The concept and criteria for declaring a Vulture Safe Zone in South Asia

Christopher G. R. Bowden[1*], Sachin Ranade[2], A. B. M. Sarowar Alam[3], M. J. I. Chaudhry[4], Ankit B. Joshi[5], Sakib Ahmed[3], Mary E. Davies[1], John W. Mallord[6]

[1] Global Species Recovery, Royal Society for the Protection of Birds, UK
[2] Bombay Natural History Society, India
[3] IUCN Bangladesh
[4] WWF Pakistan
[5] Bird Conservation Nepal
[6] Centre for Conservation Science, Royal Society for the Protection of Birds, UK

*Corresponding author: Chris.Bowden@rspb.org.uk

http://dx.doi.org/10.4314/vulnew.v89i1.3

Introduction

Of twenty-three vulture species worldwide, sixteen have an unfavourable conservation status on the IUCN Red List. Poisoning is the main driver of population declines (Botha *et al.* 2017), but the form this takes varies according to region. The use of poison-baits, driven by human-wildlife conflict, is the predominant threat on a global scale, including in South-east Asia, although the killing of vultures for their body parts for belief-based use and sentinel poisoning (associated with poaching) are prevalent in Africa (Botha *et al.* 2017). In South Asia, however, unintentional poisoning by the veterinary non-steroidal anti-inflammatory drugs (NSAIDs), is the predominant threat - diclofenac, ingested when vultures fed on the carcasses of livestock that had been treated shortly before their death, was earlier confirmed as the main (if not only) cause of the catastrophic declines of *Gyps* vulture populations (Oaks *et al.* 2004, Green *et al.* 2004, Shultz *et al.* 2004), including the loss of 99.9% of the White-rumped Vulture *Gyps bengalensis* population across India and Nepal (Prakash *et al.* 2007). Following steps to remove diclofenac, other NSAIDs which at least partially replaced diclofenac in veterinary use have been confirmed as similarly toxic (Naidoo *et al.* 2010, Galligan *et al.* 2022) prompting a need for further steps to monitor and address these drugs, too.

Since 2004, the initial conservation responses to this crisis across South Asia have involved identification of safe alternative drugs, the banning of manufacture and veterinary use of diclofenac (and more recently other NSAIDs confirmed as toxic) along with the immediate establishment of conservation breeding programmes for the most affected vulture species with the aim of future releases once the threats had been addressed. Another response was subsequently developed as an in-situ measure: to apply targeted advocacy work alongside close monitoring of the threats and remaining vulture populations – all at a landscape scale relevant to vultures. This concept was initiated in Nepal, where the term "Diclofenac-free Zone" was put forward, but this was quickly revised to "Vulture Safe Zone" (VSZ) once it had become clear that diclofenac was not the only veterinary drug that posed a serious threat to vultures.

Here we outline the advocacy-driven VSZ concept and define the methods and criteria (or checks) developed for validating the safety of such areas in the South Asian context. These actions and checks were developed through multiple consultations within the extensive network of the 'Saving Asia's Vultures from Extinction' (SAVE) conservation

practitioners and its Technical Advisory Panel. By documenting this here, we aim to help standardise the approach, highlighting important elements, such as monitoring survival and causes of mortality of satellite-tagged vultures, that could be adapted for application in other regions where different threats predominate.

Establishing a Vulture Safe Zone (VSZ)

A major challenge presented by the Asian vulture crisis has been that whilst there has been an overriding need for the strict regulation of toxic veterinary drugs – something that requires high-level advocacy and follow-up - it was also important to identify actions on the ground that could play a meaningful role in removing their threat.

The over-riding aims of establishing a VSZ are to effectively address the main threats faced by vultures through well directed and effective advocacy and awareness-raising to the priority audiences. The effectiveness of these actions must then be monitored (ie in the case of South Asia, through undercover pharmacy surveys to gauge toxic NSAID levels) and ultimately to monitor the response in terms of vulture population trends. Before any releases of captive vultures proceed, a more rigorous test of the safety of the environment is needed, and two robust options for this have been devised (see 'Safety checks', below). The first option involves intensive monitoring of survival rates and causes of mortality of GPS-tagged wild vultures, which may have wider application to areas where different threats predominate. A second option was devised for areas where tagging of enough wild birds is not practical and involves sampling and analysis of cow liver samples for NSAID residues, but is very specific and limited to areas where NSAIDs represent the overarching threat.

Initial steps taken in Nepal and the evolution of VSZ terminology

Initial efforts were made to declare Districts of Nepal as 'diclofenac-free zones', with Dang District the first area where such declaration was made (in 2010) by Bird Conservation Nepal (Bhusal 2018). This approach was soon expanded to encompass the threat of other veterinary drugs that had meanwhile proved to be toxic to vultures, and it was at this point in 2010 that the term 'Vulture Safe Zone' was adopted. There is inevitably a gap between starting VSZ work and demonstrating the safety of such an area, so the further term of 'Provisional Vulture Safe Zone' (pVSZ) was used to avoid the implication that the area was immediately safe, just because VSZ work had started. This pVSZ approach was applied more widely in Nepal, and soon adopted with local modifications in several areas of India, Bangladesh and Pakistan, with exchanges of ideas and experience mainly through a series of meetings within the SAVE network.

The location and defining the size of a VSZ

During SAVE partner meetings, it was agreed that each VSZ should have as its central point, an active breeding colony of one of the globally Critically Endangered vulture species. A 100 km radius area (total 31,400 km2) was adopted as a manageable area for implementation of the key advocacy actions. There has been a stronger focus of VSZ awareness activities within a core area of 50km radius both in Nepal (Bhusal 2018) and Bangladesh (IUCN Bangladesh 2016) but the more distant areas within the entire 100km radius have been included for carrying out the higher-level actions listed below (Table 1). Although the extent of the VSZ area was based on the ease of carrying out conservation actions, it was intended to be able to provide all the needs (nesting, roosting and feeding)

of a breeding colony of vultures. Tracking of wild White-rumped Vultures in Pakistan (Gilbert *et al.* 2007) and confirmed by more recent data from Nepal (Mallord *et al.* 2024), shows that home ranges are frequently considerably smaller than this area, although some birds occasionally travelled further. However, once the safety checks were applied, it has been the movements of tracked birds that has defined the actual safe extent of the VSZ (SAVE 2021).

Although the full VSZ area should be incorporated into planning advocacy activities, there may be topographical or political reasons why the entire circle may not be included for all activities. These may include large waterbodies or the coastal limit, higher altitude areas where target species don't occur, or international political borders. Where national boundaries are involved, this has prompted trans-boundary cooperations in some cases and highlights the needs for such initiatives.

VSZ Activities

Scientific studies. A good scientific understanding of the primary threats driving population declines is fundamental to the recovery of all threatened species. The Multispecies Vulture Action Plan and SAVE Blueprint priority actions draw upon scientific expertise and peer-reviewed information in identifying the prioritised threats to be addressed (Botha *et al.* 2017, SAVE 2025). In the South Asian context, the identification and confirmation of diclofenac as the cause of vulture population declines was the result of several years of scientific study: analysis and experimental testing of the effect of the drug on vultures (Oaks *et al.* 2004), surveys of the prevalence of drug residues in vultures across India (Shultz et al. 2004) and modelling the population effects of ingesting contaminated carcasses (Green *et al.* 2004). Threats may change over time, so ongoing systematic monitoring systems are required so they remain objective. For highly mobile species, such as vultures, where mortality causes can be difficult to determine, this is something that requires careful interpretation, as some causes are far more detectable than others, e.g. use of poison baits or electrocution. Intensive monitoring of birds fitted with GPS transmitters is currently the most objective way to determine the ongoing causes of mortality, and hence the major threats facing the vulture population. The ultimate test of any conservation programme is how it impacts the population being targeted, so assessing causes of mortality should be complemented by regular vulture population monitoring (see below). In Nepal, although mortality through the use of poison baits has been highlighted (Bhusal *et al.* 2023), continued monitoring has shown that annual survival remains high (Mallord *et al.* 2024) and populations continue to increase at the maximum possible rate (Mallord *et al.* 2026).

Awareness raising. In South Asia, awareness raising focuses mainly on the NSAIDs threat but also covers poison-baits and in some areas power infrastructure. It also emphasises the importance of vultures to the ecosystem, human health and culturally. The issue of the use of poison baits is given special attention in many areas, highlighting the major impact a single poisoning incident can have, as well as the illegality and the wider dangers beyond just vultures, including to humans. Training has also been provided in some areas, focussing on the response to poison bait incidents, with the aim of recovering sick vultures and reducing mortality (SAVE 2023). The risk of collision and electrocution on power infrastructure, and carcass availability when carcass disposal practices change to burial or incineration are also highlighted. Highlighting these additional threats requires additional materials and messaging, although care is needed not to lose the core messaging on the primary threat. This awareness work is needed at a variety of levels, and although the following target

audiences have been identified for the South Asia context (Table 1), and a wide range of actions and materials developed to target each, they are likely to be similar for other contexts.

Table 1. Key target audiences for VSZ awareness activities in South Asia

Target Audience (Scale/level)	Specific positions or forum
Government Officers (State level)	Relevant Ministries (e.g. Ministry of Environment, Forest and Climate Change) Forest & Wildlife Departments Animal Husbandry Drug Regulatory Authority Veterinary Colleges Livestock Department
Government Officers (District/Provincial level)	Forest and Wildlife Secretaries Conservator of Forests and Wildlife District Forest and Wildlife Officers District Livestock Officers Forest and Wildlife Guards Govt. Veterinarians District-level Drug Inspectors
Drug Suppliers	Veterinary pharmaceutical distributors, Wholesale drug dealers and stockists, Retail veterinary medical store owners / pharmacists, Veterinary drug representatives / sales agents Pharmaceutical Company representatives or staff and other related private sector individuals.
Local Drug store owners	Local Livestock hospital Retail veterinary medical store owners / pharmacists,
General public, Schools Livestock Owners, Local vets, Paravets.	School visits (students & teachers), innovative publicity, field visits, engagement (see below), Local communities, Ethnic groups, Local volunteer groups, Local religious places Nature clubs and environmental societies in school visits, Local community members, Community-based organizations, public awareness events, educational campaigns, dissemination of awareness material. Gatherings or events for livestock owners.

(Local to central point up to 50 km for general public/schools)	
Press & Media contacts	Press Club, Local Journalists Environmental journalists and wildlife reporters, Health and agriculture correspondents, TV and radio program producers, Digital media writers / online news portals, Press clubs (district / provincial level)

Awareness-raising materials should be produced in the relevant local languages, and culturally adapted events developed to capture local interest and attention. Details and examples of these activities are illustrated in several articles (e.g. Ahmed & Alam 2022, Insua-Cao *et al.* 2022, Ranade 2022, Shringarpure 2022, Chakraborty 2022, Bharathidasan 2022).

Monitoring. Monitoring vulture populations can be challenging due to the birds' high mobility. The main methods that have been utilised in South Asia are road-transect surveys (Prakash *et al.* 2007, Galligan *et al.* 2020) or stratified random point counts from vantage points with good visibility (Raj Kumar 2023). These methods do not give estimates of population size (unless combined with accurate distance sampling), rather producing a population index in relation to a particular fixed point (usually, the first count in a years-long series). The most important aspect of these surveys is that they are conducted in such a way that they are repeatable between years. For instance, road transect surveys in India and Nepal have been carried out over the same routes, at the same time of year and often using the same observers (Prakash *et al.* 2024). Counts of nests within vulture colonies are sometimes carried out to estimate population size and trends, but unless carried out on a large, stratified sample of survey plots distributed over a large area, i.e. country or region, they are not likely to produce repeatable results as they will not account for missed nests or localised shifts in nesting sites.

VSZ Safety Checks

Summary of safety-check criteria by which a VSZ can be declared safe from the primary threat of NSAIDs

SAVE currently recommends three principal methods for monitoring the NSAIDs threat to free-ranging vultures in potential vulture safe zones and release areas:

First, carry out undercover surveys of NSAIDs available in veterinary pharmacies within a 100km radius. Note this is relatively quick and inexpensive, and if very low levels of toxic NSAIDs are detected, then implement one or both of the following critical safety checks (see Table 2): The first critical check option is monitoring of the survival of wild vultures after capture and tagging with GPS tags. The second option which is highly specific to South Asia is sampling of the liver from cattle carcasses for chemical assays of all nephrotoxic and potentially nephrotoxic NSAIDs. Finally, if well-monitored vulture populations (through repeatable methodology) demonstrate increases, this is a further criterion to consider. The criteria can be summarised as follows (Table 2).

Table 2. VSZ Criteria and Safety checks required for the South Asia Context.

Criterion to monitor across area of 100km radius of VSZ central point.	Result required in order for the VSZ to be considered safe
Preliminary check Undercover pharmacy surveys completed	Less than 5% of pharmacies offering toxic veterinary NSAIDs within 100km radius before implementing either or both critical safety check (options 1 or 2) below (full safety test)
Critical check option 1 50 Vulture-years of satellite tracking data with intense monitoring for retrieval of dead vultures within the VSZ area (see checks section below & Green 2024b for full justification of sample sizes)	Over 90% annual survival of adult vultures, demonstrating no cases of toxic-NSAIDs as the mortality cause. This method will also highlight whether other causes of mortality are emerging as population-level threats.
Critical check option 2 Minimum of 800 cattle liver samples collected & tested for toxic NSAID residues - from cattle carcasses potentially entering vulture food chain (see checks section below & Green 2024a for full justification of sample sizes)	No toxic NSAIDs detected in 800 cattle samples collected within 100km radius
Standardised vulture monitoring in place	Population trends are stable in the VSZ or countrywide increasing over previous three years.

Threat monitoring and testing

The following activities have been devised and approved by the Technical Advisory Panel (TAP) of SAVE, either of which can be applied for seeking VSZ status within South Asia where NSAIDs remain the highest acknowledged theat.

Preliminary safety checks via undercover pharmacy survey throughout the 100km radius area.

The first step is to carry out undercover pharmacy surveys to determine whether any toxic NSAIDs are being offered to cattle owners. Only if fewer than 5% of pharmacies are found to offer a toxic NSAID, then one of the more thorough (and more costly) safety-checks - either satellite tracking of vultures to determine survival rates and identify causes of mortality, or cattle carcass sampling for toxic NSAIDs - should be initiated.

The main aims of the pharmacy surveys are to, firstly, monitor the continued (illegal) availability of diclofenac for veterinary purposes; secondly, to assess to what degree its use has been replaced by vulture-safe NSAIDs meloxicam or tolfenamic acid; and finally, to monitor which other veterinary NSAIDs, some of which are known (or suspected to be) toxic to vultures, are being offered to treat livestock. Undercover (covert) surveys are necessary to detect illegal behaviour - the selling of diclofenac for veterinary use is now illegal across most countries of South and SE Asia; hence, the true prevalence of toxic drugs may be hidden if open surveys were undertaken.

A random selection of locations should be selected, ensuring wide geographical coverage across the

entire VSZ, in which pharmacies will be surveyed. This can be carried out by means of stratified random sampling, whereby a region is divided into areas, and pharmacies are sampled randomly within each area. Only one pharmacy should be visited in each settlement to avoid pseudo-replication, i.e. patterns of drug availability due to close proximity to other pharmacies selling the same drugs. Surveyors should act as a local livestock owner and ask the pharmacist specifically for "a painkiller for an injured cow" and ideally should know the local language. No particular drug should be specified. The surveyor should then buy the first drug offered, whether it is a NSAID or not. If the pharmacist refuses to sell a drug for whatever reason, e.g. they don't stock them; lack of prescription, then this should be recorded and surveyors should move onto the next identified location. The name, address and location of the pharmacy should be recorded; the use of GPS coordinates would allow the same pharmacy to be visited in future surveys. From the purchased drug, the following data should be collected and transferred to an electronic database, e.g. Microsoft Excel, as soon as possible after data collection):

1) vial size; this is particularly important as all vials of diclofenac > 3 ml are illegal in some countries, e.g. India;

2) name and concentration (mg/ml) of the active drug; and whether it is injectable or in oral (bolus) form;

3) brand name;

4) name and address of the manufacturing company; this indicates whether a drug has been locally made or has been imported;

5) license and batch number;

6) manufacturing and expiry date; this is important to assess whether stocks of diclofenac held by pharmacies were made before the ban; and

7) price.

The above method has been specified and approved by the SAVE TAP (Mallord 2024). Note that this method alone, even if it finds no toxic NSAIDs being offered by pharmacies is not sufficient to confirm the safety of a VSZ. Once this first step has been completed and has demonstrated that the full extent of the VSZ has little or no vulture-toxic NSAIDs being offered to farmers, then the next safety tests should commence. There are two options available and at least one should be completed before the VSZ can be confirmed in a scientifically approved way as a certified VSZ. Which of these methods is the more feasible may depend on several factors, including the size of the remnant vulture population and whether tagging permissions can be obtained.

Critical check Option 1: Intensive monitoring of GPS-tagged wild vultures determining good adult survival and no mortality attributable to toxic NSAIDs.

If the monitoring of marked birds estimates annual survival rates of wild vultures above90%, which is typical for stable and increasing populations (Mallord *et al.* 2024), then the areas regularly visited by those birds can be defined as being safe. If, however, estimated annual survival is below 90%, or if the previously predominant threat is still being detected, even at low levels, then the safety of the area should not be certified. Traditionally, vulture survival has been estimated through resighting of colour-marked (rings, wing tags) individuals (Kendall *et al.* 2012). However, this method is difficult to apply over large spatial and temporal scales given their expense and time requirements (Perrig *et al.* 2019). A better, unbiased, method of not only estimating survival, but also to quantify causes of mortality, is the monitoring of birds fitted with satellite / GPS telemetry devices (McIntyre 2012). To have reasonable confidence in the survival estimates, birds should be monitored for a minimum of 50 vulture-years, i.e. 50 birds over one year or 25 birds over two years (Green 2023b), although tagging a

larger number than this would further increase the reliability of the conclusions drawn. Closely monitoring a population of tagged vultures also allows for the detection of dead birds, which can then be retrieved and sent for post-mortem analysis (Mallord *et al.* 2024), along with collection and analysis of blood and tissue samples. Such monitoring requires a ground-truthing team who can respond immediately to suspicious GPS fixes, i.e. where successive locations indicate the bird is stationary, or where additional sensors incorporated in the tag measuring movement (accelerometer), battery voltage or temperature, suggest the bird may have died (Mallord *et al.* 2024). The availability of laboratory facilities capable of carrying out postmortems and analysing samples taken from the birds is also vitally important. There are added advantages to this approach as it also helps understand vulture movements, locations of their feeding and nesting sites and better understanding of the species ecology and use of the area concerned. However, before initiating a tagging programme, certain requirements need to be met: firstly, are there enough wild vultures in the area? Is there a trained team available to trap the vultures safely and fit the transmitters appropriately? Which tags are most suitable, i.e. GSM tags have traditionally been the cheaper option, but are dependent on good mobile phone coverage. If this coverage is patchy, mortality events may be missed. Platform Transmitter Terminals (PTTs) circumvent this problem by utilising the satellite system. Transmitter manufacture is a fast-moving field worldwide; research should be carried out to determine the best equipment to use for a particular study. The combination of all these requirements demands significant human and financial resources.

Critical check Option 2: Tissue sampling of dead cattle carcasses to test for toxic NSAIDs.

An alternative to intensive monitoring of satellite-tagged wild vultures as an assessment of an area's safety is through cattle carcass sampling. Samples are taken of at least 5g of cattle liver from each carcass. The sample is labelled in a separate sterile tube and kept frozen as soon as possible. These are then extracted and sent to a reliable laboratory experienced in carrying out simultaneous multiple NSAID detection, using LCMS (Liquid chromatography mass spectrometry) techniques.

The probability, K, that a carcass is found to contain an NSAID concentration at or above the lethal level is given by:

$$K = 1 - (1-C)^N$$

where C is the *actual* prevalence of contaminated carcasses and N is the number of carcasses sampled. Cuthbert *et al.* (2014) analysed cattle carcass survey data from 11 areas of India and found that the overall mean death rate per meal (equivalent to the proportion of carcasses with a lethal level of NSAID, C) of White-rumped Vultures in India was 0.015 in 2005 (when the decline was still in full swing) and 0.0053 in 2009 (when the decline had slowed). However, Green *et al.* (2004) found that even a value of C as low as 0.001 could cause a vulture population to decline at appreciable rate. Table 3 (from Green 2023a) illustrates that analysing 800 samples has a high probability of detecting a single carcass with a lethal dose of an NSAID for both the higher values of C. However, it is worth noting that there is roughly only a 50:50 chance if the actual proportion of contaminated carcasses is low (which, after 20 years of diclofenac bans, is to be hoped for).

It should be noted that one limitation has recently emerged with this methodology: while sampling the liver is an effective tissue to detect diclofenac (and some other NSAIDs) that concentrate within the liver, the method is much less effective for nimesulide, which concentrates more around the injection site (Galligan *et al.* 2022). Thus, the cattle liver sampling method has its own limitations for

detecting different NSAIDs, and this further illustrates how important it is to develop a deeper understanding of each individual threat for a given region. To address this possibility for detecting nimesulide specifically, multiple additional cattle tissue samples would be needed, taken from both sides of the neck, as well as rump and thigh (all potential injection sites) which hugely increases analysis costs to levels that realistically may become unaffordable, and so if assured detection of this drug is a major concern (it isn't for all areas), then special attention will be needed along with extra resources.

Critical checks 1 and 2 are designed to be statistically robust, but each requires significant resources. The figures (sample sizes) mentioned for each however represent absolute minimum figures of what is needed to draw reliable conclusions.

Table 3. Probability (K) of detecting at least one cattle carcass sample with a concentration of nephrotoxic NSAID at or above the lethal level for vultures in relation to the true proportion of carcasses with a lethal level C and the number of carcasses sampled N.

	Value of K (probability of detection) for sample size:		
C (prevalence of carcass)	N=100	N=800	N=1000
0.001	0.095	0.551	0.999
0.0053	0.412	0.986	1.000
0.015	0.779	0.999	1.000

G**overnment Designation of Vulture Safe Zone Status**

So far, the only country that has taken the additional step of gazettement of two VSZs is Bangladesh. In this case, the welcome recognition was taken for the two 100 km radius areas centred on the two main remaining White-rumped Vulture breeding populations in the country. Because this step came ahead of the safety certifications described above, these VSZs should be regarded as Provisional VSZs pending the further critical checks. Regardless, the gazetted status brought important recognition and empowered the VSZ teams in this case for implementation of NSAID bans (notably ketoprofen) ahead of national bans being in place (IUCN 2017). Government recognition also highlighted the recognition of the work with local communities and especially with government officials operating in the area and provides ongoing commitment (including resources) for further steps needed to achieve the goal of full VSZ status. The two areas were gazetted by the Bangladesh Government in 2016 under article 20 (1) of the Wildlife (Conservation and Security) Act 2012 (IUCN Bangladesh 2016). This also facilitated government funding to be directed towards carrying out VSZ activities in these areas, which were mainly implemented by the NGO sector. No other country has so far taken this significant step to formally recognise VSZs as a protection status, although VSZ status appears to be a potentially suitable fit for Other Effective Area-based Conservation Measure (OECM) as a gazetted designation which governments in the region have as an available protection status option (UNDP & NBA 2022). This could be particularly appropriate since vultures are very often ranging or breeding outside more conventional protected areas.

Resourcing a VSZ team

The VSZ activities targeting the key audiences listed in Table 1 have been carried out with varying

levels of resources, and in some cases have been managed in combination with vulture breeding or non-vulture projects – but there is clearly a major staffing resource need. Typically, there should be a minimum of two trained biologists, plus a trained veterinarian available to engage with key stakeholders. Further assistants and ideally access to a vehicle are also needed to make the team effective. Budgets for VSZ teams have varied and affect the speed and how much progress can be made, but to give an indication these have varied between $US50,000 and $US150,000 per year per VSZ.

Bangladesh VSZ example: In the case of Bangladesh, community-based Vulture Conservation Teams (VCTs) have been established as core components, linking local communities with government agencies and conservation practitioners. These teams typically include trained local volunteers, village leaders, livestock owners, and external fieldworkers who are responsible for monitoring vulture nesting and roosting sites, conducting awareness activities, supporting safe carcass disposal practices, and reporting threats such as the use of harmful veterinary drugs (IUCN Bangladesh 2016). This therefore consists of: (1) a technically skilled core team (biologists and veterinarian), (2) locally embedded community teams (such as VCTs), and (3) government staff or at least nodal links. The community-based VCTs function on a voluntary basis and are supported by a senior core team, but with minimal monetary resources. The VCT members are given training in nest monitoring, vulture counting at feeding sites, installing camera-traps at the feeding station, and handling of any rescued vultures. Bi-monthly meetings are conducted between the core technical team and VCTs to review progress and to collect relevant data (e.g. nest counts and monitoring, hatchings, camera-trap footage, any mortalities etc). There has been some integration of the VSZ work with initiatives (including some funding/incentive schemes) for developing small-scale sustainable eco-tourism. The links have successfully demonstrated that investing in community-based structures significantly increases coverage, reduces costs, and enhances long-term sustainability for such conservation actions and understanding (IUCN 2017).

Challenge of adapting the VSZ concept to address different threats beyond Asia

In South Asia, addressing the ongoing number-one threat of vulture-toxic NSAIDs, is the focus of VSZ conservation actions. The process for declaring large areas safe from this threat is clearly laid out for this region as described above. For regions where different threats predominate, the actions must directly address those threats, and this may change the process of certifying the safety of the VSZ – although a modification of the safety check method that uses annual survival data of closely monitored satellite-tracked vultures may well have application here. For areas where the predominant threats are less clearly defined or understood, the highest priority should be determining what those threats really are and their severity. A VSZ certification process risks being invalidated, unless vulture populations are shown to be thriving in the area, as demonstrated by systematic and large-scale population monitoring. For example, where poison-baits or belief-based use are major threats, certifying that these threats have been fully addressed on a vulture-landscape scale is a significant challenge.

It is important to highlight that, at the core of the VSZ concept, lies the simple principle of local conservation action, which should be applicable outside of South Asia. For instance, although over the course of a year, African vultures may have substantially larger home ranges than reported for those in Asia (Kane *et al.* 2022), during the breeding season, adult birds will be constrained by

the need to return to a nest for half the year. Hence, local actions centred on vulture breeding colonies, as described here, will still be applicable, not just in Africa but wherever vultures occur. Ultimately, the goal is for a network of VSZs across a region to be established thus creating a safe space for entire vulture populations.

An important point to note is that in the Indian context where there are serious concerns that areas proposed for releases of the substantial captive-bred populations may not be sufficiently cleared of toxic NSAIDs to provide a safe environment. Here, the declaration of a VSZ could justifiably be used to validate the idea to proceed with releases in the VSZ area. But for the wider context, where threats may be less well understood, or their removal be more difficult to validate, some caution is needed in using this VSZ declaration process to condone release planning.

Post-verification monitoring

The formal confirmation that a VSZ is safe is not the end of the story. Monitoring needs to continue to ensure that threats, either the original or new ones, do not re-appear, and that vulture populations continue to increase. Despite a partial recovery (Galligan *et al.* 2020), the numbers of vultures in Nepal remain low compared to pre-decline levels, and are still at risk from external factors, whether that is the return of the NSAID threat, or something new, e.g. increased mortality through the use of poison baits, or collisions / electrocution on power infrastructure (Chaudhary *et al.* 2019, Bhusal *et al.* 2023). In Nepal, where the Gandaki-Lumbini VSZ is the only area so far declared safe, the programme of conservation advocacy continues, backed up by annual pharmacy surveys (Mallord *et al.* 2025), which continue to show the overwhelming presence of the vulture-safe NSAID meloxicam for sale. Over 100 birds still have operational GPS transmitters, so to maximise the investment made in terms of tag purchases, intensive monitoring of GPS-tagged birds continues, demonstrating that estimated annual survival still exceeds 90% (Mallord *et al.* 2024). Finally, road transect surveys to monitor vulture populations are still carried out annually, confirming that the Nepal population of White-rumped Vultures continues to increase (Mallord *et al.* 2026).

However, this is an expensive undertaking, and not all VSZs will have the benefit of large numbers of tagged birds, so we make recommendations for the minimum follow-up monitoring that should be carried out to re-confirm the safety of a VSZ. Pharmacy surveys are the easiest and cheapest surveys to conduct, so these should be repeated every 2-3 years to maintain vigilance of NSAID availability. If these surveys demonstrate an uptick in the prevalence of toxic NSAIDs, then it will be worthwhile carrying out either the cow liver sampling or a programme of GPS telemetry.

Finally, building on the VSZ concept, there is also potential to address the interconnected challenges of poverty, unsustainable livelihoods, and vulture conservation. Strengthening livelihoods, such as those connected to the dairy and livestock industries, aquaculture, and tourism, whilst conserving vulture populations, can be included in VSZ work to ensure that environmental stewardship and economic well-being reinforce each other, providing a sustainable and inclusive model for conservation and development. The benefit of VSZs to local communities has not yet been fully explored, although the potential for this is evident and will be a natural progression for the long-term legacy of Vulture Safe Zones.

Conclusion

The VSZ concept was established as a grass roots approach to focussed vulture conservation, and in South Asia, it has been supported by scientifically justified criteria for verification. The work in the

region has benefitted from international funding, which has been vital given the significant resources demanded by the verification process. The Gandaki-Lumbini VSZ used the option 1 critical verification path of sufficient vulture survival of 50+ vulture years of tracked birds to ascertain its safety. Another area, in SW Nepal (Shuklaphanta NP) will use the same approach. By contrast, in Assam, India, where trapping the requisite number of vultures may have been an issue, the option 2 safety check of cow liver sampling has been adopted and will hopefully confirm the safety of the VSZ when enough samples have been analysed.

Here we have outlined some key actions and the verification process for a South Asia VSZ, but the principles will have a wider application in areas where the primary threats are different, especially the principle of local action in an area that holds breeding vultures, as well as monitoring survival and mortality of tagged vultures to assess the major threats in a particular area. So although the messaging will be different, the idea behind the concept – locally-focussed advocacy and education supported by intensive monitoring– should be a key component of broader vulture conservation efforts.

Acknowledgements

We thank two reviewers Campbell Murn and Andre Botha for constructive comments that substantially improved the manuscript.

References

Ahmed, S. & Sarowar Alam, A. B. M. 2022. Saving the vultures of Bangladesh through Vulture Safe Zones. Hornbill, Special Edition, July–September 2022: 98-105. Bombay Natural History Society, Mumbai, India.

IUCN Bangladesh. 2016. Vultures and Vulture Safe Zones of Bangladesh. International Union for Conservation of Nature, Bangladesh Country Office, Dhaka, Bangladesh.

Bharathidasan, S. 2022. Vulture conservation initiatives in the Mayar Valley Vulture Safe Zone, Tamil Nadu. Hornbill, Special Edition, July–September 2022: 138-143. Bombay Natural History Society, Mumbai, India.

Bhusal, K. P. 2018. Vulture Safe Zone: a landscape level approach to save the threatened vultures in Nepal. *The Himalayan Naturalist* 1: 25-26.

Bhusal, K. P., Chaudhary, I. P., Rana, D. B., Thakuri, D. C., Joshi, A. B., Karki, B. & Mallord, J. W. 2023. Poisoned baits pose a threat to vultures in Nepal. *Nepal Journal of Zoology* 7: 14-19.

Botha, A. J., Andevski, J., Bowden, C. G. R., Gudka, M., Safford, R. J., Tavares, J. & Williams, N. P. 2017. Multi-species action plan to conserve African–Eurasian vultures. CMS Raptors MOU Technical Publication No. 5. CMS Technical Series No. 35. Coordinating Unit of the CMS Raptors MOU, Abu Dhabi, United Arab Emirates.

Chakraborty, S. S. 2022. Creating a Vulture Safe Zone in West Bengal. Hornbill, Special Edition, July–September 2022: 132-137. Bombay Natural History Society, Mumbai, India.

Chaudhary, I. P., Dangaura, H. L., Rana, D. B., Joshi, A. B. & Bhusal, K. P. 2019. What are the threats to vultures other than NSAIDs in Nepal? *Vulture Bulletin* 8: 41-43.

Galligan, T. H., Bhusal, K. P., Paudel, K., Chapagain, D., Joshi, A. B., Chaudhary, I. P., Baral, H. S., Cuthbert, R. J. & Green, R. E. 2020. Partial recovery of Critically Endangered *Gyps* vulture populations in Nepal. *Bird Conservation International* 30: 87-102.

Galligan, T. H., Green, R. E., Wolter, K., Taggart, M. A., Duncan, N., Mallord, J. W., Alderson, D., Li, Y. & Naidoo, V. 2022. The non-steroidal anti-inflammatory drug nimesulide kills *Gyps* vultures at concentrations found in the muscle of treated cattle. *Science of the Total Environment* 807: 150788.

Gilbert, M., Watson, R. T., Ahmed, S., Asim, M. & Johnson, J. A. 2007. Vulture restaurants and their role in reducing diclofenac exposure in Asian vultures. *Bird Conservation International* 17: 63-77.

Green, R. E. 2023a. Recommended monitoring of cattle carcasses for nephrotoxic NSAIDs in potential Vulture Safe Zones and release areas. SAVE Technical Guidance #3. Accessed 1 April 2026.

Green, R. E. 2023b. Minimum requirements for monitoring of the survival of vultures in Vulture Safe Zones and release areas. SAVE Technical Guidance #5. Accessed 1 April 2026.

Green, R. E., Newton, I., Shultz, S., Cunningham, A. A., Gilbert, M., Pain, D. J. & Prakash, V. 2004. Diclofenac poisoning as a cause of vulture population declines across the Indian subcontinent. *Journal of Applied Ecology* 41: 793-800.

Insua-Cao, P., Ranade, S. P., Shringarpure, R., Barathidasan, S. & Prakash, S. 2022. Vulture Safe Zones of India. Hornbill, Special Edition, July–September 2022: 112–119. Bombay Natural History Society, Mumbai, India.

International Union for Conservation of Nature. 2017. Banning ketoprofen: yet another milestone in saving vultures in Bangladesh. Available at: https://iucn.org/news/bangladesh/201702/blog-banning-ketoprofen-yet-another-milestone-saving-vultures-bangladesh. Accessed 27 March 2026.

Kane, A., Monadjem, A., Aschenborn, H. K. O., Bildstein, K., Botha, A., Bracebridge, C., Buechley, E. R., Buij, R., Davies, J. P., Diekmann, M., Downs, C. T., Farwig, N., Galligan, T., Kaltenecker, G., Kelly, C., Kemp, R., Kolberg, H., MacKenzie, M. L., Mendelsohn, J., Mgumba, M., Nathan, R., Nicholas, A., Ogada, D., Pfeiffer, M. B., Phipps, W. L., Pretorius, M. D., Rosner, S., Schabo, D. G., Shatumbu, G. L., Spiegel, O., Thompson, L. J., Venter, J. A., Virani, M., Wolter, K. & Kendall, C. J. 2022. Understanding continent-wide variation in vulture ranging behavior to assess feasibility of Vulture Safe Zones in Africa: challenges and possibilities. *Biological Conservation* 268: 109516.

Kendall, C. J. & Virani, M. Z. 2012. Assessing mortality of African vultures using wing tags and GSM-GPS transmitters. *Journal of Raptor Research* 46: 135-140.

Mallord, J. W. 2024. Measuring the availability of diclofenac and other NSAIDs using undercover pharmacy surveys. SAVE Technical Guidance #8. Accessed 1 April 2026.

Mallord, J. W., Bhusal, K. P., Joshi, A. B., Karki, B., Chaudhary, I. P., Chapagain, D., Thakuri, D. C., Rana, D. B., Galligan, T. H., Requena, S., Bowden, C. G. R. & Green, R. E. 2024. Survival rates of wild and released White-rumped Vultures *Gyps bengalensis*, and their implications for conservation of vultures in Nepal. *Ibis* 166: 971-985.

Mallord, J. W., Ranade, S., Bhusal, K. P., Sarowar Alam, A. B. M., Chaudhry, M. J. I., Chakraborty, S. S., Barathidasan, S., Bohra, D. L., Dube, A., Shringarpure, R., Chaudhary, I. P., Joshi, A. B., Rana, D. B., Thakuri, D. C., Dangaura, H. L., Azmiri, K. Z., Ahmed, S., Zakir, T., Ahmed, S., Fatima, H., Rahim, A., Murn, C., Bowden, C. G. R. & Green, R. E. 2025. The continued threat of toxic NSAIDs to Critically Endangered *Gyps* vultures in South Asia. *Bird Conservation International* 35: e38.

Mallord, J. W., Joshi, A. B., Chaudhary, I. P., Thakur, D. C., Thapa, I., Bhusal, K. P., Rana, D. B., Dhakal, B. K., Galligan, T. H. & Green, R. E. 2026. Continued population recovery and high annual survival rates of the Critically Endangered White-rumped Vulture *Gyps bengalensis* in Nepal after removal of the veterinary drug diclofenac. *Manuscript submitted for publication.*

Mathesh, K., Manickam, K., Mallord, J. W., Mahendran, K., Asok Kumar, M., Saikia, D., Chandra Mohan, S., Beena, V., Shree Lakshmi, P., Prakash, N., Shringarpure, R., Pawde, A. M., Green, R. E., Naidoo, V. & Prakash, V. 2023. Experimental safety testing confirms that the NSAID nimesulide is toxic to *Gyps* vultures in India. *Environmental Toxicology and Pharmacology* 103: 104284.

McIntyre, C. L. 2012. Quantifying sources of mortality and wintering ranges of Golden Eagles from interior Alaska using banding and satellite tracking. *Journal of Raptor Research* 46: 129-134.

Naidoo, V., Wolter, K., Croarty, D., Diekmann, M., Duncan, N., Meharg, A. A., Taggart, M. A., Venter, L. & Cuthbert, R. 2010. Toxicity of non-steroidal anti-inflammatory drugs to *Gyps* vultures: a new threat from ketoprofen. *Biology Letters* 6: 339-341.

Oaks, J. L., Gilbert, M., Virani, M. Z., Watson, R. T., Meteyer, C. U., Rideout, B. A., Shivaprasad, H. L., Ahmed, S., Chaudhry, M. J. I., Arshad, M., Mahmood, S., Ali, A. & Khan, A. A. 2004. Diclofenac residues as the cause of vulture population decline in Pakistan. *Nature* 427: 630-633.

Perrig, P. L., Lambertucci, S. A., Donadio, E., Padró, J. & Pauli, J. N. 2019. Monitoring vultures in the 21st century: the need for standardized protocols. *Journal of Applied Ecology* 56: 796-801.

Prakash, V., Bajpal, H., Chakraborty, S. S., Mahadev, M. S., Mallord, J. W., Prakash, N., Ranade, S. P., Shringarpure, R., Bowden, C. G. R. & Green, R. E. 2024. Recent trends in populations of Critically Endangered *Gyps* vultures in India. *Bird Conservation International* 34: e1.

Prakash, V., Green, R. E., Pain, D. J., Ranade, S. P., Saravanan, S., Prakash, N., Venkitachalam, R., Cuthbert, R., Rahmani, A. R. & Cunningham, A. A. 2007. Recent changes in populations of resident *Gyps* vultures in India. *Journal of the Bombay Natural History Society* 104: 129-135.

Raj Kumar, D. 2023. Population Status and Ecology of Vultures in Bandipur, Nagarahole and BRT Tiger Reserves. Wildlife Conservation Foundation, Mysore, India.

Ranade, S. P. 2022. Homecoming of White-rumped Vultures in Assam. Hornbill, Special Edition, July–September 2022: 168-171. Bombay Natural History Society, Mumbai, India.

SAVE 2023. First successful tagging of Red-headed Vultures in Cambodia. Accessed 28 April 2026.

SAVE 2025. SAVE Blueprint relaunched – 2025. Accessed 1 April 2026.

Shringarpure, R. 2022. Creating Vulture Safe Zones in Madhya Pradesh and Uttar Pradesh. Hornbill, Special Edition, July–September 2022: 126–131. Bombay Natural History Society, Mumbai, India.

Shultz, S., Baral, H. S., Charman, S., Cunningham, A. A., Das, D., Ghalsasi, G. R., Goudar, M. S., Green, R. E., Jones, A., Nighot, P., Pain, D. J. & Prakash, V. 2004. Diclofenac poisoning is widespread in declining vulture populations across the Indian subcontinent. *Biology Letters* 271: S458-S460.

UNDP & NBA 2022. Other Effective Area-based Measures: A Compendium of OECMs in India.

******