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RESEARCH ARTICLE

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Disregard of aquatic shrews in the Environmental Impact Assessment reports regarding hydropower dams in the Nepal Himalayas

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Abstract

The rate of hydropower dam construction on rivers is increasing in emerging economies in South Asia, to achieve economic development goals. These large infrastructure projects are likely to have many negative consequences on freshwater species but have not yet received much consideration. Among freshwater small mammalian species, water shrews are seriously impacted by these large structures. This paper aims to determine if water shrews have been considered during the Environmental Impact Assessment (EIA) of these hydro dam project sites, as well as present the sightings of the water shrews from Nepalese rivers with hydropower potential. We reviewed 44 EIA reports of such projects in Nepal using a set of four criteria and 15 questions to analyze the methods of impact assessment for mammals and the reports on the presence of water shrews in each built area. The study found that the number of mammal species reported during the EIA varied from five to 55 species but no relationships between the hydropower structure's size and any water shrew species were considered in the studies. In almost all EIA reports, the term aquatic ecosystem was prioritized over the term aquatic small mammals, and the latter was not considered in the assessment. The major reason for not considering these species is probably due to the lack of robust methods to capture small mammals such as shrews, or due to survey methods focused only on terrestrial mammals. The Aquatic Animal Protection Act was fully reviewed and assured to be followed in a majority of the reports, yet the monitoring parameters and indicators were not available for aquatic small mammals. Ignoring the presence of these mammals while constructing hydropower plants is a serious threat to their persistence. We also reported the Himalayan water shrew in the Barun River and the elegant water shrew in the Upper Tamakoshi River of Nepal. Therefore, a better understanding of these species among hydropower developers, and all concerned agencies, is essential.

KEYWORDS
environment assessment, freshwater, hydro dam, Mammalia, South Asia

Sagar Dahal and Kaustuv Raj Neupane are considered joint first author.

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1 | INTRODUCTION

The development of infrastructure projects in rivers is increasing globally, with approximately 58,000 large dams existing worldwide (Mulligan et al., 2020). In the Hindukush region alone, there are over 110 major dams and several more are proposed (Huettmann, 2020; World Commission on Dams, 2000). Despite having great hydropower potential, South Asia is an energy-poor region presenting significant opportunities for the expansion of hydropower (Vaidya et al., 2021) and hydropower are considered synonymous with economic development and environmental services (Gunatilake et al., 2020). The Himalayas are also experiencing a boom in dam construction (Zarfl et al., 2015) and Nepal is currently discussing the use of hydropower to address the energy needs of the South Asia region. In the 1980s and 1990s, foreign investments were brought to Nepal through hydropower projects financed by organizations such as the World Bank, Asian Development Bank, International Finance Corporation, and International Monetary Fund, along with Nepali capital sources (Dhungel, 2016). According to the Niti Hydropower portal, 81 hydropower projects are currently operational, 180 are under construction, and 311 have been surveyed. Among those, 58 projects under construction are more than 20 MW (Anon., n.d.), and the majority of hydropowers are located in environmentally sensitive areas and anticipated to increase in the future (Ghimire & Phuyal, 2022).

1.1 | Hydropower dams and EIA

Hydropower dam construction projects affect watersheds, human societies, nations, and the world's atmosphere at a vast scale and therefore cannot be considered a panacea for energy needs (Huettmann et al., 2020). While the development of hydropower is commonly expected to yield positive socio-economic impacts, the transient nature of these benefits is evident (de Faria et al., 2017). Dams act as a double-edged sword for the local environment, people, and economy (Ahmed & Liquin, 2023) and repercussions for biodiversity are anticipated to be predominantly adverse (Gracey & Verones, 2016). The impacts of hydropower on aquatic and terrestrial biodiversity can be categorized in three major ways: (1) alteration of freshwater habitat (longitudinal and lateral habitat fragmentation, geomorphological alteration, hydrologic alteration of the natural flow regime), (2) Changes in water quality, and (3) land-use changes due to inundation (Gracey & Verones, 2016). With hydropower construction, freshwater biodiversity is much more threatened than in terrestrial and marine environments (Reid et al., 2019). The Freshwater Living Planet Index (FLPI) documents the decline of freshwater species by an average of 84% (range: −89% to −77%), or equivalent to 4% per year from 1970 to 2016 (WWF, 2020). Impacts on freshwater mega fauna have also received some attention (He et al., 2017). A study in South America, South and East Asia, and the Balkans region shows that hydropower development will disproportionately impact areas of high freshwater mega faunal richness (Zarfl et al., 2019). Nonetheless, small aquatic mammals have not been given comparative attention due to the lack of ecological understanding and available information on them (Brum et al., 2021). Among them, aquatic water shrews are even less known and studied to date due to lesser interest and rare sightings (Sharma et al., 2017).

Environmental Impact Assessment (EIA) is both a planning and a decision-making environmental assessment tool to systematically analyze projects to determine their potential impacts and to propose measures to mitigate the negative impacts (Biamah et al., 2013). EIA is undertaken globally to prevent, compensate, minimize, or restore the impacts of proposed development projects including hydropower (Morris & Therivel, 2001). Ideally, they are supposed to minimize adverse negative effects on biological diversity by considering the impacts of projects on wide ranges of species (Knegtering et al., 2005). Assessments that fail to capture information on biodiversity in baseline studies are incomplete (Khera & Kumar, 2010). In the Hindu Kush Himalayan region (HKH), many new dams are developed without proper assessment and analysis of the potential impacts on aquatic life (Huettmann, 2020). Dams have negative impacts on small aquatic mammals, affecting both feeding and reproductive habitats in the Amazon (Alho, 2011). Understanding the presence and distribution of any species in a given area is a fundamental first step toward biodiversity conservation (Salafsky et al., 2019). Nepal, being a signatory party to the Convention on Biological Diversity (CBD), has also established an EIA system for developmental projects with the formulation of the Environmental Protection Rules 1997 (Bhatt & Khanal, 2009).

1.2 | Water shrews and their distribution in Nepal

Shrews are one of the most diverse mammalian orders globally (Wilson & Reeder, 2005), with 376 species. Among them, 13 species belonging to four genera (*Sorex*, *Neomys*, *Chimarrogale*, and *Nectogale*) are adapted to a semi-aquatic life (Churchfield, 1998; Hutterer, 1993). Water shrews are adapted to fast-flowing streams that supply high food demands for maintaining their high energy budgets (Genoud, 1988). Of these, the Himalayan water shrew (*Chimarrogale himlayica* Gray, 1842) and elegant water shrew (*Nectogale elegans* Milne-Edwards, 1870) are found in Nepal in the fast-flowing rivers where hydropower projects are under construction or planned in the future (Baral & Shah, 2008; Jnawali et al., 2011; Thapa, 2014).

The elegant water shrew is a monotypic species of *Nectogale* found in the northern part of South Asia; central and southern China; and the north of Southeast Asia (Sharma et al., 2017; Tate, 1947). The species is also known as the Tibetan water shrew or web-footed water shrew (Corbet & Hill, 1992; Molur et al., 2005). There is very little literature on the range of the elegant water shrew, but the species has been recorded from Sikkim in the eastern Himalayas (Molur et al., 2005), as well as from Uttarakhand in the western Himalayas (Sharma et al., 2017). In Nepal, the species has been recorded from Illagaun, Kanchenjunga Conservation Area located in the eastern Himalayas (Katuwal et al., 2013). The altitudinal range of the species is 900–2270 m (Baral & Shah, 2008) and according to Jnawali et al.

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(2011) it is found in Rara National Park, Annapurna Conservation Area, Sagarmatha National Park, and Makalu Barun National Park within Nepal, though the information has not been verified from the photographic evidence. Apart from Nepal and India, the species has also been recorded from Shaanxi, Gansu, Qinghai, Sichuan, Yunnan, and Xizang Provinces of China (Smith & Xie, 2013), Bhutan (Sharma et al., 2017), and Myanmar (Molur et al., 2005) (Figure 1). The morphological description of the elegant water shrew is described by Dahal et al. (2014).

The Himalayan water shrew is also a monotypic species of the genus *Chimarrogale* and is found between the elevations of 800–1800 m in some of the Himalayan protected areas and their adjacent locations in Nepal (Rara National Park, Annapurna Conservation Area, Sagarmatha National Park, Langtang National Park, Makalu Barun National Park, Kanchenjunga Conservation Area, and in Bajura and Mugu districts (Baral & Shah, 2008; Jnawali et al., 2011). Abe (1971) stated that the external characteristics of the Himalayan water shrew *C. platycephala himalyica* include a long tail with the longest hairs on the underside, short ears, and large hind feet having a fringe of flattened stiff hairs on the lateral edge of the toes which act as webbing in water. Ellerman and Morrison-Scott (1951) and Harrison (1958) included *C. himalayica*, (Gray, 1842) as a subspecies of *C. platycephala*, Temminck, 1842. Jones and Mumford (1971) did not consider *C. platycephala*, Temminck, 1842 distinct from *C. himalayica*, Gray, 1842. Later, Hoffmann (1986) showed it to be a distinct species based on a detailed taxonomic study which was accepted by Corbet and Hill (1992) and Stone (1995). Hutterer (1993) misinterpreted *C. platycephala* Temminck, 1842 to be listed by Ellerman and Morrison-Scott (1951) as a subspecies of *C. himalayica*. Morphologically, the species is known to be bluish-gray in color, with reduced eyes and dense waterproof fur (Baral & Shah, 2008; Jnawali et al., 2011).

The Himalayan water shrew is known to feed on aquatic insect larvae and small fish (Jnawali et al., 2011). However, Abe (1971) and Lunde and Musser (2002) in Nepal and Vietnam respectively, only found masticated insects in the gut. The species is known to be distributed in China, India, Lao People's Democratic Republic, Myanmar, Nepal, Taiwan, and Vietnam (Kasbekar et al., 2023; Molur, 2016a). Nationally the species is recorded only from central and eastern Nepal (Abe, 1971; Baral & Shah, 2008; Jnawali et al., 2011) (Figure 1). The extent of occurrence of this species is more than 20,000 sq. km, but the area of occupancy is less than 500 sq. km in Nepal (Molur

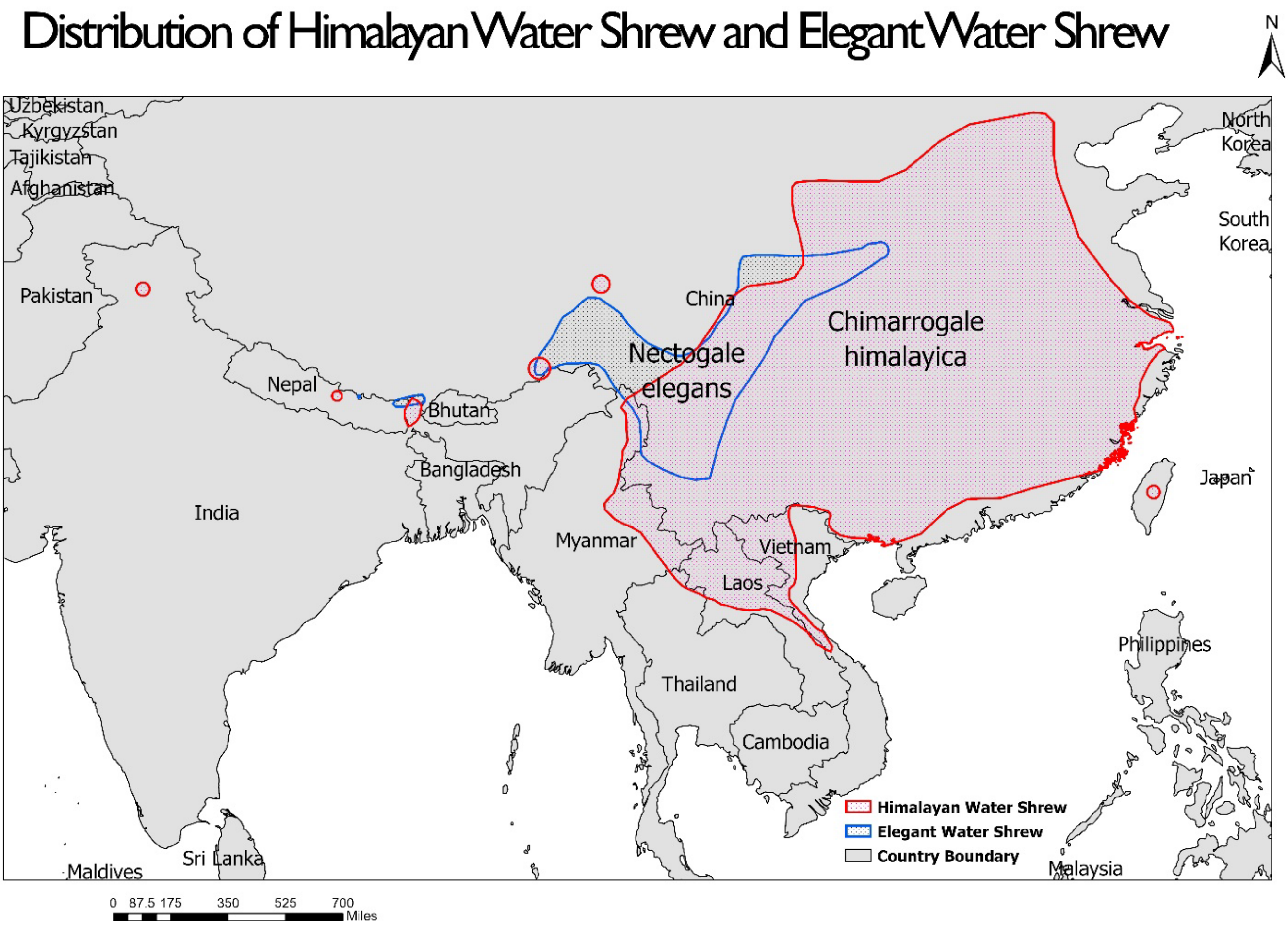

FIGURE 1 Global distribution of Elegant Water Shrew (*Nectogale elegans*) and Himalayan Water Shrew (*Chimarrogale himalayica*). *Source*: (Molur, 2016a; Molur, 2016b). [Color figure can be viewed at wileyonlinelibrary.com]

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et al., 2005). Having said that, the abundance of the Himalayan water shrew is widely believed to be lower even under favorable conditions than their terrestrial counterparts because they are highly susceptible to habitat disturbance (Arai, 1985).

1.3 | Objectives

The main objective of the paper is to determine if water shrews have been considered in the environmental assessment of hydropower projects. The secondary objective is to present the field evidence of sightings of water shrews from Nepalese rivers with hydropower potential.

In Section 2, we present an overview of our methodology. In Section 3, we present the results of a literature review on the water shrews of Nepal and a review of the EIA reports that we considered in the assessment of water shrews. We also reviewed published records of the two water shrews from Nepal and discuss key issues relevant to the conservation of these species.

2 | MATERIALS AND METHODS

2.1 | Review of EIA reports of hydropower projects

Forty four EIA reports on hydropower projects in Nepal that were available online using the keywords "Hydropower Environment Assessment Nepal" and "EIA Hydropower Nepal" were reviewed. In addition, the Ministry of Forest and Environment website was explored (between May 8 and May 16, 2021) to review reports which had been made public for consultation. During this search, only those EIA reports that were detailed and compiled from rigorous efforts were included, in comparison to the Initial Environment Examination (IEE) for infrastructure development projects (GON/MoFE, 2018). One EIA report of the Budhi Ganga Hydropower plant project was obtained from the Environment and Social Studies Department (ESSD) of Nepal Electric Authority (NEA), which is the largest hydropower project plant planned by NEA.

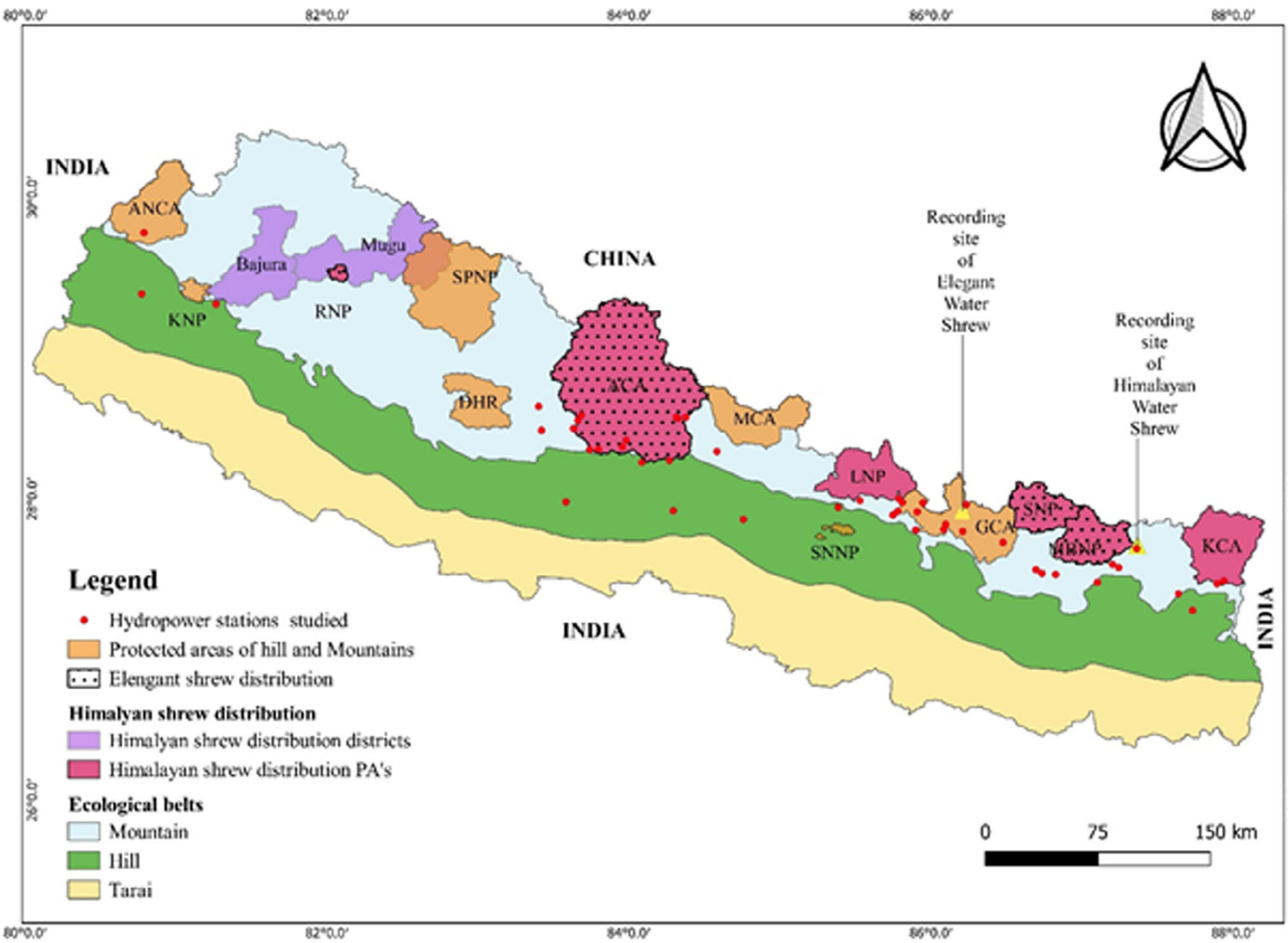

FIGURE 2 Location of hydropower projects and recording sites of Himalayan water shrew and elegant water shrew in this study. ACA, Annapurna Conservation Area; Api, Api-Nampa Conservation Area; Bajura, Bajura district; DHR, Dhorpatan Hunting Reserve; GCA, Gaurishakar Conservation Area; KCA, Kanchenjunga Conservation Area; KNP, Khaptad National Park; LNP, Langtang National Park; MBNP, Makalu Barun National Park; MCA, Manaslu Conservation Area; Mugu, Mugu district; RNP, Rara National Park; SNNP, Shivapuri Nagarajun National Park; SNP, Sagarmatha National Park; SPNP, Shey-Phoksundo National Park. [Color figure can be viewed at wileyonlinelibrary.com]

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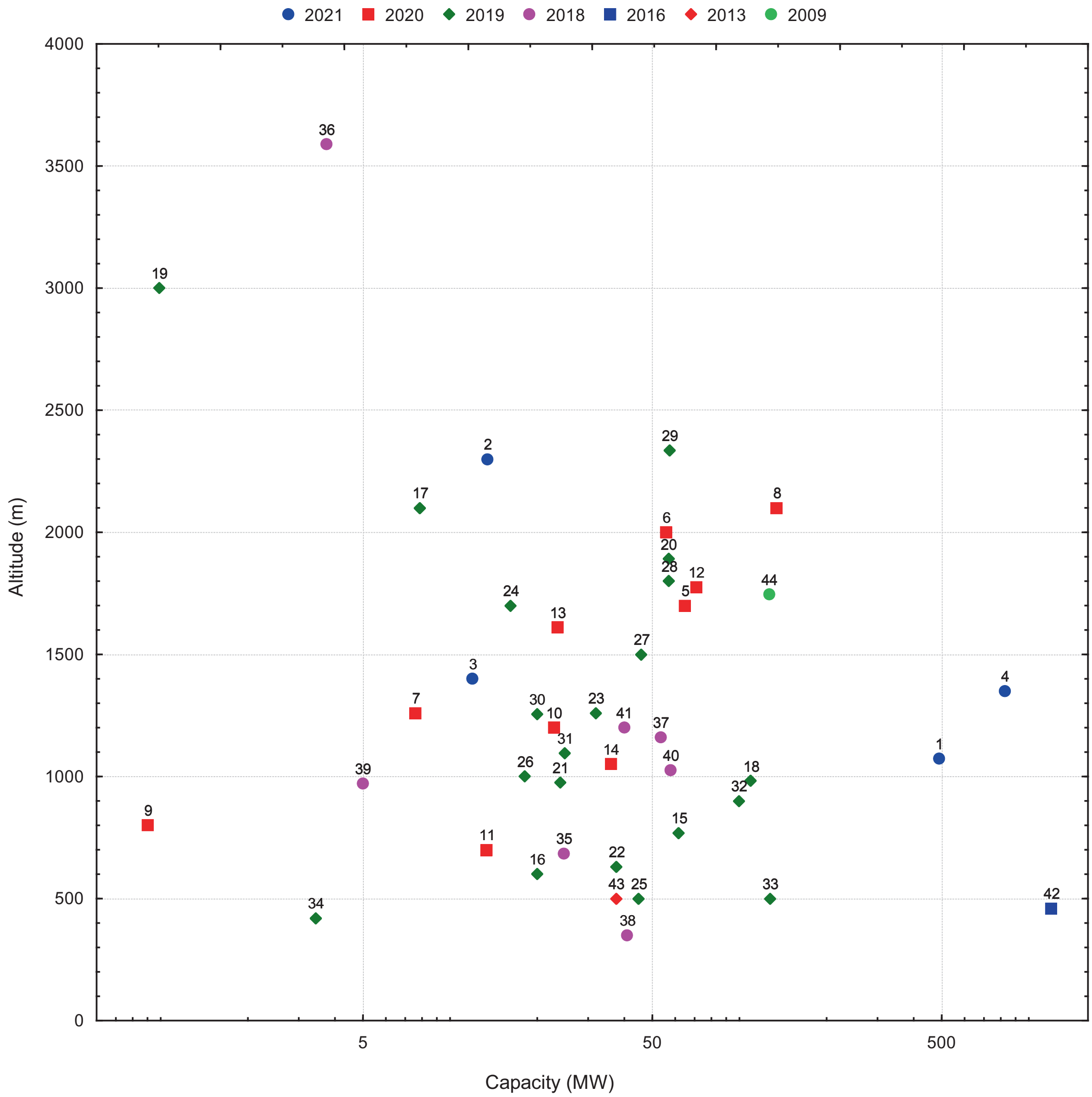

FIGURE 3 Altitude and generating capacity of hydropower projects (note the use of logarithmic scale). Color coding specifies the year of publication of the EIA report. Numbers refer to the IDs of the EIAs as given in Table A1. [Color figure can be viewed at wileyonlinelibrary.com]

The projects were located throughout the mid-hills of Nepal from the Api-Nampa Conservation Area in the west, 25 km from the Uttarakhand border to the Kanchenjunga Conservation Area in the east, within 15 km of the border with Sikkim (Figures 1,2). The majority of projects were between 500 and 2500 m in altitude, with only two small projects at 3000 m or above (Figure 2). The largest project (the Budhi Gandaki Hydroelectric Project) was 1200 MW and was located below 500 m. Only two projects had less than 1 MW generating capacity, with the majority of projects between 10 and 200 MW capacity. The majority (37) of EIA reports were published between 2018 and 2020, with 20 being published in 2019 alone. The EIA reports of 44 hydropower projects are listed in the Table A1, their spatial locations are given in Figure 2, along with, their year of publication, altitudinal range, and generating capacity in Figure 3.

2.1.1 | Determining criteria

The collected EIA reports were evaluated based on four general criteria, which include 15 review questions (Table 1). These criteria were modified from the analysis of the inclusion of biodiversity in EIA reports (Atkinson et al., 2000; Khera & Kumar, 2010) which is based on CBD and other related acts.

Based on this procedure, each EIA report was reviewed by three authors (SD, KRN, and BDB) to ensure consistency in the evaluation

TABLE 1 Criteria and questions for reviewing EIAs of hydropower projects (modified from Atkinson et al., 2000 and Khera & Kumar, 2010).

Criteria	Review questions
Awareness of aquatic mammals?	1. Had the term "aquatic mammal" been introduced in the report?
	2. Had endemic or endangered aquatic mammalian species present within the proposed project area with their respective IUCN status been included in the report?
	3. Had appropriate methodology or guidelines for assessing the impact on aquatic mammals been described?
Baseline study carried out?	4. Had the project's impact on different aquatic mammals been mentioned?
	5. Had the impact on aquatic habitat described as short-term or long-term?
	6. Were impacts on aquatic mammals included in the executive summary and table of contents in the report?
	7. The impact of Hydropower is extreme on aquatic ecosystems and is more serious than that of other aspects of the ecosystem like vegetation and terrestrial wildlife. Was project's impact on the aquatic ecosystem discussed separately in the report?
	8. Were direct and indirect impacts on aquatic mammals considered? For example, a hydropower project may affect aquatic mammals directly by killing or habitat degradation and indirectly by impacting water quality, food availability, etc.
	9. Were wildlife experts and zoologists involved in the study?
Monitoring plan included?	10. Were specific aquatic mammal monitoring plans discussed?
	11. If the answer to the above question is "Yes," does the report state that the monitoring work will be done during and beyond the course of the project?
	12. Were indicators and criteria to be used during the monitoring available in the report?
	13. Had Aquatic Animal Protection Act been mentioned and followed during the study?
Impact and mitigation?	14. Had mitigation methods for the impacts on aquatic mammals been justified?
	15. Had the impact been discussed with the locals and stakeholders and their suggestions for mitigating the impacts has been incorporated?

and as a quality control measure. Each question was answered on a three-point scale as "Not addressed," "Partially addressed," or "Fully addressed," with a numeric value.

Not addressed (0): The question has not been addressed at all.

Partially addressed (1): The question has been indirectly or unclearly addressed, for example, just the mention of the Aquatic Act but never used it to elaborate on the results of EIA.

Fully addressed (2): The question has been clearly and obviously addressed and elaboration and provide details for a specific question.

Each EIA report was systematically reviewed and particularly looked at if the EIA reports considered the citation and followed the measures Aquatic Animal Protection Act, 2017 (2060 B.S.) and if included considered as *Fully Addressed* for question no. 13. Within the report, the methods used for the collection of baseline information on aquatic mammals such as use of questionnaire survey asking the presence of aquatic mammals with the community, the number of mammals reported, and the impact and mitigation on aquatic mammals (water shrews) were analyzed.

2.2 | Statistical analysis

The tallies of reports falling into the three response categories were tested across all questions using Friedman's Two-Way ANOVA by Ranks. The null hypothesis was that there was no difference in the ratios of response categories between questions. Similarly, the tallies of questions falling into the three response categories were tested across all reports, assuming no difference in question responses across reports.

2.3 | Review of water shrews of Nepal

Opportunistic recordings of shrews were made while conducting environmental assessments for two hydropower projects in the Arun River in Sankhuwasabha district and the Tamakoshi River in Dolakha district, both in the Eastern Himalayas of Nepal. Photographic evidence of the species was recorded with a Nikkon D90 DSLR camera. Several local women were asked about the occurrence of the Himalayan Water Shrew in the area after showing them photographs.

3 | RESULTS

3.1 | Performance of EIA reports against the questions

The collated assessments of how well the 15 questions were addressed in the 44 EIA reports are given in Table A2. This data can be summarized in each dimension: (i) How well were the individual questions addressed across all reports? and (ii) How well did individual reports address the whole suite of questions?

3.1.1 | Performance of individual questions

There were a total of 15 questions for each EIA report reviewed, hence for the 44 EIA reports results of a total of 660 questions were

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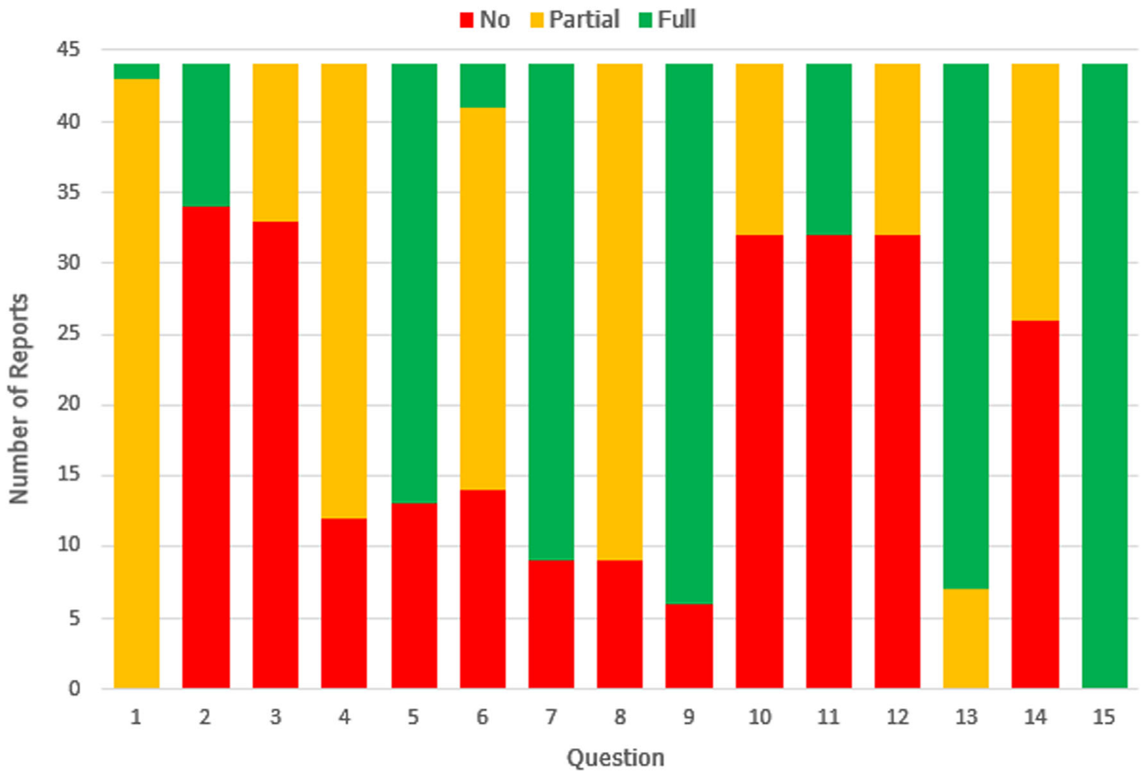

FIGURE 4 Tallies of the assessment scores for the 15 questions across all 44 EIA reports. [Color figure can be viewed at wileyonlinelibrary.com]

extracted and among them 252 questions *Not Answered*, 197 were *Partially Addressed*, and 211 were *Fully Addressed* (Table A2). The summary obtained from Table A2 indicates a highly significant difference in the degree to which the different questions were adequately addressed Figure 4. This was confirmed by Friedman's Two-Way ANOVA by Ranks ($\chi^2_{r,(14)} = 352$, $p \approx 0$). The questions fell into three groupings:

1. Five questions (5, 7, 9, 13, and 15) from criteria 2, 3, and 4 were fully covered in significant numbers of EIA reports. In particular, every report fully covered Question 15 (locals and stakeholders were involved throughout). Question 13 (Aquatic Animal Protection Act [2017] 1960 was followed) was fully covered in 37 of the reports and the remaining seven had partial coverage.
2. In contrast, six questions (2, 3, 10, 11, 12, and 14) had insufficient coverage. Approximately 75% of reports did not include proper methodology or guidelines to assess impacts on aquatic mammals, nor did they discuss specific terms such as endangered or endemic mammals or the aquatic mammalian species present in the area. These discussions could have been made using the IUCN database, but no such efforts were made during the preparation of the EIA reports. Consequently, most of the EIA reports did not include follow-up indicators or criteria for monitoring aquatic mammalian species, leading to the removal of any necessary mitigation plans for them.
3. Finally, there was an intermediate grouping of four questions (1, 4, 6, and 8) that were only partially covered in at least 66% of the reports. The term "aquatic mammals" was not mentioned in almost all report except one and therefore, the impact on these species was not included either in the report or in a summarized form. Almost all reports did not cover the direct and indirect impacts on aquatic mammals, such as direct killings or habitat degradation.

3.2 | Performance of individual EIA reports

There was also a highly significant difference in the degree to which different EIA reports addressed the 15 questions (Figure 5 and Table A2), confirmed by Friedman's Two-Way ANOVA by Ranks ($\chi^2_{r,(43)} = 171$, $p \approx 0$). Only two reports (#30; Sagu Khola Hydroelectric Project and #39; Tandi Khola Hydropower Project) addressed all questions fully or partially. A further six reports (2, 3, 4, 22, 33, and 36) only omitted one or two questions, so can be considered good examples. The worst performing report was #8 (Manang Marsyangdi Hydroelectric Project) which only fully addressed two questions and completely failed to address 12 and only considered fish species as aquatic life with no record of any fish species in the report. Six further reports (11, 21, 24, 29, 32, and 43) failed to address 10 or 11 questions, out of the 15 questions, representing at least a 67% omission rate.

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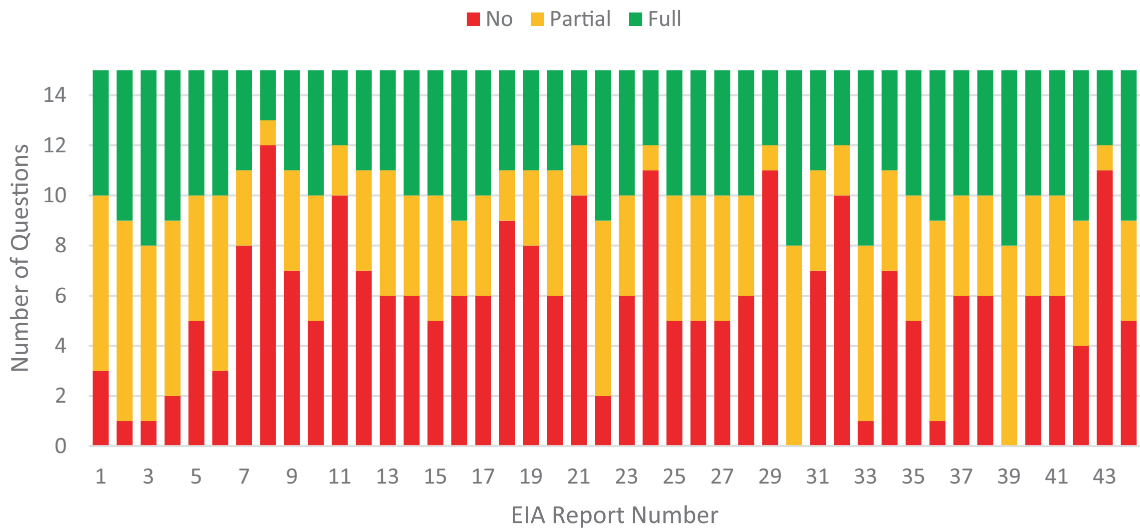

FIGURE 5 Tallies of the assessment scores for the 44 EIA reports across all 15 questions. [Color figure can be viewed at wileyonlinelibrary.com]

FIGURE 6 Elegant Water Shrew recorded in the waters of Tamakoshi River at Lamabagar (photo by Sagar Dahal). [Color figure can be viewed at wileyonlinelibrary.com]

3.3 | Recording of water shrews

Two individual aquatic mammals were recorded in the rivers where two large hydropower constructions are taking place (Figure 2). A dead specimen of the elegant water shrew was found on 1 November 2010 in the Tamakoshi River rapids in the Dolakha district at Lamabagar (1945 m asl; N 27° 54.209" E 86° 12.237"). The specimen was found by the two first authors, who noticed it on a rock at the bank of the river (Figure 6). The specimen was trapped in a fishing gear left throughout the night by an unknown fisherman engaging in artisanal fishing (Dahal et al., 2014).

The first author (S.D.) also recorded a swimming Himalayan Water Shrew in the Barun River (Figure 7). This specimen was observed foraging in the water at 08:23 h on 16 November 2018, just north of the Barun-Arun River confluence in the Arun Valley. The shrew went underwater for approximately 20 s before resurfacing and was observed for 20 min, diving in and out of the water. Local resident women reported frequent sightings of shrews in the river and saw them basking in the sun.

FIGURE 7 Himalayan Water Shrew recorded in the waters of the Barun River (photo by Sagar Dahal). [Color figure can be viewed at wileyonlinelibrary.com]

The listing of mammals in hydropower project reports lacks consistency and appears to be based on team interest rather than a true assessment of threat, with errors in distributional records of mammals found. For example, high Himalayan project sites were found to list lowland species, such as tiger (*Panthera tigris*) (Report No 39), fishing

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cat (*Prionailurus viverrinus*) (Report No 15), and striped hyena (*Hyena hyena*) (Report No 39), without any evidence. Biodiversity assessors and reviewers appeared to consider only terrestrial mammals and fish among aquatic species, with little prioritization given to other aquatic wildlife during assessments.

4 | DISCUSSION

4.1 | Aquatic shrews in EIA reports

Although EIA guidelines in Nepal prioritize the assessment of aquatic biodiversity, a review of 44 EIA reports showed that water shrews and other aquatic and semi-aquatic vertebrates, apart from fish, were not considered in hydropower project reports. Assessors have given low priorities to these taxa, and the reports' references to "aquatic life," "aquatic fauna," and "aquatic ecosystem" do not specify whether they include "aquatic mammals." While the EIA reports collected data on mammalian species using direct and indirect methods, assessments of the aquatic ecosystems mainly focused on fish diversity, with some mention of aquatic invertebrates and no effects on aquatic mammals. EIA reports should have separately discussed the severe impact of hydropower on aquatic ecosystems. In this study, most reports described the different effects on aquatic ecosystems separately, except for one report.

The Aquatic Animal Protection Act 2017 (2060 B.S.) clearly mentions water as a lake, rill, stream, river, canal, pond, ditch, reservoir, artificial reservoir, wetland, and crazed installed for aquaculture and paddy field where aquaculture is done and "aquatic animals" means any animal living in water. Animals foraging under water such as otters are considered aquatic mammals (Reidenberg, 2007) and hence water shrews can be categorized with the same argument. Moreover, in EIA reports, there is a tendency to emphasize specific aspects of biodiversity, particularly focusing on higher groups of animals or large animals or endangered species, while non-threatened or non-protected species are often overlooked or not adequately addressed (Atkinson et al., 2000; Khera & Kumar, 2010).

Hydropower projects can have both direct and indirect impacts on aquatic mammals, including habitat degradation and mortality, as well as effects on water quality and food availability. However, many impact assessment reports did not include input from wildlife experts or zoologists. While some reports included a monitoring plan for aquatic mammals, there is often a lack of information on the specific indicators and parameters used in such monitoring. While specific reviews targeting particular species were not conducted, various authors assessing EIA reports for inclusion of biodiversity assessments have consistently observed similar findings. Khera and Kumar (2010) of EIA reports in India highlighted that while monitoring was proposed as a statutory requirement, there was a lack of clarity regarding the implementation of monitoring through specific criteria and indicators. A review of the mining Environmental Impact Statement in Sao Paulo, Brazil, also highlighted insufficient mitigation measures and recommended the establishment of more comprehensive scoping procedures prior to the EIA (Mandai et al., 2021). Moreover, according to Bigard et al. (2017) in cases where mitigation measures are integrated, they tend to concentrate on reducing impacts rather than prioritizing avoidance.

Within the high Himalayas of Nepal, there are 10 protected areas but the biodiversity profiles of these protected areas, particularly on small mammals, are poorly documented or missing altogether. In general, many mammalian faunas in Nepal are considered at risk (Heinen, 1995; Heinen et al., 2019; Jnawali et al., 2011). Reports that mentioned the presence of these species mostly relied on literature reviews of either Baral and Shah (2008) or Jnawali et al. (2011), both of which are mostly based on expert opinion and review rather than empirical field-based evidence. However, the existence of these species in the trans-Himalayan region, from Sikkim to Uttarakhand, has been recorded (Dahal et al., 2014; Katuwal et al., 2013; Molur et al., 2005; Sharma et al., 2017) implying their likely presence throughout the Himalayan regions of Nepal.

4.2 | EIA reports of Nepal ignore mammal's species

The overall quality of EIA reports was poor. With regard to faunal diversity, there were frequent errors of mismatching species groups indicating the involvement of non-experts during the field assessment.

The inadequate consideration of water shrews in EIA reports likely results from poor knowledge among the scientific community and little attempt to collect baseline information on the distribution of these species. Assessment methods that prioritized only terrestrial mammals imply that mammals were considered only to be terrestrial. This issue is not unique to Nepal as even the Environmental Impact Assessment Ordinance of Hong Kong Cap.499 considers mammals to be terrestrial in their guidance note on the methodologies for terrestrial and freshwater ecological baseline surveys (Government of Hongkong, 2010). Furthermore, the Hydropower Environmental Impact Assessment Manual 2018 states to consider the impact on the riparian habitat of river otters but not on the shrews (Ministry of Forests and Environment, 2018). However, Figure 5 shows that EIA reports of Super Kabeli A Hydropower Project (#2), Super Kabeli Khola Hydro Power Project (#3), Uttarganga Storage Hydroelectric Project (#4), Isuwa Cascade Hydropower Project (#22), Tamor-Mewa Hydroelectric Project (#33), and Mathillo Bhurundi Khola Hydropower Project (#36) have only a few questions with the score of "No" suggesting better EIA reports based on our category.

4.3 | Global IUCN status

The first step in any conservation effort is to assess the presence of species. However, since the first assessment of elegant water shrews and Himalayan water shrews 16 years ago (Molur et al., 2005) there have been only two records of elegant water shrews (Dahal et al., 2014; Sharma et al., 2017) and two records of Himalayan water

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shrews (Kasbekar et al., 2023; Katuwal et al., 2013) from the Indian subcontinent. Despite being virtually unknown both species were globally categorized as Least Concern in the IUCN Red List (Molur, 2016a, 2016b). However, at the national level, the elegant water shrew is listed as Data Deficient and the Himalayan water shrew as Endangered (Jnawali et al., 2011). Over the past two decades, the Himalayan region across South Asia has experienced the construction of several large hydropower projects, but the impacts of these projects on aquatic biodiversity are poorly understood due to significant gaps in distributional records of many taxa across the region resulting from a lack of targeted studies.

The IUCN assessment recognizes habitat loss as a major threat and including hydropower projects explicitly as a driver of habitat destruction in the IUCN assessment could increase the likelihood of including these types of projects in EIA reports. Species that are threatened with extinction at the local, regional, or national level, often do not receive adequate scientific or public attention (Ceballos & Brown, 1995) and it can be challenging to protect that which is not well known by the researcher or the general public (Brito, 2004).

4.4 | Hydropower dams are a potential threats

The current distribution and abundance of the elegant water shrew and Himalayan water shrew are unknown (Molur, 2016b). In addition to this, both species are threatened by harvesting for traditional medicine, natural calamities such as landslides, and human activities such as selective logging, poisoning, and pest control (Katuwal et al., 2013; Molur et al., 2005). However, hydropower has not been mentioned as a potential threat to these water shrews in the literature even though the Himalayan water shrew is considered to have a restricted habitat (Lunde & Musser, 2002). Water shrews are predacious in nature (Sorenson, 1962) and show differences in the trophic niches between water shrews species as recorded in France (Biffi et al., 2017). This feeding behavior possibly regulates the small water animals as they predominately feed on aquatic insects and other small animals. EIAs if done in better ways can help in producing the baseline and highlight the impacts of dams on these little-known species of the Himalayas. EIA reports are formed on the basis of government regulation and have a considerable impact on the development policy document and lack of consideration for Nationally Endangered species identified by conservation agencies of the government in EIA reports can be stated as the failure to recognize the policy prepared by the government by inter agencies.

Hydropower dams in the Himalayas pose a potential threat to populations of water shrews as various other aquatic organisms have been identified to be affected by anthropogenic factors such as dams, mining, and hunting in amazon (Brum et al., 2021). With the current rate of loss of freshwater biodiversity, there is a risk of losing these small mammals without even knowing it (Richter et al., 1997), and many species facing the risk of global extinction are not recognized as such due to insufficient information (Ceballos & Brown, 1995). Aquatic small mammals, such as water shrews, are both poorly studied in Nepal and are also given low priority during the planning and development of infrastructure projects and by conservationists, especially when compared to larger mammals and birds (Heinen, 1990; Heinen & Dahal, 2023) making the possibility of their silent disappearance highly susceptible.

5 | CONCLUSIONS

EIA is an integral part of the infrastructure project that involves many stakeholders and huge resources. Generally, 10% of the infrastructure budget is allocated for the conduction of the EIA and requires lengthy time, resources, and work on execution. This is an opportunity to collect baseline information to generate knowledge in biodiversity in collaboration with various experts in different fields as well as collaborate with academia and the outcomes should be the basis of future studies. However, from this study we can conclude that EIA reports prepared for the hydropower dams in Nepal are incomplete, cursory in nature, and often vaguely mention the impacts on ecosystems and habitats without considering the species that inhabit them. Moreover, experts conducting EIA reports often do not even mention the name of aquatic mammals let alone mentions water shrew species. The conservation priority for these aquatic mammals should be based on their national red list categories (one Data Deficient and other Endangered) rather than the global red list category (Least Concern). The biological assessment standards of EIAs in Nepal need to be improved, making the materials and method section more comprehensive and inclusive for different species that may be present in the study sites. There should be a national standard and government policies should be implemented to ensure strict compliance. With better assessment results, plans can be formulated for the survival of these species during and after the construction of hydropower plants. Otherwise, we risk losing these animals forever from the Himalayas of Nepal. Therefore, we recommend rigorous and science-based field studies conducted by the subject experts to explore remnant fauna wherever hydropower dams are proposed.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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APPENDIX A

TABLE A1 List of reviewed EIA reports with the year of publication, generating capacity, and altitudinal range.

ID	Name	Year of publication	Capacity (MW)	Altitude (m)	
				Lower	Upper
1	Arun-4 Hydropower Project	2021	490.2	850	1080
2	Super Kabeli A Hydropower Project	2021	13.5	1750	2252
3	Super Kabeli Khola Hydroelectric Project	2021	12.0	1444	1703
4	Uttarganga Storage Hydroelectric Project	2021	828.0	2400	3700
5	Dudh Khola Jalvidyut Aayojana	2020	65.0	1770	2385
6	Jum Khola Hydropower Project	2020	56.0	2007	2300
7	Jurimba Khola Small Hydropower Project	2020	7.6	1260	2150
8	Manang Marsyangdi Hydroelectric Project	2020	135.0	2100	4800
9	Mathillo Sitkhola Sana Hydropower Project	2020	0.9	800	2100
10	Mid Hongu Khola B Hydropower Project	2020	22.9	1200	1560
11	Midim 1 Hydropower Project	2020	13.4	735	1145
12	Nilgiri Khola 2 Cascade Hydropower Project	2020	71.0	1575	2385
13	Super Melamchi Hydropower Project	2020	23.6	1609	1952
14	Upper Balephi A Hydroelectric Project	2020	36.0	1054	1253
15	Bhote Koshi-5 Hydroelectric Project	2019	62.0	769	920
16	Budhi Ganga Hydropower Project	2019	20.0	600	800
17	Chino Khola Hydropower Project	2019	7.9	2142	3044
18	Dudh Koshi-5 Hydropower Project	2019	110.0	1102	3079
19	Ghatte Khola Small Hydropower Project	2019	1.0	500	2000
20	Himchuli Dordi Hydropower Project	2019	57.0	1890	2700
21	Inkhu Khola Small Hydropower Project	2019	21.4	975	1233
22	Isuwa Cascade Hydropower Project	2019	37.7	630	1078
23	Karuwa Seti Hydroelectric Project	2019	32.0	1260	1515
24	Liping Khola Hydropower Project	2019	16.2	1700	2570
25	Lower Apsuwa Hydropower Project	2019	45.0	558	1190
26	Mathillo Modi Hydroelectric Project	2019	18.2	1027	1160
27	Mathilo Balephi Hydropower Project	2019	46.0	1500	1900
28	Myagdi Khola Hydropower Project	2019	57.3	1850	2420
29	Nupche Likhu Hydropower Project	2019	57.5	2336	3338
30	Sagu Khola Hydroelectric Project	2019	20.0	1255	1630
31	Seti Nadi Hydroelectric Project	2019	25.0	1095	1280
32	Tamakoshi V Hydroelectric Project	2019	99.8	975	1158
33	Tamor-Mewa Hydroelectric Project	2019	128.0	500	750
34	Tinau Khola Small Hydropower Project	2019	3.4	420	1892
35	Bajra Madi Hydropower Project	2018	24.8	685	806
36	Mathillo Bhurundi Khola Hydropower Project	2018	3.8	1218	1359
37	Middle Kali Gandaki Hydroelectric Project	2018	53.5	1100	1400
38	Sankhuwa Khola Hydropower Project	2018	41.0	354	670
39	Tandi Khola Hydropower Project	2018	5.0	973	1155
40	Tiplayang Kali Gandaki Hydropower Project	2018	58.0	1024	1160
41	Upper Chameliya Hydropower Project	2018	40.0	1050	1265
42	Budhi Gandaki Hydroelectric Project	2016	1200.0	300	600
43	Kabeli-A Hydroelectric Project	2013	37.6	500	2000
44	Upper Seti Storage Hydroelectric Project	2009	127.0	300	450

Note: EIA reports highlighted in gray are approved.

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TABLE A2 Answers to the reviewed EIA with predetermined questions.

	Question															Addressed?		
EIA ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	No	Partial	Full
1	1	2	0	1	0	1	2	1	0	1	2	1	2	1	2	3	7	5
2	1	0	1	1	2	1	2	1	2	1	2	1	2	1	2	1	8	6
3	1	0	1	1	2	2	2	1	2	1	2	1	2	1	2	1	7	7
4	1	0	0	1	2	1	2	1	2	1	2	1	2	1	2	2	7	6
5	1	2	0	1	2	1	2	1	0	0	0	0	2	1	2	5	5	5
6	1	0	0	1	2	1	0	1	2	1	2	1	2	1	2	3	7	5
7	1	0	1	0	0	0	2	1	2	0	0	0	2	0	2	8	3	4
8	2	0	0	0	0	0	0	0	0	0	0	0	1	0	2	12	1	2
9	1	0	0	1	2	0	2	1	2	0	0	0	1	0	2	7	4	4
10	1	0	1	1	2	1	2	1	2	0	0	0	2	0	2	5	5	5
11	1	0	1	0	0	0	0	0	2	0	0	0	2	0	2	10	2	3
12	1	0	0	1	2	1	0	1	2	0	0	0	2	0	2	7	4	4
13	1	0	0	1	2	1	2	1	2	0	0	0	1	0	2	6	5	4
14	1	0	0	1	2	2	2	1	2	0	0	0	1	0	2	6	4	5
15	1	0	0	0	0	0	2	1	2	1	2	1	2	1	2	5	5	5
16	1	0	0	1	2	2	2	1	2	0	0	0	2	0	2	6	3	6
17	1	0	0	1	2	1	2	1	2	0	0	0	2	0	2	6	4	5
18	1	0	0	0	0	0	2	0	2	0	0	0	2	1	2	9	2	4
19	1	0	1	0	0	0	2	1	2	0	0	0	2	0	2	8	3	4
20	1	0	0	1	2	1	2	1	0	0	0	0	2	1	2	6	5	4
21	1	0	0	0	0	0	2	0	0	0	0	0	2	1	2	10	2	3
22	1	0	0	1	2	1	2	1	2	1	2	1	2	1	2	2	7	6
23	1	0	0	1	2	1	2	1	2	0	0	0	2	0	2	6	4	5
24	1	0	0	0	0	0	0	0	2	0	0	0	2	0	2	11	1	3
25	1	2	0	0	0	0	0	1	2	1	2	1	2	1	2	5	5	5
26	1	2	1	1	2	0	2	1	2	0	0	0	1	0	2	5	5	5
27	1	0	1	1	2	1	2	1	2	0	0	0	2	0	2	5	5	5
28	1	0	0	1	2	1	2	1	2	0	0	0	2	0	2	6	4	5
29	1	0	0	0	0	0	0	0	2	0	0	0	2	0	2	11	1	3
30	1	2	1	1	2	1	2	1	2	1	2	1	2	1	2	0	8	7
31	1	0	0	1	2	1	2	0	2	0	0	0	1	0	2	7	4	4
32	1	2	0	0	0	0	0	0	2	0	0	0	1	0	2	10	2	3
33	1	2	0	1	2	1	2	1	2	1	2	1	2	1	2	1	7	7
34	1	0	0	1	2	1	2	1	0	0	0	0	2	0	2	7	4	4
35	1	0	0	1	2	1	2	1	2	0	0	0	2	1	2	5	5	5
36	1	0	1	1	2	1	2	1	2	1	2	1	2	1	2	1	8	6
37	1	0	0	1	2	1	2	1	2	0	0	0	2	0	2	6	4	5
38	1	0	0	1	2	1	2	1	2	0	0	0	2	0	2	6	4	5
39	1	2	1	1	2	1	2	1	2	1	2	1	2	1	2	0	8	7
40	1	0	0	1	2	1	2	1	2	0	0	0	2	0	2	6	4	5
41	1	0	0	1	2	1	2	1	2	0	0	0	2	0	2	6	4	5
42	1	2	0	1	2	1	2	1	2	0	0	0	2	1	2	4	5	6
43	1	0	0	0	0	0	0	0	2	0	0	0	2	0	2	11	1	3
44	1	2	0	1	2	1	2	1	2	0	0	0	2	0	2	5	4	6

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TABLE A2 (Continued)

	EIA ID	Question 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Addressed? No	Partial	Full
Question addressed?	No	0	34	33	12	13	14	9	9	6	32	32	32	0	26	0	252		
	Partial	43	0	11	32	0	27	0	35	0	12	0	12	7	18	0		197	
	Full	1	10	0	0	31	3	35	0	38	0	12	0	37	0	44			211

Note: 0 = no, 1 = partial, and 2 = full.

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