Special Issue: Inquiring into Technoscience in India

‘Citizen Science’ in ecology in India

How is it shaping up? Where is it headed?

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DIALOGUE
Science, Scientists, and Society

Table of Contents

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Abstract. The emergence of Citizen Science can be understood as the coming together of three broad contemporary trends at the intersection of scientific research and environmental regulation: the growing awareness among the public on matters of the environment, the growing availability of (big) data that has been facilitated by the rapid evolution of technologies of data gathering, transmission and analysis, all of which would broadly constitute the frame of ‘big data.’ The third of these trends is the increased interest and participation of the citizenry in scientific research and environmental monitoring on the one hand and regulation on the other. This paper is based on a detailed study of 17 different self-identified Citizen Science projects currently underway in India and seeks to provide trends, analysis and insight on this rapidly growing way of ‘doing science.’ Analysis and key findings are based on quantitative and qualitative assessments. The quantitative dimensions discuss the number of citizens participating, the volume of data contributed and collected and the time frames which the different projects operate within. The qualitative aspects of discussion are related to matters such as the concept of 'voluntarity,' the citizen science nomenclature, the possibility of challenging existing power structures within scientific research that citizen science offers, issues of data ownership and regulation and also on the promises and limitations of the technological interfaces that make Citizen Science possible.

Keywords: Science; citizen; citizen science; ecology; participation; research

Introduction – Setting the stage

> "They don't have PhDs or wear lab coats. They range in age from 10 to 75. But citizen scientists are helping actual scientists answer questions about the weather, wildlife, plant life, what's really going on in the oceans, and even what lies beyond the stars. They typically have day jobs — as graphic designers and lifeguards, business consultants, architects and bankers. Many have to take time off to head out into the nowhere lands where they collect leopard scat, report on roadkill, count birds, survey households living around wildlife reserves, set up camera traps or measure beached dolphin carcasses." (Behrawala 2018)

> "Citizen scientists can ask questions, volunteer to collect data, and analyse it. For researchers, citizen scientists are a boon: with their sheer numbers, they can contribute extensive data over vast geographical areas, something trained scientists could not dream of gathering either individually or in teams. (…) Today, thanks to smartphones, the internet and the endless possibilities of apps — with special help from Google Maps — citizen science has truly come of age around the world. And India is by no means lagging. Whether flowering patterns in trees, the mating habits of butterflies, or the arrival of migratory birds, the country's citizen scientists are helping create a vast and valuable corpus of data." (Perinchery 2018)

Citizen Science in India

If media reporting is considered a reasonable barometer of current affairs, and indeed the first draft of history, 2018 could well go down as the year when Citizen Science, particularly in ecological studies, caught the imagination in India. It may or may not have come of age as a scientific methodology yet, but there should be no doubt that it's come centre stage in the public discourse.

A quick Google based survey in August 2018 (when research for this article was being conducted) could locate about 30 news articles and reports with the central theme of Citizen Science in India published across some of the country's most prominent English media platforms for the year 2018 alone. This translates to one article/news report a week on average and is certainly prolific and substantive considering the fact that less than a third of this number (eight) of such reports could be located for the entire preceding year of 2017.

It is not just the increased volume of the reporting, but also the prominence and the space given to these articles that are instructive of the buzz around Citizen Science. The two quotes above, for instance, are from full-page lead features published in two of India's most

prominent English news-dailies – *Hindustan Times* and *The Hindu*. A close reading of these quotes also highlights many interesting features – the effusive optimism of the reportage, the 'citizen scientist' as different from the 'actual scientist' and/or the 'researcher,' the range of backgrounds (designers, lifeguards, bankers, etc.) and the broad age bracket (10-75 years) the citizen scientists come from, the diversity of ecological subjects they are contributing to and the central role being played by a set of certain kind of technologies – smartphones, apps and the internet – that is making it all happen.

And it is also not just professional journalists and reporters writing about Citizen Science. There is an increasing number of scientists and researchers, some of them at the heart of the Citizen Science initiatives, that are writing in the popular press about what they do, about the potential of Citizen Science and what it is actually delivering (cf. Agnihotri et al. 2016; Gubbi 2018; Ramaswami and Quader 2018).

In academic publishing in India

While the coverage in the media has been extensive (and increasing), peer-reviewed publishing, both in terms of the number of publications or scientific insights generated from Citizen Science projects is also starting to become visible. A majority of these academic papers have been published only in the last couple of years and are either assessments by the coordinators themselves of a particular Citizen Project like in the case of the India Biodiversity Portal (IBP) (Vattakaven et al. 2016) and Hornbill Watch India (Datta et al. 2018), or initial analysis and trends using data generated from one particular project, BirdCount India, which is the source already of about a dozen published papers (see, for e.g. Arjun and Roshnath 2018; Baidya and Bhagat 2018; Baidya et al. 2017; Kannan et al. 2018; Praveen 2017; Praveen et al. 2016; Ramesh et al. 2017b; Ramesh et al. 2017a; Roshnath 2017). Data available from the India Biodiversity Portal, a Citizen Science driven data portal has also been cited in over 100 scientific publications clearly underlining the potential this kind of data gathering offers.

Interesting scientific and conservation outputs are also beginning to be visible from these projects. This includes, for instance, the discovery of new species of spiders and frogs, range extensions of in the case of species, new information on tiger presence and movement around the Ranthambhore Tiger Reserve in Rajasthan, a better understanding of the risk of snakebites, of wild animals killed in road and rail accidents across the country and regular information on over 200 Fruit bat roosts from India and neighbouring countries.

There can be no doubt that this will all increase in the near future as more such projects come on stream and they also deepen and widen the data they gather and therefore make available

for further research and analysis.[1] This indeed is the trend worldwide and what one is seeing in India is clearly an extension of the same.

Studying Citizen Science

But the science that is happening as part of the Citizen Science projects, important and interesting though it is, is not the subject of this particular paper. This analysis is if we might use that term, a second-order study of Citizen Science in India. It is primarily about the assumptions, conceptualisations, methods and institutions that constitute Citizen Science projects on the one hand and those that these projects themselves mobilise to constitute the science that they do on the other.

This paper is based on an initial study of 17 Citizen Science projects in ecology in India (See Sec. Annexure 1). Important to note here is the classification of Citizen Science projects; we have only included those projects here that self-identified themselves as Citizen Science.[2] This identification by the key actor as a starting point for research is a key methodology in Science and Technology Studies and has been an effective and useful point of entry for us into this particular study.

The analysis that we present draws upon the information put out by these projects on their respective websites, the news reportage that has been discussed above, a perusal of the peer-reviewed literature generated from these projects (also mentioned above), one round of open-ended, semi-structured interviews with coordinators of seven of these Citizen Science projects and also one round of email communication related to the data tabulated in Sec. Annexure 1 to confirm and update the information included.[3]

Our interests and enquiries are located broadly within the fields of 'Sociology of Science and Technology,' 'Sociology of knowledge' and 'Science and Technology Studies' (STS). The study is primarily an empirical one. The conclusions offer preliminary insights into a still-evolving field in India and seeks at the same time to sketch out possible future lines of enquiry, research and insights, as there is more Citizen Science and more understanding of its methods and outputs.

[1] In some cases, in fact, 'doing science,' may not even be the primary purpose of a Citizen Science project. These projects appear directed more towards conservation planning, policy intervention and advocacy rather than generating information and insights that will be published in peer reviewed journals.

[2] 16 of these projects follow the criteria of self identification as Citizen Science. We have included the 17th project ('Community based monitoring of fisheries in Lakshadweep' that appears as Project No. 4 in Sec. Annexure 1) in spite of the fact that it does not follow this central characteristic of self-identification as Citizen Science. This particular project made a specific choice of not calling itself a Citizen Science project mainly on account of what they believed is a class issue, where those gathering data and contributing information do so generally as a) a leisure activity, b) belong to a certain social class and c) do not have a stake in the resource being studied. The idea of the voluntary here was at odds with the understanding of the same in majority of the projects that self-identify as Citizen Science. While this understanding constitutes an important narrative by itself it also has considerable value when juxtaposed againt ideas and conceptualisations that are dominant in the current understanding and articuation of Citizen Science in India.

[3] Each project we studied has a detailed 'data sheet' that includes information across 45 fields that is the basis for the analysis. Sec. Annexure 1 presents only a very brief and representative snapshot of all the data sheets. Including the full corpus of the data and data sheets is not possible for considerations of space.

The analysis we offer is of two broad categories. The first deals with matters more quantitative - details of individuals running the projects, their institutional prerogatives and priorities, the number of citizen scientists contributing, data points generated, and also an effort at the classification of these projects using one recent typology for Citizen Science (Bonney 1996; Bonney et al. 2016).[4]

The second part is more qualitative and discusses the logic and normative assumptions of using the nomenclature of 'Citizen Science,' issues with the idea of voluntarity that emerged as one of the central tropes of operationalising Citizen Science, the tools and methods of data gathering, gatekeeping and peer review and finally the possibilities of challenging the structures of power.

Before we go ahead into this analysis, however, it would be relevant to take a brief journey into the history of Citizen Science itself, the details and context of which have a direct bearing on what is happening in India today and the analysis that we ourselves have to offer.

A brief history of Citizen Science

While the specific nomenclature of 'Citizen Science' may be relatively new, its widely accepted and defining methodological characteristic – voluntary contribution of data by common citizens[5] (Bonney et al. 2016) – has a reasonably long history. Indeed, the involvement of amateurs in natural history investigations has been traced to as far back as the seventeenth century (Miller-Rushing et al. 2012). The more recent initiatives in the United States of America that have a direct bearing on the current situation include The National Audubon Society's Christmas Bird Count (CBC) that began in 1900, and the US Fish and Wildlife Service's Breeding Bird Survey and the Cornell Nest Record Card Program, both of which were initiated in 1965 (Bonney et al. 2016).

A perusal of literature suggests that the years 1995 and 2014-15 could be considered two important watersheds in the context of Citizen Science. 1995 was the year that Alan Irwin published *Citizen Science: A Study of People, Expertise, and Sustainable Development* (Irwin 1995), a book that fostered the idea of Citizen Science as a movement for the democratisation of science (Bonney et al. 2016). Central to the argument here was the idea of "scientific citizenship" and the need for greater involvement of the public in issues related to science and the

[4] Based on their analysis of projects mainly in the United State of America, Bonney et al. (2016) have classified Citizen Science projects into four different categories: a) Data collection, b) Data processing (categorisation, transcription, interpretation, c) Curriculum based and d) Community Science (initiated by members of the public). A number of scholars have classified Citizen Science in different ways and developed different typologies for the same. We use Bonney et. al (2016) only as an indicative framework that helps understand these projects in the Indian context along a particular axis. Use of other typologies will provide other insights; we don't, however, do that here because a larger study and analysis of these various typologies is beyond the scope of this paper.

[5] A deeper engagement and enquiry reveals that there may not be a full agreement on terms such as 'voluntary' and the 'citizen' even though these are central to the imaginations of the Citizen Science. This is what makes the topic an interesting and important one to investigate and some elements of this are visible in our analysis and assessment as well.

environment. Bonney et al. (2016) note further that the other more popular definition that equates Citizen Science with public participation in scientific research can also be seen emerging in 1995. This stems in part from the decision made that year by the Cornell Lab of Ornithology to use the term Citizen Science for its rapidly growing assemblage of projects involving large numbers of individuals collecting data focused on birds (Bonney 1996).

The two-decade period that followed saw an exponential growth around the world of Citizen Science projects; there were hundreds if not thousands of such projects engaging millions of citizens in collecting and/or processing data (Bonney et al. 2016; Theobald et al. 2015).[6] Influenced by all this and also the rapid spread and use of the internet (Bonney et al. 2016), the Oxford University Dictionary[7] included and defined Citizen Science in 2014 as "scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions."[8]

The following year, 2015, is important as it appears to mark the first successful efforts in the formalisation and the organisation of a community of Citizen Science. The Citizen Science Association (CSA), an organisation of professionals who design, implement and study citizen science projects, held its first-ever conference in San Jose, California, USA, in February 2015. The conference was attended by more than 600 delegates from 25 countries. Representatives of the European Citizen Science Association (ECSA) met in Leipzig, Germany, in April 2015 to plan an inaugural ECSA meeting for winter 2016 (Anon 2016) and in July of the same year, the Australian Citizen Science Association (ACSA) held its inaugural conference in Canberra (Bonney et al. 2016).

Ongoing assessments, meanwhile, have provided an overview of the scale at which Citizen Science is operating today.[9] Based on a sampling restricted to projects reported in English and from major online citizen science clearinghouses, Theobald et al. 2015 have identified 388 unique biodiversity-based projects where an estimated 1.36 to 2.28 million people voluntarily contributed an average of 21–24 hours collecting data per year. The annual value of this contribution, the authors estimated, was anywhere between US$667 million and US$2.5 billion. They also determined, primarily through a search of the Web of Life, that these projects have yielded a total of 446 scientific publications.

It is not surprising then that Bonney et al. 2016 note in their recent review paper that Citizen Science "has become nearly as big a concept as science itself. What was once a novel idea—lay people engaging in the scientific enterprise—is becoming mainstream. Each coming year is

[6] The criteria of self-identification as Citizen Science may or may not have been applied in the papers we use as a reference here. We accept these projects as Citizen Science projects because the authors in both the cases use this nomenclature.

[7] https://en.oxforddictionaries.com/definition/citizen_science; accessed 09 September 2018

[8] The **citizen scientist** has been defined as (a) a scientist whose work is characterized by a sense of responsibility to serve the best interests of the wider community (now rare); (b) a member of the general public who engages in scientific work, often in collaboration with or under the direction of professional scientists and scientific institutions; an amateur scientist. Source: https://daily.zooniverse.org/2014/09/16/citizen-science-in-dictionary/; accessed 09 September 2018.

[9] The clarification in fn 6 applies here as well.

likely to engage more people in scientific investigation as citizen science projects become more widespread, more accessible, more fun, and more rewarding" (Bonney et al. 2016: 13–14).

Citizen Science, one might conclude confidently, has established itself firmly and is here to stay.

Another interesting proxy to assess the increasing relevance and presence of Citizen Science, and one which confirms the trajectory described above, is to compare the 2017 edition (the 4th) of The Handbook of Science and Technology Studies (Felt et al. 2017), with the 3rd edition that was published a decade earlier, in 2008 (Hackett et al. 2008). While neither of the Handbooks has a substantial section or discussion on Citizen Science leave alone a full assessment or chapter of this rapidly spreading phenomenon, the entries in the index pages are instructive. While those for the 2008 edition have only a single entry for Citizen Science, the 2017 edition has 11 sub-entries under the same. The themes that a majority of these entries cover are located broadly at the intersection of the environment, geography, ecology and disaster, reiterating the disciplinary fields in which Citizen Science appears to be more relevant and useful.

The Indian Scene

The situation in India appears to reflect the broad contours of the above discussion, except for the scale and size of projects that would go under Citizen Science. While amateur contributions have been central to modern ecological studies in India for more than a century, most agree that the Asian Waterbird Census (AWC), initiated in 1987 by the Asian Wetland Bureau (now Wetlands International) and co-ordinated in India by the Bombay Natural History Society (BNHS) (Rahmani et al. 2003) was the first instance of such organised data collection by citizens here.

A look at the data available (Rahmani et al. 2003) for the earlier years of the project shows that the number of participants contributing and the wetlands covered during the counts varied considerably over the years. Data, in fact, is not even available for the years 1987-93 and 1997-98. The limitations and challenges – lack of an organised structure, haphazard coverage, repeat counts, and lack of coordination - of conducting such an exercise are evident in the comments and observations of the project coordinators of the time (see Rahmani et al. 2003).

Much has clearly changed since then and the increasing number of projects, the wide range of their coverage and the volume of data and information that has been generated (and which we discuss in the rest of the paper) is an indication of that. AWC too merged with the BirdCount project and much more is being done now than what the AWC attempted, or could have even conceived when it was initiated in 1987.

Analysis

The analysis that we offer in this paper runs along two broad axes. The first deals with matters more quantitative that emerge from the tabulation we have done in Sec. Annexure 1. The second is in the nature of a discussion of some of the interpretive and normative dimensions based partly on the interviews we conducted and partly on analysis of the data available, methods used by and also public articulations of the project co-ordinators.

Part I

Subjects of research

Citizen Science projects currently operational in India can be clubbed into four independent though sometimes overlapping categories depending on the subjects of research:

1. Class/species based: An important subset of these projects are either class and order based like BirdCount India (Project 2 in Sec. Annexure 1) and Butterflies of India (Project 17), respectively, or individual species based like the Fruit bat in the case of Pterocount (Project 14) or the tiger in the Village Wildlife Volunteers Program (Project 1) that, additionally, is also geographically confined to the landscape of the Ranthambhore Tiger Reserve in Rajasthan. These projects mainly seek data about the spread, presence/absence, arrival/departure of the species concerned, helping to build up a larger understanding of these parameters.
2. Event-based: A 2nd smaller category of projects (RoadWatch and Roadkills; Projects 6 & 12) are event/incident-specific where the species does not matter. Both seek to record and thereby provide a larger understanding and patterns of deaths of wild animals in road and rail accidents.
3. The 3rd category moves away from individual animals or species/class to look at larger ecological/environmental/geographical dimensions of the landscape. The only project that constitutes this category at the moment is the Beach Profiling project (Project 8) on the east coast of India. Citizens are involved here in regularly recording different characteristics such as slope, width and sand type to map changes in the profile of a beach over time. It is an outlier in that sense and has other interesting perspectives, particularly on the category of the 'citizen,' the nature of their participation and the logic and rationale for the use of the Citizen Science nomenclature.[10]
4. The 4th category of Citizen Science projects in India would be constituted by two projects – the India Biodiversity Portal (Project 3) and Bio Atlas India (Project 16), which are, as the names suggest, omnibus online data aggregating platforms. The focus here is on gathering a range of ecological data that is indexed geographically and species wise.

[10] The 'Community based monitoring of fisheries in Lakshadweep' that appears as Project No. 4 in Sec. Annexure 1 would also fit this category of Citizen Science projects but we have not included it explicitly for reasons explained in fn 2.

Timeframe

There are two parts to this: firstly, the vintage of these projects going by the year of their initiation and second, the timeframes over which each of them is operating and seeking to collect information. A look at the tabulation in Sec. Annexure 1 suggests that Citizen Science in India is about a decade old. The earliest projects go back to the period 2006-2008 with five of the most recent coming up in only the last couple of years (2016-18).[11]

Where the timeframes on which they operate is concerned, the projects can be divided into three main categories:

1. Ongoing projects where data is sought and being contributed continuously. This is the category in which one can place a majority of the projects we studied. There is also an overlap here with all the 'subjects of research' categories discussed above.
2. Projects which are time-bound, but episodic, where specific data is sought in a fixed period of time like in the case of migratory birds (a subset of BirdCount India) or on the presence/absence of common birds like in Citizen Sparrow (Project 13) and in the Common Bird Monitoring Program (Project 9). The episodic nature appears to be a function in some cases of the nature of the natural event (arrival of birds), while in others, like in monitoring common bird species may be linked to institutional factors such as research mandates and availability of funds.
3. The third is the one-off category, where the projects are also time-bound but in a very specific manner. The study of the invasion of the Andaman Islands by the non-native Indian bullfrog (and other alien invasives) (Project 10) (Ghosh 2018; Also see Mohanty and Measey 2018; Mohanty et al. 2018) represents this category. This project is also an outlier in its use of Citizen Science nomenclature. It was conducted like a survey by one key researcher who gathered detailed information from a number of citizens in the particular landscape. It differs from all the other projects because the contribution & participation of citizens was passive – where there were respondents primarily providing information and not pro-actively gathering data and/or information themselves as is the case in all the other Citizen Science projects we looked at.

Data related

One of the most important talking points and rationales for Citizen Science has been the huge potential it offers in terms of the spatial and temporal scales of data that it can offer. This becomes particularly relevant in a country as large and diverse as India and where gaps in ecological data and information continue to be considerable. What the Citizen Science projects in India have generated thus far in terms of data is indeed very interesting and also instructive in light of the optimism and potential expressed by project coordinators.

[11] It is important to note here that the last couple of years since the completion of this study have seen a rapid growth of interest in Citizen Science in India, confirming one of the key conclusions of this paper. Citsci India 2020 (https://citsci-india.org/), the first national conference on Citizen Science for Biodiversity in India that was conducted online in October 2020 had contributions from nearly a 100 Citizen Science projects and saw participation by 500+ enthusiasts from across the country and abroad. The second conference was successfully held online in September 2021.

The range of data points generated varies vastly across the projects we looked at. BirdCount India, following a bird-related trend worldwide, is the leader by many miles in the Indian context. The project has generated 10 million bits of information covering 1300 bird species thus far. Also uploaded to the site are more than 2,00,000 media (photo & audio) files and half a million checklists. BirdCount India is, in fact, now the fourth largest contributor[12] to the larger global eBird project that is located at Cornell Lab of Ornithology in the USA. The 2nd most data-rich project is the India Biodiversity Portal (IBP) which has about 1.4 million entries over a much larger range covering nearly 29000 species.

On the other end of this spectrum are projects such as Frogwatch (Project 4 and also a subset of IBP) with 2441 entries, Big4mapping (Project 7) (that maps India's four most venomous snake species) with about 4400 contributions, and Hornbill Watch India (Project 15) that has about a 1000 sightings contributed by citizens.

Citizen Scientists contributing

The other interesting and relevant statistic here is the number of individuals -the 'Citizen Scientists' - who are actually contributing all this data. The highest number of over 12000 individuals is again seen for the BirdCount India project. This is matched by the India Biodiversity Portal (IBP), which has 10000-12000 'users' and 1550 contributors, though perhaps with an involvement that is relatively less intense as compared to the bird project. In many of the other cases, the number of contributors runs into only a few 100s (e.g. Big4 Mapping, SeasonWatch (Project 11) and Hornbill Watch India) and in the rest, like the Village Wildlife Volunteers programme around Ranthambhore TR and the Beach Profiling programme on the Tamil Nadu coast, is less than a 100 individuals.

The potential & relevance of Citizen Science in gathering ecological data in a country like India is evident in this context – the temporal and spatial scales that need to be covered are simply not possible with the formal scientific expertise, and human and financial resources available currently. Perhaps they never will be. Citizens contributing, even while it has some clearly understood and accepted limitations, has significant advantages and potential: huge reach on the one hand and minimum cost to the establishment on the other.

Data Quality

The issue of the 'quality' of data is one of the big concerns where Citizen Science projects are concerned and this is visible explicitly in the two quotes below, the first from a poster of the CitizenSparrow Project (*Citizen Sparrow Report* 2012) which presents an analysis of nearly 11000

[12] Source: https://www.gbif.org/news/hWuwJwM98IisAqWaeGIQm/annual-ebird-refresh-adds-more-than-85-million-observation-records; Accessed 09 September 2018

observations of sparrows contributed by 5655 participants and the second from an interview conducted with Suhel Quader of BirdCount India:

> "The results presented here are based entirely on the contributions of members of the public from different parts of India. Although we trust that every piece of information has been contributed with good faith and the best intentions, the summaries shown here must be interpreted with caution. Because this was an opportunistic survey, the number of responses vary widely across regions and cities. In particular, reporting was much higher from cities than from towns and villages (clubbed here as "rural"). Results based on small sample sizes should be treated with appropriate caution. There is likely to be an unconscious bias on the part of participants towards reporting information about locations where sparrows are present. This would lead to an under-reporting of sparrow absence, which is very likely to be the case here." (*Citizen Sparrow Report* 2012).

> "Huge amounts of information is coming in, but it is low quality information. So that's the balance – small but high quality information and large volumes of low quality information. And ebird has decided on this end of the trade-off. We can devise the computational and analytical tools to deal with low quality information so long as we have large volumes of information." (Interview, Suhel Quader, 26 May 2017).

The quotes highlight both, the central challenges before the Citizen Science kind of data collection and also the important fact that the project proponents are acutely aware of the various challenges. One of the key criticisms of the Citizen Science kind of data gathering is indeed related to the quality (Harvey et al. 2018) and even the validity of the data that is contributed.

A certain level of awareness and effort at dealing with this is already visible in the Citizen Science projects in India at the moment. This is seen on either side of the data gathering exercise: creating computational tools, as Quader mentions, to analyse and make sense of the data that has come in already, and creating, on the other end, effective gatekeeping and peer review systems that screens and allows (or rejects) data that contributors are uploading:

1. BirdCount India has perhaps the most substantial processes for these. There are automatic filters that perform the first-level check on the data that is uploaded. Mobilising big data techniques, this is approved or flagged and brought to the attention of the review system. There is an elaborate mechanism by which powers of review are granted for the 2nd level of checks and reviewing. The review process is multi-layered, with reviewers being drawn from the pool of contributors itself, leading to a multi-layered gatekeeping and review mechanism that is also the most inclusive of the current crop of Citizen Science projects.
2. In other projects, Roadwatch and Big4 Mapping in particular (the same individuals are behind this project), the smartphone-based app that drives the project has features that limits the kind of information that can be uploaded. Only those images that have been clicked 'at that moment' via the app can be uploaded to the database. The intention is to ensure that no 'cheating' is done and only

genuine instances of these road kills are recorded.
3. In the remaining projects, which is the majority, the review process is controlled either by the key project coordinator or a team appointed by the coordinator. This either happens proactively like in the case of the Bio Atlas India and its various sub-projects or by default like in the Village Wildlife Volunteers programme where no review mechanism appears to be in place or has not been specifically articulated, at least.

What is also visible from an overview perspective is that this issue has not yet been given the attention it perhaps deserves. One way to account for this is the recent vintage of the projects. One might expect to see a more engaged and rigorous quality regime as the projects mature and also face the challenges first-hand. While this might not be as big a concern in projects where the main mandate is awareness generation and conservation policy intervention, it will have a significant bearing in those projects where the claims are more scientific in nature.

Part II

Discussion

Citizen Science as data collection

It emerges in the present context that the projects labelling themselves as Citizen Science in India like is the trend across the globe, fall primarily in the data collection category of the Bonney et al. (2016) typology. Very few of the projects fit any of the other categories and if they do, these are more in terms of co-lateral engagements (see fn[4]). The best examples of this would be the SeasonWatch project that has an explicit mandate of science education through data gathering (Curriculum-based in the Bonney et al. 2016 typology), and the Beach Profiling project where the public is quite central to the development of the mandate and the agenda (Public Science in the Bonney et al. 2016 typology).

From within the establishment

The other complementary and instructive dimension of Citizen Science in India as a data gathering exercise is the institutional location of the projects. All of these have been initiated from within the structures of formal/institutional science; either, institutions with considerable state support and a mandate that is primarily academic, or non-governmental organisations that have ecological science and conversation as their primary agendas. In a majority of the projects, the key individuals behind each of these projects too have doctoral degrees in the

broad field of biological/ecological sciences or have an explicitly stated interest in conservation science and practice.

It is noteworthy that it is the scientist and the scientific establishment that is seeking to invoke the category of the citizen and not the non-scientist citizen seeking to invoke a phenomenon (or a possibility) called science. It is almost as if the scientist needs the citizen more than the citizen needs the scientist. It could be a function either of the need and the agency of the scientist, perhaps both, that explains the current scenario. This would perhaps be reinforced if one tried to answer such basic questions about these projects as: Who initiates the projects and who participates? Who creates (perhaps even owns) the structures of data gathering and aggregation? Who takes the decisions on good quality data? How are citizens motivated to participate and to contribute?

The only project that does not fit this categorisation would be the Beach Profiling project along the eastern coast where the key initiators, though also in the non-governmental sector, have primary mandates in the social sciences and/or public mobilisation of political/social issues.

Technologies of Citizen Science

A common characteristic running across Citizen Science projects is the set of technologies that are being used for recording, collecting, transmitting, aggregating and analysing data (Harvey et al. 2018). It is in fact this particular set of technologies – smartphones, apps specially created for these handheld instruments, recording devices, different software and the internet (Google maps, for instance) – that has made these Citizen Science projects possible in the first place. The imaginaries of most of the projects we studied are centrally created around the availability of these technologies and many proponents were explicit in their articulation that what they are doing would not have been possible otherwise:

> "It [technology] is a great leveller – my dad never had access – until internet came into his life. Influx of technology levelled [it] for every one and made it possible for anyone to take part." (Interview, Ramit Singal, Project: BirdCount India, 25 May 2017).

> "And that is where technology actually changed my scenario. We made an app; (…) we [also] added (…) frog calls into it – so people can now listen to them. (…) And this February we made a frog bot. We have a Facebook page (…) where it actually responds (…). So [if] you ask for *Rhacophorus malbaricus* – it will give you a list of things the database has. You ask [for its] it calls [and] it will play that sound (…). For me, in the field, it has changed a lot. So the way I used to do my fieldwork way back in 2000 (…), it has changed drastically. Even call recording devices have already come up with software and techniques where it triggers itself. You need not have to sit there - it triggers automatically for a frog

call and records for long hours." (Interview, KV Gururaja, Project: FrogWatch, 27 May 2017).

The absence of such technologies was also presented as one of the central reasons why such projects could not have been executed in the past, an explanation, perhaps, of why the Asian Waterbird Census could only do this much and no more. The availability of technology like the internet is now also facilitating the aggregation of data and information generated in the pre-internet era. One of the key efforts in some of these projects is to access, digitise and upload data from personal and institutional archives to create histories and understandings that go much further into the past.

A prominent thread in the argument is of the widening of the net and of greater inclusion that technologies such as the internet and smart devices offer. This technology-driven possibility does however also have a counter-point in the implications this can (and in some cases already does) have for the kind of data that can be collected, the nature of science that can be done and indeed for the very claims of inclusion, increased participation and 'levelling out' of the field. People without access to these handheld devices or to the internet, or those without the skills to handle these technologies are likely to get excluded from the very beginning

This manifests in a very particular way, for instance, around the idea and the discussion of 'voluntary contribution'

Voluntarity

The idea of 'voluntary contribution' of data by citizens, was in the opinion of most project proponents, central to the idea of Citizen Science. It emerged in the interviews and the detailed discussions, however, that the idea is much more fluid and complex that was initially assumed. Many meanings of 'voluntary' emerged even as it became evident that different kinds of incentives were indeed being offered to the citizens implicitly and/or explicitly for their contributions. These included, among others, a mobilisation of the individual's sense of satisfaction in contributing to 'science,'[13] authorship over the data and scientific outputs, positively structured competitive frameworks that help in increased contributions at the same time as creating a sense of achievement for the citizen, a public acknowledgement of notable contributors, giving the 'citizen' the label of a scientist, in one case a letter of appreciation by a very prominent individual, and in another, a certificate of participation and acknowledgement as a citizen scientist.

Money itself was not offered in any of these projects, except, interestingly, in the Village Wildlife Volunteers programme. The project, which has 'Volunteer' in its title, refuses to label itself Citizen Science because the 50 odd rural citizens that are the major data contributors do

[13] A corresponding assumption, sometimes articulated explicitly as well, was that citizens should not except any returns/rewards because they are making a meaningful contribution; this was an appeal to their capacity for altruism.

not do it voluntarily; they are paid a monthly stipend. On the one hand, it reinforces the idea of voluntarity being central in the current imagination of Citizen Science, while on the other it also re-emphasises the fact that concepts and their meanings are still very fluid as researchers, scientists and project proponents go about implementing and simultaneously understanding Citizen Science and its many dimensions.

The Citizen Science nomenclature

A similar ambiguity and fluidity emerged on the rationale and the decision of using the Citizen Science nomenclature. Most (though not all) of the interviewees admitted that the choice had been made without any substantial thinking or discussion on the logic, need and implications of using the term. It seemed the most natural thing to do - suggesting significantly - the spread and tacit acceptance and the normalisation of the nomenclature. Many of the project proponents found the discussion with us refreshing and useful because they were explicitly engaging with issues such as those of 'voluntarity' and the use of the term 'Citizen Science' for the first time. It was forcing them, they said, to think deeper and more carefully than they had done in the past.

The discussions revealed many different reasons, understandings and logic for the use of the term and the way it was operationalised. Our idea of sharing some of these logics is not to indicate one is better than the other, leave alone which is right or wrong but to mainly show the diversity in terms of understanding, articulation and interpretations. The three different quotes below - from Prabhakar Rajgopal of the IBP, Suhel Quader of BirdCount India and Sudarshan Rodriguez (in summary) of the Beach Profiling programme - highlights this quite explicitly:

> "Q) This IBP for instance – is it a citizen science project?
>
> Ans) So I don't know the terminology. I don't know what terms you use. The way the (…) India biodiversity portal is constructed, (…) we would like to consider it as (…) an integrated biodiversity information platform. And what do we mean by that? There are a couple of modules there that get (…) biodiversity information from a variety of sources and put them together for people to access. (…) So there are essentially four modules that the IBP has – it has what we call an observation module which is essentially a citizen science [module] - public access, amateurs, any user comes and puts in data and asks the question (…). And anybody can observe any species – that is the citizen science…that is the observation module. That is really the public, citizen science etc. etc. module that we have." (Interview, Prabhakar Rajgopal, 25 May 2017).
>
> "And when the public, the lay public, the untrained non-science public is involved in some way, I guess, for me that is citizen science. Maybe, a slightly more suitable term being used (…) much more [now] is (…) PPSR – Public

> participation in Scientific Research. That's more descriptive because it describes what's going on. Citizen science is a bit ambiguous - are citizens doing the science entirely, are they part of science? But even PPSR can be misleading because sometimes it may not be public participation but maybe (…) public [driven] entirely." (Interview, Suhel Quader).

Sudarshan Rodriguez, interestingly, had a narrative that was quite in the opposite direction. It was a very explicit decision in their case, he noted, to label their Beach Profiling project as 'Citizen Science' and not, for instance, 'Community-based monitoring.' This was done, he said, to explicitly acknowledge that rural folk are also 'citizens'. There is, in his opinion, a class bias in the thinking and the assumptions in other citizen science projects, and this is something they wanted to explicitly address by staking a claim, as it were, on the idea of the citizen and of citizenship.

Challenging structures of power (Democratisation of Science)

All of these dimensions – the data-centric nature of Citizen Science, the facilitation by and use of a particular set of technologies, the fluidity in the operation of the idea of voluntarity and different catalysts and trajectories by which the project proponents have come to Citizen Science – all have significant implications for the use and justification of the Citizen Science nomenclature, the nature of the participation by the citizen, the kind of science that might actually (not) be possible, and also some of the specific normative claims that Citizen Science projects are making like those of challenging the 'structures of power.'

This challenging of the power of institutional science and structures within science, sometimes articulated specifically as 'democratisation of science' was made by a number of the projects and was in some senses the most explicit and substantial foray into the normative domain. Our effort here is to capture the nuances in this context and also present some thoughts and pointers from the discussions that are interesting and relevant:

> "Ya, science carries disproportionate weight and scientists carry disproportionate voice. (…) And often it's unwarranted. I would say especially for two particular cases – (…) one is the soft sciences and I include ecology as a soft science. Ecology is a complex system, there is large amounts of uncertainty, but that is glossed over. So the fact that it is a soft science is glossed over. People say things with far greater certainty than they should, which is unscientific and the 2nd is this blurring between one's individual role as a scientist and one's role as a citizen (…) People make proclamations as scientists whereas actually they are just giving their opinions. Usually they are value based opinions as people who like wildlife. The science actually is non-existent. Because they have a PhD their voice carries too much weight. So, in both of these situations, I think, one has to

> sceptical about science, about scientists. Science is fine, but the scientists are a problem." (Suhel Quader).
>
> "Look at the kind of things that are being talked about as citizen science. Huge ideas and there is no other way of doing these things, specially in the areas of bio, geo, distributed systems. (…) Everybody the world over is talking about it. Look at (…) google earth and google maps… Look at the satellite image data that has come out. I mean these are massive changes that we are seeing. You can be in your shell and say not consider citizen engagements but soon it will all be blasted out. (…) The scientific citadels will not last… – you must democratise science! (…) You know, people may not see this in India now. You can see these things breaking down all over. (…) These are means of democratising science. And we have seen this journey from 2008 onwards (…) I don't see any stoppage of this tide. I don't see any stoppage of this tide, do you?" (Prabhakar Rajgopal).
>
> "So I thought why (…) people can't do this? If they do it, it helps at two levels. One is people are aware of what kind of species they have. 2nd thing is it actually makes scientist to be on his toes. Saying that boss you don't have to talk about diversity (…) - we already know. Can you talk beyond diversity? Can you talk about why a frog lives in this condition? Why not there? So that will actually force scientists to really set their bars high. So that's the thinking." (Gururaj KV).

Pushing this idea further was Sudarshan Rodriguez who spoke of doing "counter-science" using Citizen Science, to build a corpus of data and understanding of the environment that will challenge the science put out by the state agencies, particularly when decisions related to land and other natural resources are involved.

This was very similar to what Naveen Namboothri of the Community-Based Fisheries Monitoring project in the Lakshadweep had to say – they were working with the community to get a sense of the availability of fisheries resources that was contradictory to what the fisheries and other departments were saying. In both the cases, the agenda is a lot more political - of creating a narrative opposed to or certainly challenging the narrative of the state.

There appear to be two broad strands asking in different ways for the democratisation or decentralisation of power *via* the current Citizen Science projects. Prima facie there are important and obvious differences in these two kinds of Citizen Sciences and deeper analysis will be needed to get a fuller understanding of these contours such as the kind of data being gathered, the technologies in use, the strata of society that is centrally involved, and even the purpose of gathering the data.

In Conclusion

The focus of this study has been to document and analyse Citizen Science as an evolving phenomenon in the country. Some of the broad trends related to this phenomenon - regarding the volume of data and information being generated, the Citizen Science nomenclature itself, the issue and the understanding of voluntarity, the central role of a set of new technologies and ideas of questioning existing structures of power in knowledge creation – have been outlined and discussed above.

One thing that appears clear is that Citizen Science in ecology and other allied fields is here to stay in India and as we have noted is rapidly growing. The question of interest to all - project proponents, those participating in these projects, sociologists and ethnographers of science and those in policy-making and administrative circles – would be about the questions that will arise and the issues that will have to be dealt with going forward with Citizen Science. Some of these were visible to us in our interviews when we asked questions related to challenges, opportunities and threats to the projects we spoke to.

Based on some of this, on our extended reading and our analysis and interpretation of the information and the interviews, we present here some key markers of what the emerging issues are (or are going to be).

Key findings:

1. There is a growing interest and use of the methods and tools of Citizen Science to do ecological research in India. The phenomenon is about a decade old here, with recent years seeing heightened interest.
2. A majority of the projects are being initiated by trained scientists/ecologists situated within state-supported scientific institutions or in NGOs/research organisations that have a conservation mandate.
3. The number of citizen scientists contributing to these projects varies considerably on account of a range of reasons. It ranges from a few 100 (sometimes even less) in many cases to a little more than 12,000 in the project with the highest participation.
4. A majority of the projects are what one might call 'data contributing' projects where citizens are uploading atomised data units in pre-determined formats. The volume of this data being contributed also varies considerably across projects – from a few 1000 data points in a majority of the projects to nearly ten million in the case of the most popular, the BirdCount India project.
5. A majority of the projects are family and/or species based, but there are also those for mapping of environmental parameters (like for beach profiling) and others that map certain events (animal kills in road and train accidents). Another prominent category of projects are those that aggregate information such as the India Biodiversity Portal and Bio Atlas India.
6. Central to the increasing popularity, even the possibility of Citizen Science, is a set of modern technologies that facilitate the recording, transmission and analysis of data. The technologies

include among others, smartphones and a range of apps that help in recording and documentation, the internet that facilitates transmission of data and a range of tools and software that help in analysis.
7. There is a growing interest in the mainstream media in these projects, their potential and the outcomes. There is a slow but visible trend in the publication of scientific papers based on analysis and data generated from citizen projects.
8. Many project proponents highlighted financial sustainability as one of the key constraints in ensuring that the projects can continue. This was related to both, the challenges of maintaining the technological architectures needed and also in keeping alive the interest and the motivation of the citizen contributors.
9. One issue that will need discussion and resolution in the context of Citizen Science is that of data ownership and conditions for use. While there is some discussion on these matters, it requires much more thought and deliberation in the context of data ownership and the larger trends and politics of information and ownership in this context. One can already see differences of opinion and ideology and while one may not expect a convergence in understanding, discussions on this matter are needed and will certainly help.

Annexure 1

Table 1 Enter your caption here

No.	**Title of Project**	Year	Project website	Co-ordinating Institution/s	Coordinator (Individual/s)	Species/Taxa/ Subject	Geographical spread of project	Notable outputs, Examples
1	**Village Wildlife Volunteers (VWV)**	2013	***	Tiger Watch	Dharmendra Khandal	Tigers (Mainly); also leopards;	Around Ranthambhore TR (RTR), Rajasthan	New information of tiger presence; Contribution in arrest of many poachers, successful relocation of tiger
2	**BirdCount India**	2014	https://birdcount.in/; https://ebird.org/india/home;	Nature Conservation Foundation	Ramit Singal; Suhel Quader	Birds	All India	Many! (Check website for details!)

3	**India Biodiversity Portal**	2008	https://indiabiodiversity.org/	Strand Lifes Sciences	Prabhakar Rajgopal; Thomas Vettakavan	All biodiversity	All India
4	**Frogwatch**	2014	https://indiabiodiversity.org/group/frog_watch/show?pos=7	Individual driven; collaboration/ piggybacking on IBP	KV Gururaja	Frogs	All India
5	**Community-based monitoring of fisheries in Lakshadweep**	2014	https://www.dakshin.org/	Dakshin Foundation, Bengaluru	Naveen Namboothri	Fishes and Fisheries	Lakshad Islands
6	**Roadwatch**	2018	https://www.roadwatchers.org/	Wildlife Trust of India	Radhika Bhagat, Jose Louies	Road kills of animals	All India
7	**Big4 Mapping**	2016	https://snakebiteinitiative.in/snake/	Individual driven	Jose Louis	Snakes (particularly the four poisonous snakes of India)	All India
8	**Beach Profiling**	2013	***	Tata Institute of Social Sciences	Sudarshan Rodriguez; Vivek Coelho; Jesu Rethinam; Gandimathi Alagar	Beach characteristics	Karaikka Nagapat and Cuddalo districts TN; also Puduche
9	**Common Bird Monitoring Project (BNHS)**	2015	***	Bombay Natural History Society	Nandkishore Dudhe,	18 common bird species	All India

10	**The invasive Indian bullfrog on the Andaman archipelago**	2015	***	DST-NRF Centre of Excellence for Invasion Biology, Department of Botany and Zoology Stellenbosch University	Nitya Prakash Mohanty	Indian bullfrog, Giant African snail Common myna, house sparrow,	Andaman Islands	An understanding of the spread of an invasive species
11	**SeasonWatch**	2008	www.seasonwatch.in/	Nature Conservation Foundation and the National Centre for Biological Sciences	Geetha Ramaswami	Leaf phenology, flowering and fruiting of 100+ common trees in India	All India	Some insights whether flowering of trees is changing?
12	**Roadkills**	2018	www.roadkills.in	Wildlife Conservation Trust	Milind Pariwakam	Animal kills in road and train accidents	All India	
13	**Citizen Sparrow**	2012	http://www.citizensparrow.in/	BNHS, MoEF	***	Sparrows	All India	***
14	**Pterocount - South Asia Bat Monitoring Programme**	2005	https://pterocount.org/	Zoo Outreach Organisation	Sanjay Molur; Shahroukh Mistry	Bats; in particular Flying fox or Fruit Bat	India and neighbouring countries	Information on over 200 roosts in India and neighbouring countries observed. At least three PhDs
15	**Hornbill Watch India**	2014	http://www.hornbills.in/	Nature Conservation Foundation	Aparajita Datta	Hornbills - 9 species found in India	All India	***
16	**Bio Atlas India**	2017	http://bioatlasindia.org/	National Centre for Biological Sciences	Krushnamegh Kunte	All biodiversity	All India	***

17	**Butterflies of India**	2009	http://www.ifoundbutterflies.org/home	National Centre for Biological Sciences	Krushnamegh Kunte	Butterflies	All India	***

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