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Biodiversity and Problems of Auditing Wildlife in General and Snakes in Particular

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Abstract

Background: Biodiversity is one of the proud domains of any country in the world. Wildlife as a whole is one of the greatest contributors to the environment worldwide in the human race. It is known as one of the vital assets of all countries of the world. Protecting wildlife is also synonymously used as protecting the future of the earth and humanity by researchers worldwide. It becomes essential in the changing environment to give more attention to the conservation of wildlife. There seem many inherent problems in protecting wildlife, and it is very difficult to deal with these problems. One of the needs is to address the problems of audit and audit ability of wildlife in general and snakes, particularly in India. We need data and facts for auditing. Can this be done with 'counting snakes? (Interesting / chilling /challenging?) The management and governance problems even with the controlled environment like reserved forests from audit perspective for the bodies like forest department of the country and government agencies like "Zoological Survey of India (ZSI)/Botanical Survey of India (BSI)," etc. How difficult is it to count animals? Especially snakes? Almost impossible. Needs innovative approaches to solving these problems.

Keywords

Biodiversity, audit, audit ability, animal ethics, reptiles, snakes, wildlife, forest department, poachers, and threats

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Background

Wildlife conservation is not only about animals but about the protection of flora and fauna in the country. The fauna of British India and all its parts are dedicated to wildlife understanding of India in the British Regime. Volume III -Serpentes is a part of this series, which speaks about snakes [1]. Till now, many researchers and organizations are contributing to conserving/protecting wildlife for different reasons. Globally, the Governments of various countries are taking many initiatives in this domain, and India is no exception. With the changing priorities of the people and the governments, it is known that forest areas are shrinking because of faster urbanization [2]. Researchers very well understand that auditing wildlife is one of the most difficult tasks to achieve with the changing nature of problems faced by wildlife and civilizations. Moreover, now, there is also a need to develop new technology-based methodologies to solve the problems [3].

Understanding the nature of problems it is a very difficult task because of the uncontrolled environment of wildlife. It is seen that audits and auditing are difficult in an uncontrolled environment. The new study is saying that there are serious challenges to stop species loss. Forestry in India is a major source of rural industry and environmental resources. Multiple reports are stressing the shrinking of forests [4].

As per the "Controller and Auditor General of India, environment, and climate change auditing guidelines," Environmental Audit is an emerging audit vital for India; it is also a major interest area of Supreme Audit Institutions. As per the CAGs auditing guidelines, the audit is categorized as a financial audit, compliance audit, and performance audit [5]. The audit will help to address the environmental issues. The guidelines speak about the array of topics like "Biological Diversity including forests and forest management, wetlands, mangroves, air pollution, water pollution, waste management, climate change, coastal zone management," etc. For this paper, the researchers are interested in finding out problems and probable solutions in conservation. The basic requirement is for biological diversity and conservation, including forests and forest management in general and reptiles/snakes in particular within this topic [6]. The document also focuses on items like liabilities, contingen-

cies, commitments, asset impairments provisions, etc., which is all based on "Article 48A in the Constitution of India 1949". The guidelines also speak about providing an expected logical framework for undertaking environment audits. If the environment is protected, only humankind and the surrounded environment, including animals and all living organisms, will survive. The cost required for such things is too high. However, considering future threats like any pandemic, it is essential to incur the cost on the environment and its sustainability [7]. It is well understood that such audits are the job of high-level professional skill auditors. However, it needs a deep understanding of issues. One such issue is raised and discussed in this research paper. As per environment audit guidelines, there are four steps in auditing: 1.The understanding problem of environment and impact on society/economy 2. The response of government towards these issues 3. Selection of the audit topic and deciding priorities of audit and objectives 4, [8] Carrying out the audit. Only population surveys and audits should not be the objective of audit as far as reptiles in general and snakes, in particular, are concerned. Census word that is closer to the universe survey from a statistical perspective may never be achieved in the wildlife for smaller animals and reptiles [9]. There are many laws and acts with guidelines published from time to time by the government about wildlife and its protection/conservation, especially since 1972 when "The Indian Wildlife (Protection) Act, 1972," came into the picture. After that, amendments were done from time to time

Review of literature

A review of the literature consists of mainly the guideline documents and acts/laws from the government of India. Internationally, there are many guidelines available about wildlife conservation and protection in general. It mainly includes performance audit documentation. It is not very evident that those documents include reptiles in general and snakes in particular from an auditing perspective [10]. The searches come back with more documents from African, Asian, and European/American countries depending on the availability of wildlife in the country, which speaks about big animals and birds with marine biodiversity. Very little work is done on geckos, lizards, and snakes, particularly in India. Conservation success depends on effective and efficient monitoring methods. Sampling and detection efficiencies are related to cost efficiencies [11]. The cost-effectiveness of census depends upon the appropriate method for monitoring methods for wildlife. However, there is little attention paid to cost-effectiveness. The participation of citizen science is becoming one of the major parts and also big data analytics in action for population estimation. Citizen-based monitoring systems are important for monitoring efforts and crowed sourcing the efforts, which can be evident from the recent research paper published about the monitoring of Greylag goose.

However, no such effort was taken in India for reptiles and snakes. "The Supreme Audit Institution (SAI) India" is controlled by the "Controller and Auditor General (CAG) of India." It is a constitutional authority. The CAG of India derives its mandate from Articles 148 to 151 of the Indian Constitution, which prescribes functions, duties, and powers of the "CAG (Comptroller and Auditor General of India, 2008)." The Ministry of Environment and Forests conduct the environment and forestry programs. It is also a nodal agency in the country for the United National Environment Program (UNEP) [12]. A report published by Controller and Auditor General of India on Environment auditing in India throws light on air, water, waste, biodiversity, and environment management systems. Nevertheless, very few such reports and laws speak about reptiles in general and snake in particular. Recently "CAG report on performance audit for Karnataka" is published where the species of reptiles found are listed. However, there is no mention of statistical evidence of the population of those species. The report has some records which state that the reptiles are killed in the forest area, but the report is silent on the road kills of reptiles [13]. As per the report, many reptiles and amphibians end up in road kills while crossing the roads, which is critical in the Western Ghats, which might lead to a deviation in the audit report if accurate data cannot be recorded and reported further, which applies almost to all states. Maharashtra is not an exception for that. From an audit perspective, it is very important to have statistically analyzed numbers to have a true and fair examination of the situation from a wildlife audit perspective [14]. The literature review cannot be completed without the mention of the Wild-life Protection Act 1972, where the legal framework and guidelines are mentioned about the conservation and protection of wildlife in India. The act is amended several times. Six schedules provide varying degrees of protection to wildlife in In-

dia. It was very difficult to find the literature from a reptiles/snakes auditing perspective except for species at different locations [15]. "Zoological Survey of India (ZSI)," which is the initiative of the "Ministry of Environment, Forest and Climate Change, Government of India," has different projects running about biodiversity and wildlife. Its primary objectives include many which are relevant to auditing." However, none of their publication list, which is published in 2014, speaks about reptiles and snakes, in particular, directly [16]. Some organizations like the World Wildlife Fund (WWF) and others work in very specific specialized areas for conservation and protection of wildlife, carrying out various studies. However, again, these efforts seem concentrated on more pure science studies except auditing perspective of the same as a whole. Of course, these are also required for the topics discussed in this research paper [17]

Existing methods and efforts in estimating the population of snakes

Identifying and statistical surveying of wild animals in general and snakes, in particular, is kind of a non-trivial problem. Especially when it comes to insects and reptiles, the degree of difficulty is very high in the field. It might be a little easier with European or Western countries than India because of the acts and procedures for the permissions. There are two major categories, which include the presence or absence of researchers in the field. The cost-effectiveness of these survey/sampling methods is also very important with herpetofauna [18]. There are many existing methodologies for surveying the snakes in the field. It is always a challenge surveying snakes in the field because of their secretive habits. Few approaches try to include hybrid approaches depending on the availability of resources and understanding of the field. "Henry S. Fitch did an interesting study, Division of Biological Sciences, the University of Kansas." [18] They have tested it on 43 seasons and compared the effectiveness of these methods. They tried it with three methods 1) Live Traps, 2) Artificial Shelters, and 3) Random Encounters, which was done from 980 to May 1991. As per their observations, artificial shelters were the most successful and Live traps for the intermediate size of snakes out of these three [19]. Some of these methods with the experiment are discussed in a study as 'Efficiency of snake sampling methods in the Brazilian semiarid region.' Existing methodologies of such surveys include:

Walkabout search

This method is a traditional method for many years adopted by the researchers, which needs the researcher to be present in the field. A team of researchers explores the designated/marked field for the sighting of snakes depending on their behavioral habits. Like all other animals, snakes also have specific requirements of physical/environmental conditions to be seen. Though this is one of the very common approaches, identifying individuals is very difficult with this approach. Here, the idea is to walk along your survey route, also known as transect at your site, which involves 1) slow walking as reptiles have very strong senses and high sensitivity for vibrations, 2) looking for basking spots (reptiles need sunlight), 3) Avoiding sudden movements. 4) By hearing a rustle, you may find animals after some time at the same spot 5) By observing natural refugia, i.e., to look carefully under old sheets, stones, wooden planks, etc. 6) You may find molts of snakes near the rocks where they shed their skin. 7) Recording the environmental variables like temperature, humidity, hiding spots, etc. Usually, the recommended approach for this has multiple visits depending on the species habitat requirements in different seasons.

Time-Constrained Search

This is done given the time constraint, and the researcher needs to be in the field to carry out this method. The time frame is decided to carry out the survey.

Occasional encounters

This is one of the common methods used for the survey. Whenever researchers are in the field, they keep recording over the period where they encounter any species. This method does not require the researcher to constantly be in the field, hard to standardize. It does not have strict planning and is also criticized by many. However, still, this is useful when you have a very large number of researchers in the field.

Artificial Traps

This is a method that does not require the researcher to be in the field. Pitfall traps (PIT) are the most commonly used method.

Artificial Shelters

This is rarely used. It needs funding and resources to carry out the survey, which may depend upon the

environmental study and abundance of species in the specific area.

GPS telemetry

For the last few years, technology is bringing change in many areas. The use of GPS telemetry now is more frequent depending on the 'Acts and Regulations' of a specific country. Snakes are also no exception for the same. Mainly it is being deployed to mammals and birds. The basic understanding is that for conservation purposes, these technologies may generate high-quality data about ecology and behavior. These have been tested on 'large constricting snakes,' as studied by Smith et al., which yielded interesting results. One such very successful effort was made by researchers in the "Environmental Information System (ENVIS) Centre" at "the Wildlife Institute of India." The publication is known as 'Application of radio telemetry techniques in snake research: King Cobra, as observed by Ophiophagus Hannah, Cantor in Agumbe, Karnataka, India.'

Here, researchers could get very important ecological parameters, including home range, translocation paths, den sites, etc. The first-ever field study in India for snakes using radio telemetry. They were also able to obtain crucial information on the King Cobra's spatial ecology, which allowed them to develop better conservation plans, resulting in the "world's largest venomous snake's pioneering research."

For the last few years, many snake species are studied worldwide using telemetry and able to reveal data about ecological parameters, which address movements (distance, duration), ethology (diet, predation), demography (abundance, age, mortality), life history (grown, fecundity), habitat, reproduction, and conservation, etc.

The primary aim of this study was to quantify seasonal movement patterns, home range characteristics, habitat, comparing the spatial ecology of rescued snakes, and also, to study the translocated snakes and their paths, thermal ecology, which is more important for female snakes attending nests, remotely observing daily/seasonal activity patterns of King Cobra, etc., which was also to use GIS to examine habitat fragmentation of King Cobra and come out with the conservation strategies by studying habitat requirements. Here, they rescued five adult King Cobras from the human habitat and got them to Agumbe Rainforest Research Station (ARRS). They were implanted with a 25-g temperature sensing radio transmitter (Model AI-2T, Holohil Ltd., Ontario, Canada with three years of battery life)

They were released 24 hours after surgery, and they released three snakes at exact locations where they are captured. Two were released away 20 km from where they were captured.

"International Union for Conservation of Nature (IUCN) organization," was created in 1948. Since then, it has grown into the largest and most diverse environmental network in the world. It is composed of government and civil society organizations. Now, it has approximately 1,300 member organizations and around 13,000 experts. They are organized into six commissions: Species Survival, Environmental Law, Protected Areas, Social and Economic Policy, Ecosystem Management and Education, and Communication. As they are involved in so many activities, interested people can visit their website. In this article, we will look at their efforts in statistical data collection about snakes. IUCN maintains a list known as the Red List of Threatened Species [20] , one of the most comprehensive lists. It tries to maintain the inventory of the 'global conservation statuses of plant and animal species. It tries to look at the extinction risk of species and subspecies.

This list is used by government agencies, wildlife departments, conservation-related NGOs, natural resource planners, educational organizations, students, and the business community.

The status is alarming. Quoting from the IUCN website," The bad news, however, is that biodiversity is declining. There are more than 91,520 species on The IUCN Red List, and more than 25,820 are threatened with extinction, including 41.

Despite these figures, we are working to reverse or halt the decline in biodiversity. Increased assessments will help to build The IUCN Red List into a complete Barometer of Life. To do this, we need to increase the number of species assessed to at least 160,000 by 2020.

A research was published as 'Are snake populations in widespread decline? Published in the 'Biology Letters' by the 'Royal Society Publication' in December 2010. As per their results, 17 snake populations, which included eight species from France, Nigeria, Australia, Italy, and the UK, 11 species saw a sharp decline. Of course, there are multiple variables, including habitat quality deterioration, prey availability, global climate change, pollution, disease, etc. The methodology used

by the researcher was an identical survey methodology every year.

Methods

While looking at the usefulness of technology, the researcher developed an android application with his team named 'Pranimitra' in the year 2014. It was tested in the field (Maharashtra in general and Pune in specific) for five months, i.e., from Jun 2014 to October 2014. The snake rescuers primarily used this application after a small training module to them about how to use this application. This application also included birds and mammals with snakes for the sighting of the animals. Here, the idea was to start crowdsourcing for information about the sighting of the snakes. They did not have to worry about the species, though this application was included detailed scientific information about species. Once a snake is sighted, they just had to click on the photograph of the snake, and other information like latitude, longitude, temperature, and humidity was fetched online and stored. The main aim of this project was to document the evidence of occurrences of the species and, if possible, and reveal the relationship between environmental factors like temperature and humidity. The relationship between these two important variables to the reptiles, including species, is well known in the scientific community. The researcher has tried to analyze the results of this activity.

Though this sample size is not good enough to establish scientific results, the universe itself is not yet possible to define. Because of these efforts, it was evident that technology and crowdsourcing are possible for wildlife conservation efforts. Of course, many technologies can be immensely useful for these activities. Even for the wildlife audit purpose, enough required data needs to be collected. There are some methods for the census of animals, but those seem 'not enough' or 'less effective' near nothing for the snakes. Following are few images of the 'Pranimitra' app interface. Figure 1 Indicates the Interface for Application User to Call the Accessible Numbers of the Rescuers Area Wise.

Figure 2 indicates the photographs of the snakes for identification of the snake sighted. This interface also has a facility where the user can click on the image once the snake is identified. The database will be populated with the species name, time of the sighting, latitude-longitude data, and environmental data like temperature and humidity.

Figure 1. Rescue a snake

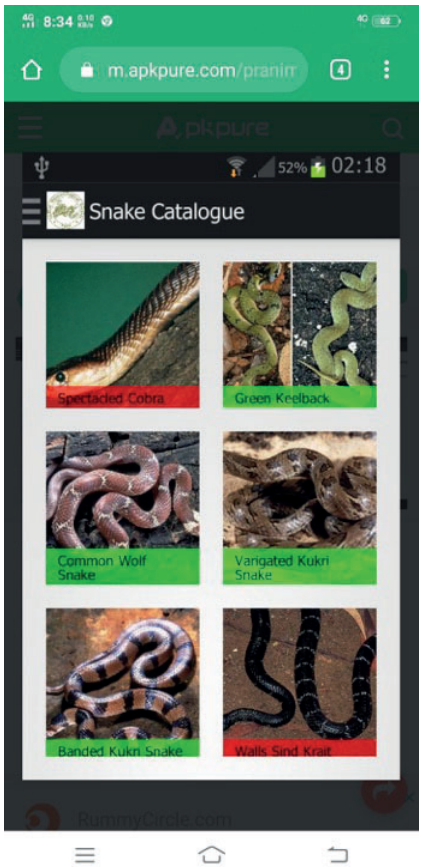

Figure 2. Snake catalogue

Figure 3 shows the different categories of the animals which are part of the application, like mammals, birds, reptiles, etc.

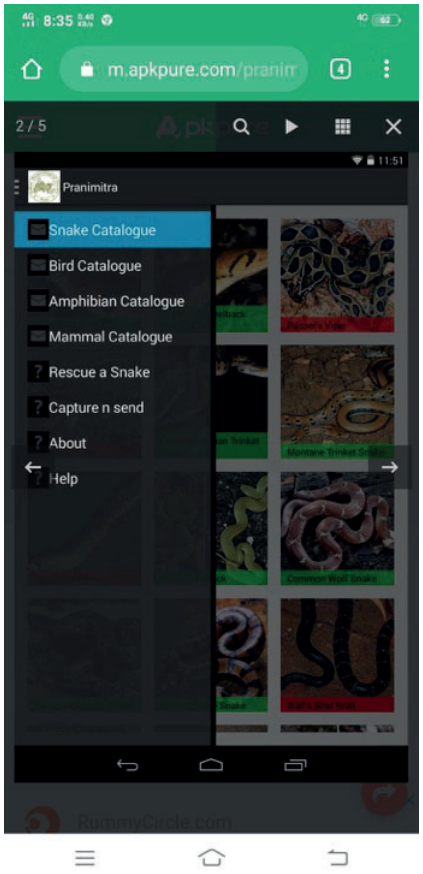

Figure 3. Different categories of the animals

The following graph (Figure 4) shows the number of snakes reported on the app for various varieties during the said period. It was noticed that the maximum reported snakes are Indian Cat Snakes during that period in Maharashtra in general and Pune in specific. The researcher experiences that the probability of Indian cat snake citing is more because the period covers the rainy season.

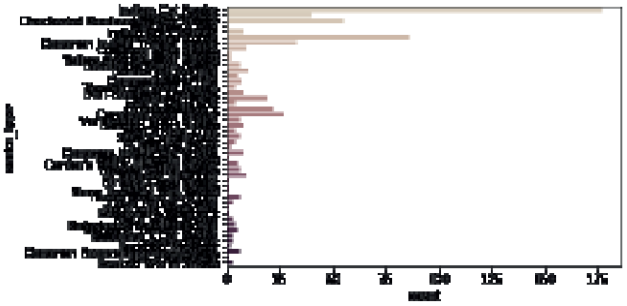

Figure 4. Types and number of snakes

The above graph (Figure 5) shows the atmosphere of the place where the snakes were reported.

Problems in auditing wildlife

The list of problems starts from the beginning itself Environment, Ecology, Forestry, Zoology, Botany, Biodiversity, Biology, Management, Governance/ Government, Social Studies, Geology, Geography, and many more domains are engaged in these studies if we truly want to categorize the problems in different disciplines/domains. This multidisciplinary domain is making wildlife studies more complex. The expertise needed to encompass the whole understanding of the ecosystem; is so large that it becomes difficult to get all threads together.

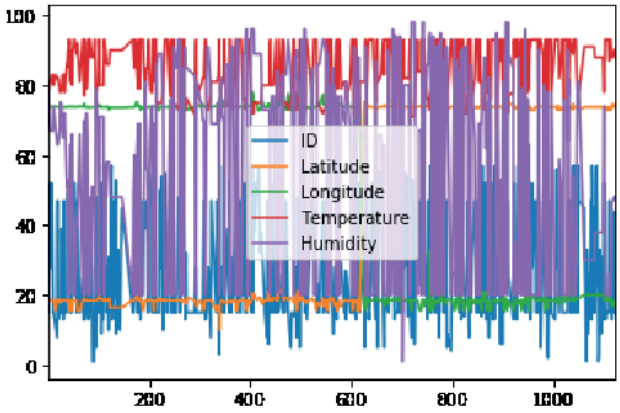

Figure 5. Atmosphere

- The primary problem of auditing wildlife is the lack of valid and authentic primary data. It is extremely difficult to have such data even with the controlled environment if the area under study is more. The sampling methods are not sufficient to have such data that can estimate the population of the species. The existing methodologies address the census of large animals like tigers, elephants, rhinos, lions, etc. This problem is more serious with the reptiles, especially with the snakes, where no primary population data is available for different reasons. It is very important to have such data from the audit perspective, starting with the controlled environment.
- One of the major hurdles in auditing wildlife in general and reptiles-snakes, in particular, is in the wild they are not seen as we can see bigger animals like tigers, elephants, or deer. Identification and tracking of these reptile species need greater scientific skills. Above all, identifying individuals is extremely difficult, even if they are seen without a taxonomical study of the species. So, in wildlife, acquaintances of snakes are very rare in nature unless they are being followed with the help of technology.
- Like any other wild animal species, many of the snakes may also be endangered. International Union for Conservation of Nature IUCN keeps a red list of threatened species. In Southeast Asia's list

Ahaetulla dispar (Gunther's Vine Snake) is Near Threatened, but many of the snakes we can see Data Deficient in this list for India. So, we do not have a clear idea about the status from an auditing perspective. Some studies are done for a specific region or species, but not really from population perspectives. These studies are more from a zoological or environmental perspective. The ecology of snakes is still a distinct dream for India exceptionally. The study about Ophiophagus Hannah (King Cobra) carried out by famous herpetologist Romulus Whitekar is world-famous, but this seems a unique case about such a study.

- The reports are repeatedly saying that wild animals, plant population monitoring surveys are poorly designed. They are not correctly representing the species, which we would like to understand, leading to wrong assumptions and estimated trends. It is extremely difficult to plan or develop conservation programs because of misleading data.
- Forests are shrinking due to the changing priorities of the human worldwide, especially in India and Indian urbanization scenario. This phenomenon poses a great danger to wildlife in India and from plain lands to the Himalayas, the problem is being observed. With current news, we can see the astonishing impact of industrial projects on the forests. Artificial forests cannot be a solution to this problem. Even Indian Governments auditor acknowledges that conditions under which these projects are given forest land are widely violated, and experts said government data are under-estimates. TV Ramachandra at IISC says that dense forest areas in northern, central, and southern Western Ghats have decreased by 2.84%, 4.38%, and 5.77%, respectively over the last decade, which is also impacting the reptiles and snakes as they are cold-blooded and highly dependent on environmental factor change.
- One of the serious problems of auditing reptiles/snakes is the spread of these species in the wildlife and human habitats. This spread is diverse. Frequently, new species are being discovered. For different environmental and ecological reasons, reptiles and snakes are diversified in different geographic regions. Though many of them are common species found in many places, identifying them is still difficult even for experts in the area. The environment also poses threats to snakes as some of the news flashed in 2003 about dying snakes because of cold waves as they are cold-blooded.
- Because they are found even in the human habitat, conflicts are more common than the bigger wild animals like tigers. Leopards are known more near the human habitat; snakes live in the human habitat itself. Current unstarred question No. 2581 speaks about conflicts and non-compiled data for the human-wildlife conflict because of the conceptions and misconceptions about the snakes; most of the time, they have killed the so-called threats which they pose to human life. So, the acquaintances are more in an urban area with snakes. The general tendency is to kill this animal, which is also a threat to conservation which is also one of the side effects of urbanization of the society.
- Many times, it is also observed that the so-called wildlife rescuers involved in illegal activities are one of the threats to wildlife conservation/protection. Different parts of these wild animals are the source of income for such people, and they are sold in the market. Also, auditing is difficult for the snakes and other species because of the number of these people. Governing these kinds of situations is also difficult for governments, especially in India.
- Awareness about snakes and scientific knowledge about the same is a major challenge in India. Because of the volume of people to be made scientifically aware of the facts of snakes, the primary data required to undertake the audit is extremely difficult. As snakes are popular religious beliefs worldwide, they have many different connotations attached even for the sighting of snakes. So, crowd sourcing for such scientific activities is very difficult to even for sample data.
- So, it seems extremely difficult to raise expectations as per the standard auditing understanding of the true and fair examination of records, as no authentic records are available. Because of the multidisciplinary nature of the subject, experts seem to work in silos, and the common thread is missing, which will compile all this information together from an auditing perspective.
- As yet, no formal scientific studies have been done on wildlife corridors, especially for the snakes. It becomes more important to study the habitat, ecology, and behavioral biology of the snakes. However, nobody seems to know whether all species of snakes have a home range and where they stay.

There are different reports on previously unseen behavior of snakes and reptiles as not confirmed studies are available, which is again one of the hindrances in carrying out audits for the reptiles and snakes in particular.

Approaches to face challenges of auditing wildlife

- Being said all the above, we need better and better approaches to face these challenges. We cannot escape without coming out with more rational approaches, methodologies, and ways to deal with the situation for a better future. Conservation of wildlife in India supported by well-designed plans is a need of an hour.
- We need a better understanding of wildlife and surrounding with a scientific approach for reptiles/snakes. The current report submitted by the Government of Karnataka is also recommending that all endemic species need to be monitored. Appropriate conservation plans can be drawn for better management, which stresses more and more activities for getting scientific information about the species to be monitored. Unless we get the authentic and audible data that can be verified, we cannot deal with audit and audit requirements.
- We need better sampling and survey methodologies designed separately for snakes and reptiles. There are existing methodologies, and new methodologies need to be supported by innovative technologies. Though the use of GPS is already started for surveys, the efforts and the number of people required are extremely large. We do not have those many experts available.
- We will need more scientific awareness about snakes in the population, stressing ecosystem conservation requirements. The participation of local communities for conservation and protection is going to play a vital role. Again, even with the government, we need to have these communities aware of reptiles and snakes in particular. Now, as per the Lok Sabha starred question no. *270, the local communities are involved in tiger and elephant reserves. However, there is no mention of any other species than these two.
- In India, we need more awareness about the dependency of human civilization on wildlife than ever before. Crowd sourcing such programs need to be undertaken. Though everybody seems to know about wildlife, it is more from the attraction perspective than the scientific awareness aspect. The interdependency of environment protection and human existence needs to be stressed in different ways and methods.
- Better governance systems need to be designed to deal with reptiles and snakes in particular by understanding the ecologies and environmental variables better. Population surveys on the local/regional level and the data compiled centrally will help better understand the situation.
- Possible use of technologies needs to be explored from an auditing perspective. GPS use needs to be increased for reporting the species. The location of species with scientific parameters like temperature, humidity, etc., needs to be recorded.
- More frequent scientific efforts and collaborations need to be initiated. As we do not know the universe from a statistics perspective, the sampling size is difficult to decide. We might need to devise a better sampling size formula for reptiles, in particular including snakes.
- Scientific documentation about population and other biological factors needs strengthening. A Management Information System needs to be designed and developed for better auditing capabilities for wildlife in general.

Conclusions

It is evident from the above discussions and analysis of the existing situation that auditing in wildlife is difficult and a critical task for the world and India. We need to put much effort into wildlife auditing in general and reptiles/snakes in particular. We also need to have a better understanding of environmental issues and their interdependencies. System dynamic model development might help to understand the whole picture of wildlife and environmental issues. Many challenges need to put on higher priorities before it is too late. Apart from big animals, there is a larger population of reptiles and snakes, which is neglected. However, they might be the key to the conservation of overall environmental components, including big animals, as they contribute to the food chain and ecological dependencies. New approaches for sampling, surveys using technologies need to be explored and implemented to audit the existing population and thus help maintain the balance of wildlife in general. Reptiles and snakes cannot be ignored while devising plans for the conservation and protection of wildlife, which seems neglected at this moment.

Competing Interest

The authors declare that they have no competing interests.

Availability of data and materials

The data set supporting the conclusions of this article is available to the authors.

Author's contributions

Aniruddha Joshi conceived the study, and he with the team developed the 'Pranimitra' App for data collection. Madhura Ranade and Aniruddha Joshi wrote and finalized the manuscript.

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References

1. Buckland, S. T., & Johnston, A. (2017). Monitoring the biodiversity of regions: Key principles and possible pitfalls. Biological Conservation, 214, 23-34.
2. Chakravarty, S., Ghosh, S. K., Suresh, C. P., Dey, A. N., & Shukla, G. (2012). Deforestation: causes, effects and control strategies. Global perspectives on sustainable forest management, 1, 1-26.
3. Chapter 1 Introduction of Karnataka Report No 6 of 2017 on Administration of National Parks and Wildlife Sanctuaries | Comptroller and Auditor General of India. (n.d.). Retrieved August 1, 2020, from https://cag.gov.in/content/chapter-1-introduction-karnataka-report-no-6-2017-administration-national-parks-and-wildlife
4. Constitution of India. (n.d.). Retrieved July 30, 2020, from https://www.constitutionofindia.net/constitution_of_india/directive_principles_of_state_policy/articles/Article 48A
5. Edwards, R. C., Godley, B. J., & Nuno, A. (2020). Exploring connections among the multiple outputs and outcomes emerging from 25 years of sea turtle conservation in Northern Cyprus. Journal for Nature Conservation, 55, 125816.
6. Gaidet-Drapier, N., Fritz, H., Bourgarel, M., Renaud, P. C., Poilecot, P., Chardonnet, P., ... & Le Bel, S. (2006). Cost and efficiency of large mammal census techniques: comparison of methods for a participatory approach in a communal area, Zimbabwe. Biodiversity & Conservation, 15(2), 735-754.
7. Gower, D. J., Giri, V., Captain, A., & Wilkinson, M. (2016). A reassessment of Melanophidium Günther, 1864 (Squamata: Serpentes: Uropeltidae) from the Western Ghats of peninsular India, with the description of a new species. Zootaxa, 4085(4), 481-503.
8. Gowrishankar's Blog | King cobra – Research & Education. (n.d.). Retrieved August 1, (2020), from https://pogirigowrishankar.wordpress.com/
9. Grauer, A., König, A., & Bunnefeld, N. (2015). Citizen science based monitoring of greylag goose (Anser anser) in Bavaria (Germany): Combining count data and bag data to estimate long-term trends between 1988/89 and 2010/11. PloS one, 10(6), e0130159.
10. H. J. Hensbergen, G. C. White, Review of methods for monitoring vertebrate population parameters, 489–508, (1995). The Wildlife Society.
11. Himadri Ghosh. In just 30 years, India has lost large forests to 23,716 industrial projects. Scroll. In (2016). https://scroll.in/article/809286/in-just-30-years-india-has-lost-large-forests-to-23716-industrial-projects
12. Hochachka, W. M., Martin, K., Doyle, F., & Krebs, C. J. (2000). Monitoring vertebrate populations using observational data. Canadian journal of Zoology, 78(4), 521-529.
13. International Union for Conservation of Nature - IUCN. (n.d.). Retrieved July 31, (2020), from https://www.iucn.org/
14. Ittonen, K. (2010). A theoretical examination of the role of auditing and the relevance of audit reports.
15. IUCN Red List of Threatened Species | IUCN. (n.d.). Retrieved August 1, 2020, from https://www.iucn.org/resources/conservation-tools/iucn-red-list-threatened-species
16. Lok Sabha. (2018). Questions : Lok Sabha. Parliamentary Questions. http://loksabhaph.nic.in/Questions/QResult15.aspx?qref=65105&lsno=16

17. P. S. Committee, Forest Fires and Its Effect on Environment, Forests, Bio-Diversity, and Wildlife and Remedial/Preventive Measures. In Parliament of India, Rajya Sabha, 299, (2016). http://rajyasabha.nic.in
18. Reilly, B. K., & Reillly, Y. (2003). Auditing wildlife. Koedoe, 46(2), 97-102.
19. S. Dasgupta, (n.d.). Good quality monitoring surveys key to wildlife conservation: new study. Retrieved August 1, (2020), from https://news.mongabay.com/2017/08/good-quality-monitoring-surveys-key-to-wildlife-conservation-new-study/
20. Vincent, J. P., Gaillard, J. M., & Bideau, E. (1991). Kilometric index as biological indicator for monitoring forest roe deer populations. Acta theriologica, 36(3-4), 315-328.