science itself has existed since the start of scientific practice, developments in sensing technology, data processing and visualization, and communication techniques, are creating a wide range of new opportunities for public participation in scientific research. Public participation in scientific data collection activities is important from the point of view of facilitating larger coverage as well as instilling a sense of ownership and empowerment. Citizen participation in science is an across-cutting concept that has emerged from and across many disciplines. As a methodology, it has been promoted for interdisciplinary research as it automatically fosters collective reflection. Public engagement may take a variety of forms- volunteers, collaborators, paid task-force; and a variety of actors- students, women, senior citizens, etc. Activities which are generally pursued, but are not limited to, under Citizen Science include mapping of biodiversity, migration of species, water bodies, hazard damages (e.g. during earthquakes, tsunamis, cyclones, landslides, flash floods/cloud bursts, hail storms, forest fires), weed infestation in crops, sites of epidemic diseases, sites of crop failures; measurement of groundwater level in wells, river water level, rainfall, water quality in streams, wells, lakes, ponds, air pollution, etc. This paper discusses the state of citizen science in a hydrological context and explores the potential of citizen science to complement more traditional ways of scientific data collection and knowledge generation for hydrological sciences and water resources management. Although hydrological data collection often involves advanced technology, the advent of robust, cheap, and low-maintenance sensors and equipment provides unprecedented opportunities for data collection in a citizen science context. These data have a significant potential to create new hydrological knowledge, especially in relation to the characterization of process heterogeneity, remote regions, and human impacts on the water cycle.

Keywords: Citizen Science, Environment, Hydrology, Data monitoring, Himalayas, India.

INTRODUCTION

Citizen science concept

Citizen science refers to the participation of the general public (i.e., non-scientists) in the generation of new scientific knowledge. A large variety of approaches exist, ranging from community-based data collection to soliciting contributions, to carrying out various scientific tasks with the help of large groups of people through the use of the internet i.e., crowd-sourcing (Dickinson *et al.,* 2012). In citizen science, people who are not professional scientists take part in one or more aspects of science systematic collection and analysis of data, development of technology, testing of natural phenomena and dissemination of the results of activities. They mainly participate on a voluntary basis (UNEP 2014). The

purpose of monitoring by the citizen groups is generally to provide early detection by citizens of issues of environmental concern, which can then be investigated by scientific experts. Consultative monitoring has also been suggested for areas where illegal poaching of endangered species is a concern. Citizen scientists can thus provide a watch-dog service for government organizations. Citizen science is one form of open innovation, a paradigm where organizations solicit the efforts of external contributors with unique perspectives who generate new knowledge and technology or otherwise bolster organizational resources. Projects in citizen science and open innovation are usually designed to advance science or create new technologies. But many projects have added impacts including supporting practices in education, management, and public policy. As illustrated by the Audubon Christmas Bird Count, citizen science projects that contribute to scientific research also can support conservation through raising awareness of environmental concerns. Information produced by citizen scientists also may inform policy decisions. Citizen participation in science is a cross-cutting concept that has emerged from and across many disciplines. As a methodology, it has been promoted for interdisciplinary research as it automatically fosters collective reflection (Wechsler *et al.,* 2014). Citizen science is not an entirely new concept, but it is becoming increasingly popular in natural science research. In broader terms, public involvement in science has also been referred to as civic science (Silvertown 2009; Kruger *et al.,* 2000), community science (Carr 2004), and more recently, public participation in scientific research (Shirk 2012). The philosophy is also affiliated to concepts such as community-based monitoring (Fry *et al.,* 2011), community-based management, and crowd-sourced data collection (Lowry 2013). What separates citizen science from less collaborative forms of public participation in scientific research is the element of an "active" engagement; it is an approach where by non-scientists are actively involved, to differing degrees, in the generation of new scientific knowledge, from which they also actively stand to benefit either intrinsically (e.g., increased scientific literacy) or extrinsically (e.g., increased social capital). Previous citizen scientist projects have involved classifying organisms/objects with fewer projects focusing on field measurements. A prime example is the Christmas Bird Count, which has been organized annually since 1900 by the Audubon Society. Others include identifying galaxies/stars (Galaxy Zoo; Citizen Sky); data entry and measurements of fossils (Open Dinosaur), identifying birds (eBird); measuring precipitation (CoCoRaHs; RainLog; Weather Spotter Network); collecting images and qualitative stream data (Creek Watch); and documenting wildlife corridors by monitoring road kill Wildlife Crossing. (Buytaert *et al.,* 2014) presented an exhaustive review of citizen science applications in hydrology and water resources. They discussed not only the state of citizen science in hydrological data collection but also the challenges in terms of data collection, processing, interpretation, and use. In the field of hydrologic sciences, the U.S. Environmental Protection Agency (EPA) runs a volunteer monitoring program for water quality and stream gauging (Wersma *et al.,* 2010).

Some citizen science experiments in India

India has numerous protected areas and natural sanctuaries that were developed in recent decades, but the involvement of volunteers in science is relatively uncommon. Countrywide collaborative scientific projects began to evolve in the mid-1990s with the People's Biodiversity Register (PBR) as one of the first projects implemented across India (Gadgil 2006). It aimed to support rural communities' and individuals' understanding of their ecological setting, document local ecological changes, and lead to local resource management and countrywide documentation of these actions. Following PBR, the Indian government formed "Biodiversity Management Committees" that created biodiversity registers in consultation with the local people, which led the way to broader collaborative scientific projects that involved local "people's knowledge" to enhance "official knowledge" (Gadgil 2006). In January 2010, a citizen science project was initiated in Malappuram region of Kerala to study the

mammalian diversity of the area. School children in the age group of 12-15 years were involved in collecting data on the presence and number of small wildlife species that are found in their backyards and near their houses. (Radhakrishna *et al.,* 2014) candidly admitted that their experiment failed, mainly for the reason that the participating children did not derive enough enthusiasm and motivation for the activity. Whereas some other similar experiments by institutions like Salim Ali Centre for Ornithology and Natural History (SACON), National Centre for Biological Sciences (NCBS), and Science Popularization Association of Communicators and Educators (SPACE) had fared better because of their better preparatory work and wider participant-base. It was concluded that citizen scientists are motivated to continue their work only if they feel that they are making valuable contributions to the study. In their review, (Roy *et al.,* 2012) highlighted the importance of tailoring projects to match the interests and skill sets of participants and understanding the motivations of the diverse and disparate communities participating in the activity. Vigyan Prasar- an autonomous organization of the Department of Science and Technology, Govt. of India is facilitating a network of about 12,000 Science Clubs (VIPNET Clubs) in schools. Science Clubs carry out regular programmes to orient and educate students on concepts and newer developments in the field of science and technology. These clubs also organize demonstration projects, host annual competitions and on special occasions such as solar eclipse etc., plan exposure visits and group activities (Misra *et al.,* 2013). A strong foundation in science is considered essential to transform India into a knowledge superpower. Unfortunately, the science education and research in the country are facing a crisis, which is impeding the development scenario. With the present system, fewer students feel interested in the science education. The general lack of motivation and creativity among teachers often fail to make students understand that science describes the world around them. There is an urgent need to learn and practice science, develop scientific ways of thinking, and relate the modern S&T with the socio-cultural milieu of people. Learning of indigenous traditional knowledge (ITK) and its relevance in the modern context is equally important. Courses should be made more engaging to harness students' own skills and enhance their learning through hands on experiences, e.g. by creating an interface with professionals handling real life problems (e.g. engineers, technologists, scientists, villagers, artisans, technicians). A solution of real life problems in villages and similar places will provide excellent learning opportunities to students, who enjoy working in such outdoor laboratories. The author introduced a new concept of hands-on learning for the students of Jawahar Navodaya Vidyalayas (JNV) where they were exposed to the real life problems prevailing in the village adjoining their school. The solution for these problems was worked out by a team of students and teachers in collaboration with the local villagers, using local resources, traditional knowledge (TK) and appropriate technology interventions (Goyal 2009). Through such activities, it is hoped that students and teachers will find satisfaction of active participation in community based works and feel motivated as citizen scientists. GPS-based monitoring of the damage caused by June 2013 flash-flood tragedy in Uttarakhand is a classic example of the Citizen Science activity. Under Indo-Dutch bilateral assistance programme, APWELL project was implemented in the State of Andhra Pradesh. The concept of Participatory Hydrological Monitoring (PHM) was tried wherein the set of activities, such as monitoring of groundwater level in wells and rainfall, and preparation of water use plans and water budgets were undertaken by the local community (Das 2000). Community Led Environment Action Network (CLEAN-India) of Development Alternatives (http://www.cleanindia.org/) is engaging schools and students in preparing water quality maps in different parts of India. Community-based organizations such as Arghyam (Bangalore), Centre for Science & Environment (CSE, Delhi), Ashoka Trust for Research in Ecology and the Environment (ATREE, Bangalore), UNICEF, and many academic institutions, are implementing water quality monitoring of water bodies through students and local communities.

Challenges and opportunities

Citizen Science faces a number of challenges in terms of both implementation and coordination issues. Effective community engagement, communication between scientists and volunteers, and data quality assurance are some of the major challenges in citizen science activities. Yet, vast opportunities also exist in terms of newer technologies, sensitized and environmentally-aware youths, pressures from the impacts of climate change and anthropogenic activities, and involvement of numerous international agencies in supporting citizen science activities. Some of these challenges and opportunities are listed in (Table 1).

Table 1. Challenges and opportunities in citizen science

❖ **Challenges**
- Data collection errors
- Data quality assurance
- Data compilation, storage, and retrieval
- Data sharing protocols
- Project monitoring and management
- Volunteer engagement
- Financial support to citizen science activities (Citizen Participation Fund)
- Communication between scientists and volunteers
- IPR issues

❖ **Opportunities**
- Large pool of data (spatially/temporally), especially from virgin regions.
- Creating sensitivity and awareness among citizens on environment-related issues.
- Horning of skills especially among youths.
- Large network of schools, colleges, and Panchayats.
- Smart phone and satellite-based communication technologies.
- Web-based crowd sourcing technologies

Environmental field data monitoring issues in the Himalayas may include

Biodiversity mapping, Pollution tracking (e.g. in streams, ponds, lakes), Hot-spot identification, Identification of areas impacted by natural hazards (cloud bursts, landslides, forest fires, crop failures due to hail storms, earthquakes), Mapping of vulnerable areas, Mapping of resilience facilities, Soil health monitoring, Rain, snow, hail and groundwater level monitoring, Stream flow and spring flow monitoring, Soil erosion, Crop acreage, Water demand, Mapping of water harvesting/ conservation structures (e.g. CDs, ponds), Mapping of health epidemics etc.

DISCUSSION AND CONCLUSION

Citizen participation in science is a cross-cutting concept that has emerged from and across many disciplines. The wide range of researchers involved, such as biologists, environmental scientists, hydrologists, watershed planners, science communicators, social scientists, etc., brings to the citizen science a good blend of expertise to lend credibility to the activities (Conrad 2011) as a methodology, it has been promoted for interdisciplinary research as it automatically fosters collective reflection. The purpose of monitoring by the citizen groups is generally to provide early detection (by citizens) of issues of environmental concern, which can then be investigated by scientific experts. India has numerous protected areas and the vast amount of natural resources that need to be sustainably developed, but involvement of volunteers in science in India is relatively uncommon. The Indian Himalayas provide a great opportunity of utilizing citizen science activities such as, but are not limited to, mapping of biodiversity, migration of species, water bodies, hazard damages (e.g. during earthquakes, tsunamis, cyclones, landslides, flash floods/cloud bursts, hail storms, forest fires), weed infestation in crops, sites of epidemic diseases, sites of crop failures; measurement of groundwater level in wells, river water level, rainfall, water quality in streams, wells, lakes, ponds, air pollution, etc. Scientific data collection through citizen science activities has a significant potential to create new environmental knowledge, especially in relation to the characterization of process heterogeneity, remote regions, and human impacts on the natural resources.

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