Conservation and Society 16(1): 91-101, 2018

Article

Modern Wildlife Monitoring Technologies: Conservationists versus Communities? A Case Study: The Terai-Arc Landscape, Nepal

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Abstract

The use of new and advanced wildlife monitoring technologies is shifting the paradigm of wildlife conservation and management. These digital technologies are helping wildlife conservationists and researchers around the world to monitor and manage wildlife with more precision and efficiency. However, this research study highlights some of the key drawbacks of using such modern technologies for wildlife conservation and management especially in developing countries, where the digital divide often clearly separates well-endowed conservation organisations and rural communities. It provides an insight into how the extensive use of such digital wildlife monitoring technologies can often marginalise the role of local and indigenous communities in wildlife management. Our case study, which was conducted in the Terai Arc Landscape (TAL) in southern Nepal, includes interviews with several wildlife experts, biologists, and members of local and indigenous communities. Findings indicate that the increasing militarisation and centralisation of protected area management, and the lack of universal access to the information gathered using modern monitoring technologies, have notably led to the marginalisation of local and indigenous communities in the region. These developments not only undermine the benefits of using such technologies but have also caused a rift between conservation organisations and local communities. As a result, this research study recommends that conservation organisations who advocate for the use of such technologies need to hold consultations and dialogues between conservationists and local and indigenous community members in order to be more inclusive and allow for a cross cultural and an interdisciplinary understanding of the best practices for the conservation and management of wildlife.

Keywords: wildlife, monitoring technologies, endangered species, traditional knowledge, poaching, natural resource management, protected area, Terai-Arc landscape, Nepal, drones, camera-traps, collaring, remote sensing

INTRODUCTION

The loss and degradation of natural habitats, poaching, and the illicit trade of animal parts; all pose a major threat to wildlife, particularly in least-developed countries. The Living Planet Report 2014 indicates that poaching threatens all wildlife species, particularly vertebrate species whose populations have halved in size within the last four decades (WWF International and ZSL 2014).

Assessing the population status of wildlife species, particularly those threatened with extinction, and determining the possible threats leading to their decline is, thus, one reason why monitoring of wildlife is important. Conversely, a rapid population increase of certain wildlife species can pose a threat to human livelihoods (Kaswamila et al. 2007; Acharya et al. 2016). In such circumstances, wildlife monitoring can help to minimise the risk of

Access this article online	
Quick Response Code:	Website: www.conservationandsociety.org
	DOI: 10.4103/cs.cs_16_83

possible human-wildlife conflict (Latham et al. 2015; Kays et al. 2015).

The monitoring of wildlife includes keeping track of animal movements, studying the population distribution of wildlife, the condition of natural habitats, and the identification of possible threats to different wildlife species, including poaching. Such information promotes a better understanding of the status of different wildlife species and also contributes toward the better management of wildlife both in-situ and ex-situ.

Prior to the use of modern wildlife monitoring technologies, traditional ecological knowledge (TEK) allowed local communities to conserve available resources for future generations. Although the use of TEK has experienced certain limitations, several communities around the world continue to rely on it for wildlife management and conservation (Grenier 1998; Berkes et al. 2005; Boafo et al. 2015).

In recent years, the development of modern monitoring devices such as camera traps, collaring devices, and conservation drones has however ushered in a new era for wildlife monitoring and management (Pimm et al. 2015). While these have supported local communities in claiming, defending, and monitoring their natural resources (Arts et al. 2015), such digital devices have also modified the way nature conservation, particularly in protected areas, is perceived by citizens. Modern tools mediate our relation to wildlife, and in turn, influence the type of conservation policies chosen and implemented (Büscher 2016).

Satellite-tracking technology has been employed in numerous cases to study several species of birds, fish, and large mammals. For instance, the feeding habits of albatrosses around the South Pole and the Indian Ocean, and the movements of blue fin tuna across the entire Atlantic into the Mediterranean Sea, have been tracked using modern satellite-tracking technologies (Wikelski et al. 2007).

Camera traps, which can be triggered remotely to capture videos and photographs, are also widely used to track elusive species (Maffei et al. 2011; Kelly and Holub 2008). Key discoveries in wildlife research, including the documentation of Amur leopard after 62 years in China have, for instance, been attributed to camera trap technology (Hance 2011).

The use of drones for wildlife conservation has also soared recently. In 2012, a prototype conservation drone flew 32 missions in Aral Napal Area, adjacent to Gunung Leuser National Park in Sumatra, Indonesia; and captured valuable photographic evidence of oil palm plantations and their consequences on orangutans (Koh and Wich 2012). Since then drones have been deployed in several national parks to help rangers and game guards tackle poaching and illegal hunting (Mulero et al. 2014; Lunstrum 2014).

Given the various advantages of using modern wildlife monitoring technologies in wildlife conservation, the government of Nepal and its local and international conservation partners have also been using and experimenting such technologies in the Terai Arc Landscape (TAL) in Nepal. Monitoring technologies such as radio collars and camera traps have been in use since the late 1990s in protected areas (PAs), satellite collars since early 2000s, as well as conservation drones since 2012; to study and monitor endangered flagship species. In recent years, camera trap data from the TAL-Nepal region provided valid evidence of genetic flow between tigers of India and Nepal. As a result, trans-boundary resolutions were signed in 2010 by both governments dedicated towards the conservation of Royal Bengal tigers (WWF-Nepal 2010). Such policy implications of using monitoring technologies for wildlife conservation not only benefit wildlife populations but also have a positive impact on human populations living in the vicinity of PAs and buffer zones. The Vulture Conservation Action Plan for Nepal (2009-2014) was released and included the development of vulture safe zones as a priority. The action plan officially banned the use of the drug Diclofenac (Ministry of Forests and Soil Conservation 2009) which, thanks to remote sensing technology, has been scientifically linked to the declining population of vultures. In addition, these technologies help reduce human wildlife conflicts (Marvin et al. 2016).

However, even as more advanced monitoring technologies are being introduced in the region; government agencies and conservation non-governmental organisations (NGOs) may have overlooked other aspects of using such technologies. An increased digital divide might for instance create a clear segregation between well-endowed conservation organisations and isolated rural communities with lower capabilities (Arts et al. 2015). Specifically, how the use of such technologies can affect already existing TEK as well as the tripartite relationship between the government conservation agencies, local and international conservation organisations, and local communities is a crucial issue; since it constitutes the backbone for the sustainability of any wildlife conservation initiative.

Against this backdrop, this research aims to investigate how the use of modern wildlife monitoring technologies in PAs could lead to the marginalisation of local communities in natural resource management and impact the influence of TEK in wildlife conservation. Results gathered through the case study of TAL-Nepal will contribute to uncover and analyse the effects of using modern technologies on conservation practices in the region and elsewhere. This includes inter alia the relationships with traditional monitoring practices, the accessibility for local communities to such technologies, and the extent to which conservation stakeholders--in particular local communities--benefit from information gathered using modern monitoring technologies. It will also highlight the important drawbacks that can act as a barrier when upscaling or replicating such projects in other instances. Hence, this analysis could help organisations to better plan their short-term investment in such technologies and take necessary prudent measures while employing such technologies for wildlife conservation.

CONCEPTUAL FRAMEWORK

The active involvement of local communities and the use of local TEK is said to be vital in the field of wildlife conservation.

Berkes et al. (2005) define TEK as "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission about the relationship of living beings (including humans) with one another and with their environment".

For its proponents the use of TEK continues, and should continue, to play a significant role in wildlife conservation and management. In Colombia for example, the Tukano community continues to rely on traditional knowledge passed down through generations of shamans in order—both—to hunt and preserve certain species of locally found wildlife (Berkes et al. 2005).

Of course, some studies also argue that TEK is primitive, less universal and less empirical (Gadgil et al. 1993; Ellen et al. 2000). While western science stresses on quantitative and objective research and is based on analysis and reductionist methods, TEK is subjective and contextual, usually based on intuition and spiritual beliefs and often relies on oral history and folklore to be transmitted to future generations. Hence, its inherent insufficient scientific basis, subjectivity, and the possible distortion of knowledge due to oral transmission of TEK is a key factor why it may not be simply translated into practical knowledge for conserving biodiversity. The history of the Mayas and Anasazis in the Americas serves as a stark reminder that not all indigenous communities in the past have managed to co-exist in harmony with nature (Mazzochi 2006).

Despite such criticism, studies suggest that traditional knowledge can indeed usefully complement western science. Moller et al. (2004) and Schmidt and Stricker (2010) argue that incorporating traditional knowledge into wildlife monitoring will not only increase the effectiveness of the wildlife conservation; but will also decrease conflicts, promote healthy dialogue between conservationists and local experts, further our understanding of biodiversity, and contribute to longer-term sustainability. Bohensky et al. (2013) indeed highlight several cases where indigenous knowledge has been integrated into the management of fisheries and indigenous protected areas in Australia. The growing synergy between western science and TEK is also evident in the case study of Nicaragua where applying TEK has in fact helped to improve the results obtained via camera trapping (Jordan et al. 2013).

Yet the recent increasing use of advanced wildlife monitoring and management technologies in PAs across the world is shifting this paradigm of synergetic wildlife management and conservation. On the one hand, digital tools may democratise environmental data collection and monitoring down to the community level, including for under-represented, illiterate communities (Arts et al. 2015). Mobile phone communication was effective in reducing human elephant–conflict and empowering local people in Kenya (Graham 2012), and the low-cost Sapelli mobile data collection platform has helped communities to map and report forest activities, for instance in the Congo Basin (Stevens et al.2013). However, eventually this digitisation is also a potential threat to the future of TEK and the participation of local communities in wildlife monitoring and management. A digital divide might widen (Hargittai 2003) in regions of limited internet access; but also second-order divides such as the lack of autonomy, social support networks, and skills (Arts et al.2015) will lead to exclusionary processes in places where advanced wildlife monitoring and management technologies are increasingly used. Joppa (2015) demonstrates how various socio-economic and geographical conditions, especially in remote and unexplored areas, by themselves, pose a big challenge if local communities were to be trained and educated on the use of modern wildlife monitoring technologies. It could provoke communal tensions, cause anxiety, and can be considered by indigenous communities as a forceful external intervention in their domestic affairs. Sandbrook (2015) similarly contends that the use of conservation drones has the potential to create confusion and fear amongst certain rural communities. The use of surveillance technology may not only intimidate tribal communities but could also lead to possible provocations due to suspicion and fear (Humle et al. 2014). Other studies explore how monitoring technologies used in developing countries could itself pose a threat to wildlife conservation. Digital surveillance technologies such as camera traps and drones could for instance fall into the hands of poachers, organised criminal networks and local gangs of illegal hunters (Robert 2007) and could serve ulterior motives and prove to be detrimental to the future of wildlife populations (Duffy 2016).

Such risks will be further elevated if digital technology finds its role in the war for conservation, and potentially reinforce the arms' race already sparked by the massive efforts of several governments to militarise their game guards inside PAs (Duffy 2015; Lunstrum 2014). In the Kaziranga National Park in India, 'shoot to kill' approaches were embraced and legally backed at the state level. Forest guards are shielded from prosecution for killing poachers, and some reports talk of "rewards" being received if they successfully kill or wound a poacher (Simlai 2015). And new warfare methods such as drones, recently brought into conservation, will only accelerate this tendency towards "green militarisation".

Therefore, as newer forms of technology are introduced in order to fight illegal wildlife crime, monitor and manage wildlife populations, the question of who should be permitted to deploy such technologies and between whom should the information collected be shared, may help to shed light on the existing regulations and legislations concerning the use and benefit sharing of such technologies (Wal et al. 2015). Despite the benefits of modern digital technologies for the management and conservation of wildlife, its use especially in areas inhabited by indigenous communities is a particularly sensitive topic. Without proper consultation and dialogue with local authorities, the use of such modern technologies may lead to marginalisation, inter-stakeholder tensions and ultimately strain the relationship between conservation agencies and local authorities.

CASE STUDY AND METHODOLOGY

Study area

The Terai Arc Landscape (TAL) is a conservation landscape that stretches from the Bagmati River in Nepal to the Yamuna

River in India. It covers approximately 49,500 sq. km and includes 14 PAs (Figure 1). Approximately 49% of the total area covered by this landscape lies in Nepal (referred to as TAL-Nepal) where it covers an area of 23,199 sq. km and includes five PAs, three Ramsar sites and two World Heritage sites. The TAL-Nepal region also includes five biological corridors, which interconnect various PAs to one another including those located in India (Figure 2). These biological corridors play a vital role in the movement of animals and are crucial to maintain a healthy biodiversity in the region.

TAL-Nepal is also considered a 'biodiversity hotspot' and includes two of the WWF's Global 2000 eco-regions (Ministry of Forest and Soil Conservation 2004). This region supports several endangered species such as the Gangetic Dolphin (*Platanista gangetica*), Gharial (*Gavialis gangeticus*), among others, and is also home to three flagship species, i.e. the Royal Bengal Tiger (*Panthera tigris tigris*), Asian Elephant (*Elephas maximus*) and Greater One-Horned Rhinoceros (*Rhinoceros unicornis*).

TAL-Nepal is home to more than 6.7 million inhabitants, approximately 26% of Nepal's population. After the eradication of malaria in the 1960s, thousands of immigrants from the hill regions of the country migrated to Terai (Government of Nepal 2004). Migration from the nearby hills continues to be the leading cause for population growth in the region. Besides cattle rearing, locals practice subsistence agriculture, which yields limited agricultural produce. Hence, the livelihoods of people in this region have become inextricably linked to the forests of the TAL-Nepal region. In this aspect, the poor socio-economic development of this region continues to exert tremendous pressure on biodiversity in this region (Government of Nepal 2004).

Historically, the use of various modern wildlife monitoring technologies surged after the end of the decade long Maoist insurgency in Nepal (1996-2006). Poaching inside the PAs and the buffer zones became rampant during this period primarily because several Nepalese Army patrol posts were consolidated to form larger garrisons for security reasons. This strategy left vast spaces inside the PAs virtually unguarded and inadequately patrolled. In 2001 the Army had manned 32 posts, but in 2006 only 7 were garrisoned (Martin and Martin 2010). As a result, poaching of wildlife, particularly of flagship species such as rhinos and tigers, escalated during this period (Figure 3).

Figure 3 indicates how the poaching of the Asian one-horned rhinoceros escalated during the midst of the Maoist conflict, especially in 2002 and 2003. Thereafter, in order to increase monitoring efforts and gather more data regarding the status of wildlife within the PAs in this region, the Department of National Parks and Wildlife Conservation (DNPWC), with support from international and domestic conservation organizations, decided to scale up the use of modern monitoring technologies. Besides camera traps and radio collars, digital wildlife monitoring technologies such as conservation drones, GPS collars and SMART[1] were also introduced from 2010 onwards. Similarly, molecular and genetic studies for tracking and monitoring wildlife were introduced in the same year, for instance by the Center for Molecular Dynamics Nepal (CMDN), which launched in 2011 the Nepal Tiger Genome Project with support from USAID and in partnership with the Government of Nepal.

Field methods

For the purpose of this research, five PAs in the TAL-Nepal region and the Khata corridor, which connects Bardia National Park of Nepal to the Katarniaghat Wildlife Sanctuary in India, were selected as study sites. Fieldwork was carried out between September and December 2014. In-depth key informant interviews with relevant personnel representing different conservation stakeholders were conducted in the five PAs (study sites) in the TAL-Nepal as well as in the Khata corridor. In total, 35 participants who were selected through the snowball sampling method were interviewed. Participants included independent researchers, wildlife biologists and heads of departments of the public and the international

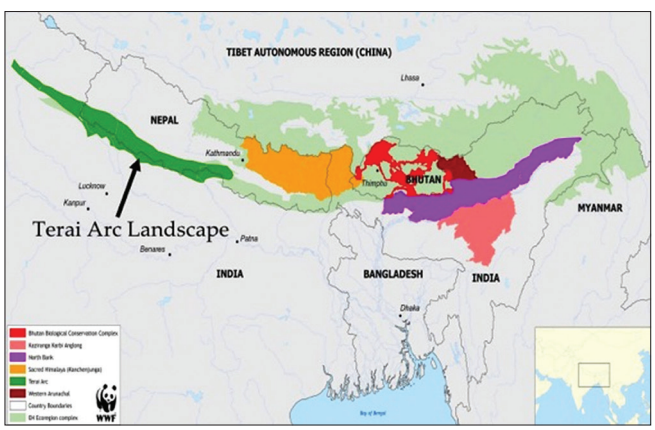

Figure 1
The Terai Arc Landscape (TAL)
Source: WWF Nepal 2014

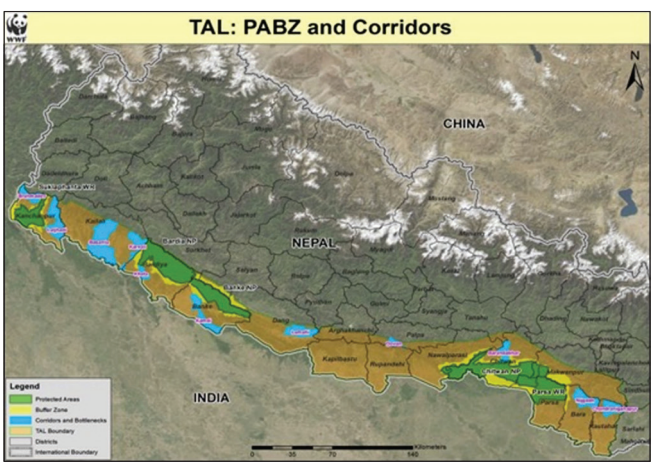

Figure 2
Detailed map of Terai Arc Landscape of Nepal (TAL-Nepal) showing PAs in the region (green) and biological corridors (blue)
Source: WWF Nepal 2014

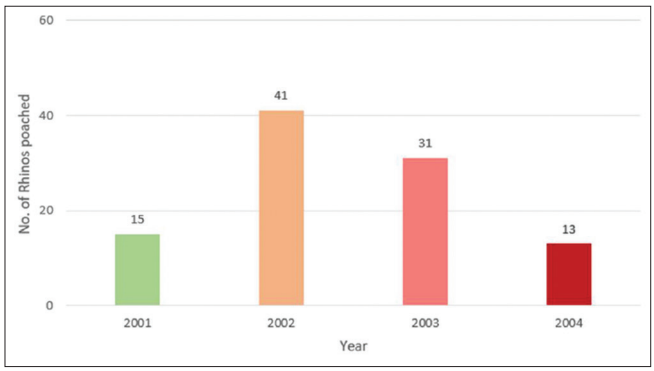

Figure 3
Rhino poaching figures: 2001-2004
Source: Martin, et al.,(2009)

NGO sector. In addition, local conservationists and field staff involved in conservation were also chosen as participants. The selection criteria for the participants included key factors such as previous work experience in wildlife conservation, past experience regarding the use of wildlife monitoring technologies and their current responsibilities in the field of wildlife conservation in the TAL-Nepal region (see supporting material for an anonymous list of respondents).

Interviews were mostly conducted in Nepali (see supporting material for the full interview questionnaire in English). First, qualitative interviews followed a semi-structured format with both open and closed-ended questions. These encompassed topics such as the history of wildlife monitoring in the region, types of wildlife monitoring technologies used, training processes for the personnel using such technology, the financing and acquisition of monitoring technologies, results and impact of using wildlife monitoring technologies, and policy recommendations relevant to the subject. A quantitative survey containing 17 questions was thereafter handed to the respondent in order to assess his/her opinion on the topics discussed during the qualitative interview. This quantitative part was designed using a Likert scale[2], which indicated the level to which participants agreed or disagreed with a certain statement.

Qualitative data analysis consisted first in studying the transcripts for each respondent to explore responses via key word, phrase, or sentence searches. Key information uncovered was highlighted and noted. For each question, responses were then analysed across all respondents to look for repetition of certain words, remarks, and phrases, in order to determine and detect similarities and patterns. Common answers provided were grouped together and coded to form categories for further analysis (Miles and Huberman 1994). Qualitative data which deviated from the pattern was reconfirmed with the respondents for clarification and verification before being considered for analysis.

Quantitative survey responses were analysed using Microsoft Excel. The software functions helped to analyse the results for each question and note the variations between the categories of responses. These responses were also analysed by focusing on response variations occurring due to the factors such as age, organisation, level of education, and years of experience. Personal observation and participation in field activities were finally used to confirm and triangulate information collected through both these qualitative and quantitative surveys.

FINDINGS

For almost two decades, monitoring technologies such as camera traps and collaring devices have been used to collect information on wildlife in TAL-Nepal. Despite the frequent use of such technologies by wildlife conservation organisations, independent researchers and government agencies, the lack of proper dissemination of the information gathered, the poor quality of training offered to local experts, and an increasing centralised system of wildlife management threatens the effectiveness of using modern wildlife monitoring technologies in the TAL-Nepal region. Such drawbacks are presented in depth below.

Lack of universal access for local communities to information

Information collected using monitoring technologies, primarily camera traps, collaring devices and SMART technology include GPS locations and directions to specific sites within the PAs where certain species have been sighted. In this context, several park officials, including chief wardens, game scouts, and wildlife technicians along with law enforcement officials, were questioned on how such data gathered are shared with local communities and the conservation stakeholders in the region. A game scout responded: "The information from the camera traps is not shared with any non-park personnel. Even we do not get to keep the pictures; we submit all the pictures to the department and based on that they analyse the pictures and write reports" (Respondent 6 pers. comm. 2014).

Park officials argued that sharing information, especially obtained through the use of camera traps, collaring devices, SMART patrols and geo-tagged genetic data, could potentially disrupt conservation efforts within the PAs if such data were to fall into the hands of poachers (Respondent 6 pers. comm. 2014). Therefore, conservation experts along with the upper management employees in the PAs regulate the extent to which information gathered using modern monitoring technologies are publicly shared. An official employed by an international conservation organisation further elaborated that the use of monitoring technologies, particularly SMART technology, pertain to law enforcement and therefore argued that matters concerning law enforcement inside the PAs do not concern local communities(Respondent 31 pers. comm. 2014). Qualitative data from interviews also suggest that such policies, which prevent the sharing of information gathered via monitoring devices, have become exceedingly restrictive during the past few years. Consequently, quantitative results indicated that game scouts, local conservationists, and members of local communities remain unsatisfied with the current level

of information sharing by the government and international conservation organisations based in the region:16 out of 34 the respondents (47%) agree that the use of such monitoring technologies has shifted the decision making power and leverage to those institutions which purchase and provide such technologies to the conservation stakeholders in the region.

Local conservationists and game scouts (a majority of them being local citizens employed by national parks) criticised this lack of free and fair access to information and suggested that such practices have a negative impact on monitoring efforts and the level of local awareness. In particular, a field representative from a conservation organisation highlighted that such policies and practices between the conservation stakeholders may be easily perceived as discriminatory and also jeopardise monitoring efforts in the long term. He, for instance stated that, "one of the main problems is that we don't share all the information with all the staff, especially those working at the field level. We tend to underestimate the people working at that level. However, this can lead to problems and confusions.

Ideally, we should be explaining and sharing all information with all the staff" (Respondent 28 pers. comm. 2014). It was further elaborated that such restrictive policies are a hindrance when conducting surveys and census of certain species: camera-trapping initiatives, which are executed largely by game scouts and wildlife technicians, could be susceptible to miscalculations due to the lack of sufficient background information on the movement and the location of species.

As a result of such restrictive policies concerning information sharing, discussions with several game scouts and park employees further revealed that several camera traps are vandalised every year. One of the main factors for such acts of vandalism, as identified by respondents, was that community members are often not well informed about why camera-trapping programs are important and how such devices work. When local communities are not informed, those who are legally collecting firewood or grass as fodder panic when camera traps take their photographs and hence they often destroy the camera trap in order to protect their identity. Respondents believe that if local communities were more involved and educated on why and how camera traps are being used, less camera traps would be vandalised each year.

In this regard, park officials indicated that on average 8-10 camera traps in each PA are destroyed during camera-trapping sessions (vandalised by humans and wild animals), which result in thousands of dollars of losses every year (Respondent 15 pers. comm. 2015). In total, quantitative data indicate that 88% of the respondents suggested current guidelines and policies on the deployment of monitoring technologies were not sufficient and that such policies need further clarification and improvements. In particular, better protocols need to be established on how local communities can be made aware prior to the use of camera traps and other modern monitoring technologies.

As a response to such general dissatisfaction, recently a few conservationists have made an effort to change their practices. A respondent from an international conservation organisation clarified the new paradigm:

"Before we start any program, we call for a community meeting. In previous years, we did not engage much with the community, however, now for example during the satellite collaring of the rhino, our first step was community consultation with local leaders, conservation groups, clubs, etc."(Respondent 30 pers. comm. 2014).

Nevertheless, how this approach will be implemented and sustained in the longer term remains to be seen.

Inadequate capacity building undermines the effectiveness of modern monitoring technologies

The effectiveness of using modern monitoring technologies is overwhelmingly dependent on the ability of the users to understand and exploit the various technological features of those monitoring devices. Game scouts and wildlife technicians who are well trained to use modern monitoring technologies will undoubtedly be able to use such technologies more efficiently than those who are poorly trained. Hence, in order to maximise the effectiveness of using such technologies, capacity building trainings for game scouts, technicians, and the users of monitoring technologies in general, are vital.

Yet, findings reveal that trainees were not satisfied with training sessions organised by conservation stakeholders such as WWF, the National Trust for Nature Conservation (NTNC), and the Department of National Parks and Wildlife Conservation (DNPWC).

On the one hand, game scouts and wildlife technicians who attended previous workshops indicated that the trainings were often too brief and lacked in-depth explanations on how such technologies function. Majority of game scouts who were previously enrolled in camera trap training sessions also responded in a similar manner. Indeed, according to trained game-scouts their trainings mostly focused on the basic operating mechanisms of camera traps, which only included identifying potential locations where camera traps can be installed and the removal and insertion of memory cards inside the device. Interestingly enough, at higher hierarchical levels the same fact is also acknowledged, as illustrated by a chief warden of one of the PAs:

"Very few people here actually know how to use camera traps effectively. The training sessions are too short and not on a timely basis; trainings are given only when camera-trapping installations are planned. Otherwise there is no training sessions for game scouts" (Respondent 7 pers. comm. 2014).

On the other hand, majority of game scouts employed within the PAs are not fully capable of understanding the instructions and guidelines (generally in English) mentioned within the user manuals for monitoring devices. Information gathered on the educational qualifications of local game scouts shows that of the 8 game scouts and wildlife technicians interviewed; only two respondents have completed basic schooling. Given their poor educational background, respondents, particularly those working at policy level stated that camera trap training sessions for game guards are often designed to train them solely on a need-to-know basis. Consequently, the training for the

utilisation of more advanced technologies such as drones and satellite collaring devices are exclusively limited to qualified experts and PA law enforcement officials.

Ideally, trainings and workshops for local community members on the use of wildlife monitoring technologies could promote a more sustainable use of local expertise for wildlife monitoring. Survey results indicate that 32 out of 34 respondents agreed that it is important for conservation agencies to educate and explain members of local communities about how advanced monitoring technologies function and the potential outcomes it can produce. But budget constraints, as well as illiteracy and an insufficient level of educational qualification among the game scouts; according to respondents, may be important factors for this inadequate level of capacity trainings. In fact, the lack of extra initiatives from conservation organisations to tackle such issues and design better training workshops suitable for game scouts and the local population limit their ability to use monitoring devices to their full potential.

Conservation drones in the TAL-Nepal region: a mere scare tactic?

Since 2012, several models of conservation drones have been tested in Bardia and Chitwan National Parks, as the latter are home to the largest populations of key flagship species such as tigers, elephants, and rhinos. The protection of these species remains a top priority for the government and its conservation partners. The primary objective of the drone program, which was launched in partnership between the Government of Nepal and WWF-Nepal, is thus to assist law enforcement officials in the PAs and the Nepali Army; to curb poaching. The light and easily deployable drones are designed to fly reconnaissance missions in areas inside the PAs which are particularly vulnerable to poaching, and transmit images or videos to law enforcement officials on the ground.

However, as per our research, law enforcement officials and wildlife technicians remain unconvinced about the success of the drone program. Findings suggest that due to absence of real-time monitoring technology in the drones, which allows law enforcement teams to view images and videos captured by the drone instantly, the drones currently used in the TAL-Nepal region have not concretely contributed towards curbing poaching. Respondents mentioned that the time consumed in downloading and analysing the video footages from the drones used currently, delays the process of trying to catch perpetrators. In addition, findings also showed that the thick sub-tropical forest cover in the many areas in the PAs also limits the extent to which drones can capture activities on the ground.

Therefore, as per experts, such limitations undermine the success of the drone program. In fact, some respondents indicated that the conservation drones have not succeeded in detecting any illegal poaching activities in the test sites so far. Regarding this, a senior scientist at an international conservation organisation stated:

> "Drones have also been introduced mainly to curb anti-poaching, however, I am not convinced that in Nepal they can be used effectively. It can be used for habitat mapping and maybe it could also be used for rhino count. Tall grasslands are a problem when using drones, poachers can easily hide behind the tall elephant grass, another problem is that the feedback from the drones is not real time and hence there is a delay in getting the information" (Respondent 25 pers. comm. 2014).

Such evidence highlights that benefits of using wildlife monitoring technologies do not necessarily apply to all devices used in the region. Conservation drones, which are arguably among the most expensive technologies deployed solely for the purpose of reducing illegal poaching within the PAs, have not produced any significant outcome thus far in Nepal.

Interestingly, the only outcome achieved by the drone program so far was to create some unease amongst the local communities. A respondent working in the TAL-Nepal drone program stated:

> "Once the news that drones are being used in PAs were heard by the local communities it created a whirlwind of rumours about what these drones can do and the pictures that it can take of all illegal activities inside that park. Therefore, these drones do create some sort of a fear factor. Bottom line this has been good for conservation" (Respondent 26 pers. comm. 2014).

These results clearly indicate that the drone program is actually being mainly used as a scare tactic in PAs in order to reduce wildlife crime and poaching, at the cost of limiting the level of public participation in PAs and instilling fear amongst locals.

The risk of modern wildlife science substituting TEK

Interviews with several park staff and wildlife experts highlighted that prior to the use of modern wildlife technologies, wildlife experts, and game scouts relied principally on TEK in the region. This included identifying and studying the pugmarks and scat samples of large animals in order to determine their location, sex, and estimate the population of the specific species. Regarding this, experts mentioned that features such as the size of the pugmark, distance between the toes in the pugmarks, and other signs such as scratch marks or certain insignias, could provide clues that can be used to track down certain wildlife species. Initially, local hunters and foragers used such traditional methods in order to score a successful hunt or forage forest resources such as grass and firewood. As per local experts, these skills are mainly applicable when tracking large mammals such as tigers, tiger-prey species, rhinos, and elephants.

However, respondents still familiar with the use of such traditional methods referred to several instances when physical evidence such as pugmarks, scat, and carcass remains were affected by natural conditions such as heavy rains, texture,

and quality of the soil and the local climatic conditions, thus jeopardising tracking and monitoring efforts. A local game scout who has practiced traditional methods for tracking wildlife for over 25 years mentioned that,

> "although, this method was not reliable for counting the numbers of tigers or certain species, pugmark experts can differentiate between male, female, and cubs of different species. However, when the pugmarks did not appear clearly due to the texture of the sand, wind and other factors, readings were very poor" (Respondent 5 pers. comm.2014).

As a result, several respondents, especially game scouts and wildlife technicians, mentioned that due to the effectiveness of modern wildlife monitoring technologies, TEK used to monitor wildlife would gradually become obsolete. According to game scouts, mainly, inaccurate and inconsistent results when applying traditional methods would eventually steer the way for a modern technology-driven wildlife monitoring system in the near future. Consequently, findings indicated that after the introduction of modern monitoring technologies, the use of traditional knowledge to track and monitor wildlife has declined and was being gradually forgotten by the new generation of game scouts.

In this context, a recent trained game scout stated: "We can conclusively say that because of the growing use of camera traps, the traditional methods of studying pugmarks and scats are becoming obsolete gradually" (Respondent 6 pers. comm. 2014).

Yet quantitative results suggest a more nuanced picture. While 15 of the 34 respondents (44%) indicated that the use of modern monitoring technologies would indeed result in wildlife monitoring teams losing their traditional skills and ability to track and monitor wildlife, the remaining 19 respondents did not agree with this statement.

Wildlife experts and technicians suggested that despite the low levels of accuracy while using traditional methods to track wildlife, some traditional knowledge and skills continue to help park officials and wildlife researchers during camera trap installation and collaring studies. According to them, traditional knowledge and skills of local conservationists and game scouts are crucial in order to identify potential camera trapping locations and track species such as rhinos, tigers or elephants for satellite or radio collaring studies. In essence, local knowledge and expertise on the movement of wildlife and the forest surroundings help researchers and wildlife experts to work more efficiently because it provides background information which increases the chances of animal sightings for research or monitoring purposes.

Therefore, a substantial finding from the analysis shows that despite the decline in the use of TEK, wildlife researchers and experts continue finding added value of applying traditional knowledge and skills simultaneously while using modern monitoring technologies. This suggests that, beyond solely substituting traditional methods with modern monitoring technologies, a growing synergy between modern wildlife science and some useful aspects of TEK is possible, which could further allow conservationists to work together with local experts for the conservation and management of wildlife. Yet, such collaboration necessitates information sharing, capacity building, and trust, among others, which so far still need to be fostered, as revealed above.

DISCUSSION

Nepal has celebrated 365 days of zero poaching four times, a result that is unmatched by any other country (WWF International 2016). The country's conservation success is quickly becoming a global example for other nations to emulate (Aryal et al. 2017) and has sparked the interest of several media outlets (Rauniyar 2015). The use of anti-poaching drones in Chitwan and Bardia National Parks and its support to conservationists in the frontlines were also abundantly covered by the media (Casey 2014). However, a critical analysis of the country's conservation strategies, particularly in the TAL-Nepal region suggests that the government and its conservation partners may have compromised the participation of local communities by sidelining them in order to achieve some of these results.

Local communities and field employees are being increasingly sidelined from the decision making and the information sharing processes. Poor capacity building of field employees (who are usually members of local communities) and consequently their lack of sufficient expertise on the use of camera traps are clear indicators of this marginalisation process. Furthermore, the inadequate sharing of information collected via monitoring technologies with the members of local communities and lower-level park employees reflects the risks associated with marginalisation, as mentioned elsewhere by Roberts (2007).

Instead, this study reveals the presence of a highly hierarchical organisational structure within the conservation community and the centralisation of the decision making power. Consequently, such circumstances elevate the risks of the misuse of power, incompetency, and nepotism. The discontentment amongst the workforce, particularly among the game scouts, and the several cases of camera trap vandalism by the locals not only highlight the challenges of using modern monitoring technologies in rural regions, as suggested by Joppa (2015), but also provide evidence to the growing issue of re-centralisation of power into the hands of few conservationists, including the Nepali Army.

The Madhesi (locals of the Terai region) protests in 2015-2016, in which approximately 50 locals were killed during clashes with the police forces, also shed light into how local communities and indigenous tribes in the Terai region have suffered the brutal consequences of marginalisation and inequality for decades (Jha 2016).

In many aspects, similar to the reaction of the government to the political demands of the locals of this region, militarised control of the PAs and the buffer zone areas has remained a dominant conservation strategy for the government. As

similarly observed in neighbouring India (Simlai 2015), increasing militarisation of PA security and the introduction of new technologies used by the armed guards within PAs suggest that the government's solutions to control poaching and other illegal-wildlife activities in the region is primarily through "green militarisation" (Lunstrum 2014; Duffy 2015).

In both countries, this legitimised use of violence is justified by discourses talking of emblematic species representing national heritage being at the brink of extinction because of very well organised criminal groups (Simlai 2015). In turn, measures adopted by governments indicate that some monitoring technologies such as drones are being used mainly as an instrument of fear (Sandbrook 2015). As a result, the current policies regarding the use of modern wildlife monitoring technologies are in fact alienating the local and indigenous populations, portrayed as threats, and clearly marginalising their participation in wildlife management in the region.

Despite the repercussions of using wildlife monitoring technologies at the cost of marginalising local communities and their contribution to conservation, a growing synergy between TEK and modern wildlife monitoring science is still needed. Although game scouts often find some traditional methods to be inefficient and unreliable (Gadgil et al. 1993), wildlife experts find added value in applying traditional knowledge during camera trap, radio and satellite collar studies, as also suggested by Jordan et al. (2013) in Nicaragua.

Moreover, incorporating traditional methods with modern wildlife science may in fact help to bolster community participation in wildlife conservation and ensure long-term sustainability of conservation initiatives in remote regions (Moller et al. 2004; Schmidt and Stricker 2010). Especially in regions such as TAL-Nepal, where wildlife and human populations live side-by-side, conservation agencies need to find new ways to integrate traditional methods and practices into modern wildlife science in order to support both rural development and biodiversity conservation.

CONCLUSION

It is understandable that the task of conserving wildlife and also promoting socio-economic growth in a densely populated region such as TAL-Nepal is an immense challenge for international and local NGOs, as well as government agencies. However, marginalising indigenous communities in the decision making process and increasing militarised response in order to conserve and manage wildlife are not appropriate solutions to these issues.

Before replicating and scaling up such wildlife conservation approaches based on modern technological devices, conservation agencies need to break down the existing communication barriers. They should create space for a more transparent, democratic, and participatory model of conservation, building the local population's sense of ownership and responsibility over biodiversity. Only by gaining the support of local communities and by ensuring a participatory approach towards conservation can the continued contribution of modern wildlife monitoring technologies become noteworthy. Sustaining access and benefit sharing as well as technology transfer approaches, both critical pillars of the Convention on Biological Diversity, will indeed mitigate conflicts and rule breaking, and in turn reduce significant costs associated with these.

To improve trust among the workforce as well as the adjacent communities, conservation agencies need to increase the level of operational transparency, especially concerning the use of monitoring technologies. Although anti-poaching activities require an understandable minimum level of secrecy, frequent dialogues with local and indigenous communities could offer a platform for conservationists to debate and share information so as to ease discontentment. In addition, these discussions with local experts and indigenous communities may further allow conservationists to tap into better aspects of TEK.

Therefore, we contend, investments which are being used to finance certain very costly modern wildlife monitoring technologies such as drones (which have failed to produce concrete results in the TAL-Nepal context) may be reallocated for more constructive and cost effective purposes such as organizing training and community workshops for game scouts and local experts. Research wise, views from local communities, in particular in the vicinity of protected areas, should be better taken into consideration. Indeed, for time and budget reasons, this research could not entirely reflect the voices of affected local people living adjacent to protected areas. Hence, future research should also further focus on capturing neighbouring population's feedbacks. This will in turn, help better inform conservation policies and protected area management in Nepal and elsewhere.

ACKNOWLEDGEMENTS

The authors would like to thank Professor Claudio Chiarolla for his support and guidance. They would also like to thank all the participants of this research and one of the author's colleagues at WWF Nepal for their time, patience and valuable suggestions during the fieldwork. The authors are grateful to World Wildlife Fund's Russell E. Train Education for Nature Program for providing one of the authors with the financial assistance for a master's program at Sciences Po. Paris. This work was also partly supported by the Agence Nationale de la Recherche of the French government through the Investissements d'avenir [ANR-10-LABX-01] programme.

NOTES

1. Spatial Monitoring and Reporting Tool (SMART) is a new and improved tool for measuring, evaluating and improving the effectiveness of wildlife law enforcement patrols and site-based conservation activities.
2. Likert scale is a non-comparative technique used to measure a single trait. Respondents are asked to indicate the level to which they agree or disagree with a certain statement on a given ordinal scale.

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Received: June 2016; **Accepted**: August 2017