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The Efficacy of Biodiversity Mitigation Plans and Stakeholder Engagement in the North-Western Himalayan Region of India

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Abstract:

This study explores the factors influencing the effectiveness of Biodiversity Mitigation Plans (BMPs) in the north-western Himalayan region of India. Using a case study approach, field surveys, stratified systematic sampling, random transect walks, and a bilingual questionnaire (English–Hindi) were conducted across the Project Influence Area (PIA). The questionnaire, comprising 24 translated questions across seven themes, was distributed to 50 respondents, with additional structured face-to-face interviews (n = 3) providing deeper insight into local perspectives. Findings highlight a clear gap between regulatory frameworks and their implementation on the ground. In particular, the involvement of local Consultancies emerged as a critical factor in BMP effectiveness. These entities operate at the intersection of national and international agencies, environmental policy, and local communities, mediating knowledge, education, and practice. The paper offers a theoretical framework positioning Consultancies as key agents in translating policy into action. It underscores the need for context-sensitive education, effective communication, and stakeholder collaboration to improve the implementation and impact of BMPs. Given the ecological sensitivity of the Himalayan region to threats such as climate change, deforestation, and infrastructure development, continued biodiversity research is essential to inform future mitigation strategies.

Introduction

Research was carried out to evaluate the mediating factors which influence the efficacy of Biodiversity Mitigation Plans (BMPs) and stakeholder engagement in the Himalayan region of India. To do that, a relationship framework is proposed which suggests a connection and relationship between National and International Agencies who devise BMPs, Stakeholders who engage at ground level, and the Environment of flora and fauna (Figure 1). Figure 1 is a diagrammatic framework illustrating an interconnecting relationship between three elements: National and International Agencies, Stakeholders, and the Environment. This research will investigate this relationship and build on this relationship framework by using the literature review and results data to validate the framework.

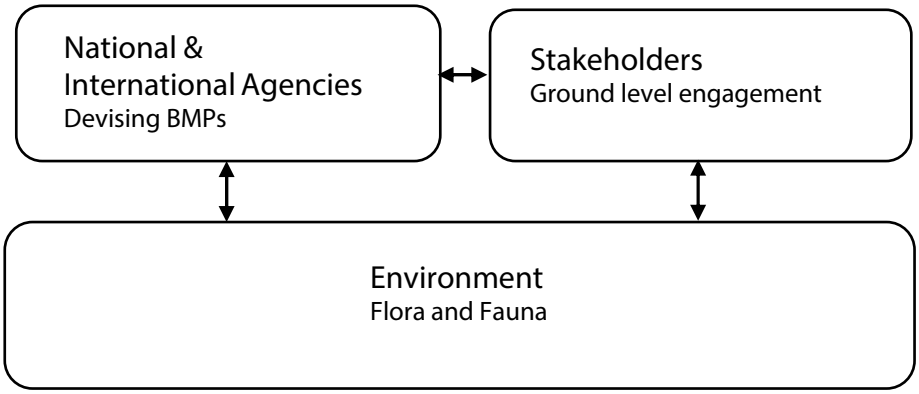

Figure 1. Relationship Framework illustrating interconnecting relationship between elements

The framework reflects the layered structure of biodiversity governance in India. National and International Agencies include bodies such as the Ministry of Environment, Forest and Climate Change (MoEFCC), the Convention on Biological Diversity (CBD), and other multilateral environmental organisations. Local stakeholders encompass a diverse set of actors including State Biodiversity Boards, Forest Officers, Biodiversity Management Committees (BMCs), non-governmental organisations (NGOs), and local communities directly affected by or involved in biodiversity planning and implementation.

The Indian National Report (NR6) was submitted to CBD in 2018, highlighting the progress in implementation of the National Biodiversity Targets (NBTs) (MoEFCC, 2019). However, the study provides the evidence that the north-western Himalayan region has been overlooked and hence failed to reduce biodiversity degradation and increased the exploitation of forest produce and other natural resources. This study concurs with Boruah (2021); this study in eastern Himalayas also revealed that there is a lack of collaboration between the Forest Officers, State Biodiversity Board and Biodiversity Management Committees due to intangible constraints. The studies in eastern and western Himalayas have similar results, noting a national level attention towards Biodiversity conservation.

This study also aims to contribute to educational development by highlighting the knowledge gaps among various stakeholders, including government officials, local communities, and NGOs, regarding biodiversity policies and conservation practices. The research process integrates elements of environmental education by engaging stakeholders in discussions around the ecological consequences of infrastructure development and by encouraging reflection on current practices. This case study provides a valuable opportunity for experiential and community-based learning, particularly by promoting awareness of Biodiversity Conservation and Action Plans (BCAP) among local populations.

This case study research investigates this relationship framework to evaluate the relationship between each element within the framework. This research was carried out to enhance the efficacy of BMPs which impact activities such as deforestation, infrastructure development and pollution.

Study Background

Of the 47,000 plant species found in India, 3295 species (7.32%) are reported in the Himalayas, and out of 91,000 species of animals, the study area houses 5721 species, amounting to about 6.28% of Indian fauna, which shows the biodiversity richness in about 1.7% geographical area of the country (Kumar et al., 2015). The official website of the Himachal Pradesh Forest Department delineates the geographical area of north-western Himalayas as 55,673 sq. km, which is approximately 1.69% of the total Indian geographical area (HPFD, 2021). The Protected Area network around the Himalayas has five National Parks, 26 Wildlife Sanctuaries and three Conservation Reserves, which cover 15.10% of geographical area of the State (MoEFCC, 2019).

Research objectives and framework

The Indian legal framework comprises of numerous regulations, notifications, rules and acts in favour of biodiversity conservation. The most significant of these in the context of infrastructure development include

the Environmental Impact Assessment (EIA) Notification of 2006 (and its amendments), Forest (Conservation) Act, 1980, Coastal Regulation Zone (CRZ) Notification 2011, and the Wildlife (Protection) Act, 1972 (and its amendments) (Wildlife Institute of India, 2016). The critical administrative arrangements of the legal framework are based on EIA reports and decision-making, the procedure for granting forest clearances, and the coordination of different regulatory requirements. India participated in the decisions taken at the United Nations Conference on Environment and Development held at the Rio de Janeiro in June 1992; the states were advised to provide sufficient access to administrative and judicial procedures (United Nations Environment Programme, 2005).

The preliminary studies and consultations held with various stakeholders indicated that the impact on Forestry and Wildlife components of these regulations is the most important concern for stakeholders when implementing projects. Moon and Cocklin (2011) note the impact of stakeholder motivations with regards to conservation are a common barrier to participation in biodiversity programmes. The draft biodiversity impact assessment and mitigation plans' objectives are to establish a decision-support tool to help biodiversity-inclusive linear road development planning and implementation. The overall aim is to assess the status and trends of biodiversity along the Project Influence Area (PIA); with that aim, a rapid assessment along the project road to gauge the potential resources derived from biodiversity in the area was carried out.

Literature Review

As noted by the Wildlife Institute of India (WII, 2016), the forest cover in India is estimated to be 21.34% of the total geographical area of the country, out of which the Protected Area (PA) network covers 4.89% presently including 536 wildlife sanctuaries, 103 national parks, 67 conservation reserves, and 26 community reserves.

The International Union for Conservation of Nature appraises at least 37,400 species threatened with extinction out of 28% assessed species. Nguyen et al. (2021) mentions a study based on satellite data stating that the planet has lost 1.3 million square kilometres of forests during the period 1990–2016, compared to a loss of trees in approximately 30 football fields every single minute. Additionally, the Global Forest Resources Assessment 2020 (FAO) reported that the total forest area in the world is 31%, which is declining at an alarming rate (Cepal, 2021). The Central Pollution Control Board (CPCB) assessed that the north Indian region, along the foothills of Himalayas has highly polluted industrial clusters that do not meet national or international limitations on the level of pollution in air, water or soil emissions (Chatterji, 2021).

Threats to Biodiversity

Linear infrastructures act as barriers for movement, dispersal, and genetic exchange for some species due to habitat dissection, mortality due to animal-vehicle-collisions (AVC), avoidance behaviour due to traffic noise volume and road surface characteristics (Nayak et al., 2020). The Himalayan mountainous area occupies approximately 70% fragmented habitat, and consequently, the biological wildlife habitat is divided (Seo et al., 2021). This leads to changes in species distribution, habitat resource selection, and population density (Neumann et al., 2012). Biodiversity experts estimate that the existing attempts to conserve biodiversity are inadequate and changes in policies and programmes are called for (Dhar et al., 1999). Habitat fragmentation is a phenomenon which can be potentially termed as 'natural' but is caused by unnatural human activities and is considered a primary issue of concern in conservation biology; the magnitude of distributional shifts is now estimated to be 2.5 times greater than expected (Taheri, 2021).

Another threat to Indian biodiversity conservation is the international wildlife trade, however, Indian legislation protects the unlawful imports and exports of floral and faunal products (Shahbaz et al., 2021). The policies are compliant with the Convention on International Trade in Endangered Species of Wild Flora & Fauna (CITES), governing import and export of permitted species of Wildlife and their products. The policy is designed after consultation with the Management Authority for CITES in India which is enforced through the Customs Act, 1962. Furthermore, import/export of other derivatives of wildlife is restricted (Munoz, 2016). Arguably, there are huge disparities between the approaches and resources for the enforcement of EXIM policies and wildlife trade regulation on an international level. Misra (2014) claims that international patrolling differs in developed and developing countries; the infrastructure, training, and equipment essential to obtain

the minimum standards for enforcement are often lacking. The legal trade alone is estimated to be worth over 320 billion USD per annum as billions of plants, animals, and products are traded across international borders. (TRAFFIC, 2009).

Environment researchers point out that India has potentially compromised implementation on environmental protection goals, in order to pursue economic goals (Shahbaz et al., 2021). Evidently, India is facing challenges in achieving SDG within the current economic policies (Taghizadeh et al., 2019). However, a more focused approach targeting selected regions based on their ability to indicate fundamental changes in ecological conditions according to Himalayan landscape-scale changes, including infrastructure development impacts, should be critical pointers to conservation practices (Tallis et al., 2015). While the emissions from urban and rural regions compound one another, it is essential to harmonise inter-state responses to regulate long-term sustainable and multi-sectoral approaches. (Chatterji, 2021).

Research gap analysis

This research investigates the factors that influence the effectiveness of Biodiversity Mitigation Plan (BMP) in the Himalayan region; this includes the impact of road construction on endangered species, flora and fauna. Trombulak and Frissel (2000) define the effects of roads on terrestrial and aquatic ecosystems in seven broad ways: (1) increased death or population decline from road construction, (2) increased human animal conflict resulting in faunal mortality, (3) animal behaviour adaptation, (4) modification of the physical environment, (5) variation in the chemical environment, (6) increase in exotic species, and (7) increased modification due to habitats usage by humans.

Thus, from the literature and preliminary studies, a refined conceptual framework can be established which builds on figure 1 noting the influence of Stakeholders (Gullino et al., 2018 refers). This uses a cause-and-effect relationship between the National and International Agencies and the Environment; the literature shows that National and International Agencies devise BMPs, and those BMPs have an impact on the environment. However, level of engagement by the stakeholders, so the ground level engagement dictates how effective those BMPs are, aligning with Moon and Cocklin (2011). Hence the National and International Agencies are the independent variable and Environment is the dependent variable. The Stakeholders are the mediator variable in this framework as the Environment is affected by the National and International Agencies with input from the Stakeholders (Figure 2 refers).

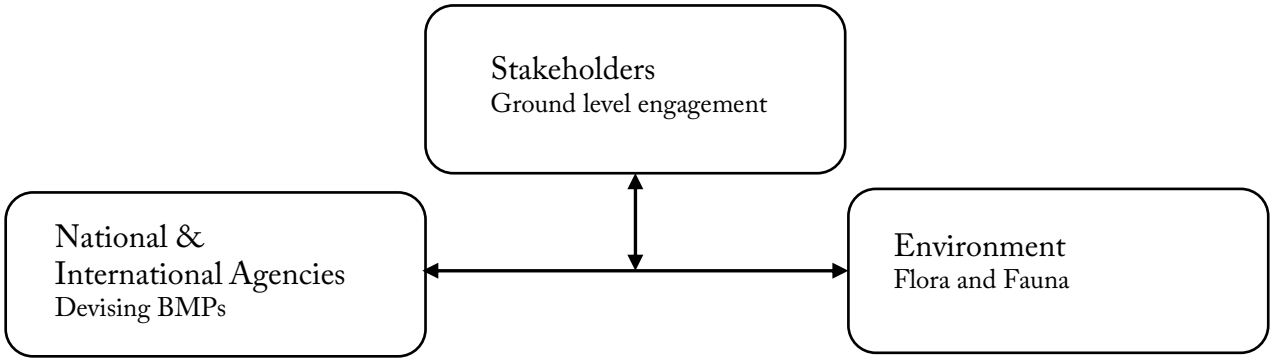

Figure 2. Refined Conceptual Framework showing presence of moderator variables

Methodology

A mixed methods approach was used, where primary field surveys were carried out to establish the base line for demographics included population dynamics, average temperature, rainfall, altitude, and a list of threatened species were listed. This was done to compare the impact of road development in a specific region so that comparative data could be analysed. In addition, a questionnaire and interviews were used to identify gaps in knowledge of the impact of the BMPs.

The participatory rural appraisal (PRA) approach was also used, a method acknowledged by non-governmental organisations and other agencies involved in national and international development (Cavestro, 2003, Uddin & Anjuman, 2013), which aims to incorporate the local wisdom and knowledge and opinions of rural people in the planning and management of development projects and programmes.

This study area included delineation of the zone based on direct influence of the road construction. The assessment corridor was a 128 km stretch located in the state of Himachal Pradesh, India in the foothills of the Himalayas, the area falling within 2 km was considered the core impact zone and 5 km was the extended buffer zone on either side of the road. The zone of actual impacts of the project however varied depending on the physical location of other peripheral developments, proximity of tourism destinations and associated infrastructure.

Field Analysis

There were 53 participants at five road corridors under Tranche-I package. The area considered for collection of data corresponding to vegetation and faunal survey and habitat assessment of impacts is termed as the study area for this research. The study area (14 km) for this project is divided into 2km and 5km areas, each on both sides of the road for different parameters depending on their sensitivity and availability. The details of the study area of 500 m radius on either side from the centre of the road is considered as the core impact zone as this zone is likely to have the maximum interface with project development. All ecological parameters, flora and fauna, endangered and vulnerable species were studied within this zone. The subsequent 1500 m radius on either side from the centre of road is considered as the immediate buffer zone interface with project development but not to the extent of the core impact zone.

Systematic Stratified Sampling has been carried out in the core impact zone (500 m) and the immediate buffer zone (1500 m) totalling to a 2km strip on either side from the centre line of the road. Random Sampling was also carried out in the extended buffer zone (5 km) on each side from the immediate buffer zone. The vegetation survey has been carried out intensively on forested areas. The grid falling on inaccessible steep rocky slopes, densely populated, rivers and outside the state boundaries has not been surveyed. Grid points were laid along the google map sheets and systematic stratified sampling was conducted using grid points as the subset strata as these can be distinguished (Sanders et al., 2019). The points situated within steep slope with hilly terrains, densely populated forests, water body or agricultural areas were labelled as inaccessible areas, those points were not surveyed by the field staff.

The sample plots were laid out following systematic sampling based on the system of grids of latitude and longitude or distance. The size of grid was ascertained using the area along both sides of the concerned road and the optimum sample size and sample grids selected. The survey was carried out abiding to National Working Plan Code – 2014. Sample plots were systematically laid out which is indicated on the Survey of India topographic sheet (toposheet) on the scale of 1:50,000. The alternate grids laid at a distance of 500m on the survey sheet, and Tree count survey was done in full plot of 31.62m x 31.62m = 0.1ha plot. All trees having diameter 10cm and above were enumerated, species wise and diameter class wise from all the identified sample plots of 0.1 ha and recorded. The surveys for shrubs and herbs were done in 3m x 3m and 1m x 1m plots respectively inside the main plot.

For quantitative data analysis, primary field surveys were conducted to elaborate baseline data along PIA. Along with stratified systematic sampling, random transect walk observations were also recorded. The transect walk was performed by traversing along the corridors of impact, recording the occurrence of the entities of study (Mahiri, 1998, Sekar et al., 2023). Transects were linearly laid along 500m length. The baseline data included demographic, population dynamics, average temperature, rainfall, altitude and a list of threatened species were listed. The data was collected by conducting field visits and interviews with local communities and forest officials.

A survey was used alongside the stratified sampling with purposive snowball sampling. Purposive sampling was used as this allows the selecting of participants possessing the required characteristics. The survey questionnaire aimed to identify gaps in the knowledge of the impact of BMPs and was based on the literature and experts' input and was circulated to a population size of fifty (50) with 100% response, therefore n = 50 (Appendix 1). The source questionnaire is in English, and the target questionnaire is in Hindi. Translation

was carried out by the researcher who is fluent in both languages; this ensured the questions have the same meaning to all respondents (Saunders et al., 2019). 24 questions were translated into Hindi and organised into 7 themes. The questionnaire used a combination of open-end questions and questions which asked for a response using a 5-point Likert scale.

In addition, the researcher completed face-to-face questionnaires (n = 3); each question was read out exactly as it was written (in Hindi) to ensure questionnaire validity and reliability, and to remove bias (Saunders et al., 2019). The data collection can be described as deductive because the study began with a relationship framework (Figure 1 refers) (Saunders et al., 2019). This allowed the researchers to interpret meaning from the lens of the respondent. Given the research objective, purposive sampling was used as certain information was required from the targeted individuals.

Participants

Local Communities

The participants who were directly impacted by the road construction are the people who live within or have agricultural, farm, orchard lands and the local business owners with offices situated along PIA. The NGOs are also considered as part of local communities because they provide participatory development for BCAP (Biodiversity Conservation Action Plan) practices, usually an oversight by government (Thomas *et al.,* 2010). There was a total of 27 participants from *local communities* who completed the survey.

— 51% people from local communities participated in the study.
— 42% were females and 58% were male.
— 26% in the age group of 20-35 years; 74% respondents were above age 35 years.
— 67% respondents were farmers and orchardists; 22% were small business owners; 11% were NGOs.
— 74% participants were housed along the PIA and 26% used the corridor for other purposes, such as farming or small business.

Official Staff

The participants who served the government were categorised as official staff; this included the employees of state Forest Department 15, Pradhan (leaders) from Panchayati Raj Institution (PRI); a special framework for village level governance (Goswami, 2021) and resident government employees who have their housing settlements along the PIA. The resident employees were included in this category because their voice is an intersection between local community and the government. There was a total of 26 participants from official staff completed the survey. All of them had extensive work experience of 10 years and above.

— 77% of respondents were serving the Government of India (GoI), out of which 58% were employed by Himachal Pradesh Forest Department (HPFD) and 19% in other state departments.
— 23% were serving the PRI, as the governing leaders of village settlements; 17% were females and 83% males' participants.
— Out of 77% GoI respondents, 35% respondents were senior level officials and 65% belonged to mid-senior and lower level.
— The 19% resident GoI employee had houses and settlements along the PIA.

The sample size for local communities and the GoI staff is similar viz a viz 27 and 26 respondents respectively. The observation aligns with Mowla and Islam (2013), as the natural water drainage gets disturbed and causes obstruction to the smooth flow incurring huge loss in socioeconomic and environmental costs, due to unplanned construction and urbanisation.

To assess the level of pollution along the road corridor the participants were asked to mark the air water and land pollution on a 5-point Likert Scale (1=least, 2=least but increasing, 3=medium, 4=medium and increasing and 5=high impact).

With regards to the existing human interference in ecosystem services, the participants were asked to quantify the exploitation of forest produce. The nature of exploitation was categorised into 4 variables; Natural Springs, NTFP (Non-Timber Forest Produce), Timber and Pollution. The definitions of the labels are:

Fuel wood (used by local villagers as firewood), Chir Pine resin (medicinal use of the turpentine obtained from resin of *Pinus roxburghii*), livestock fodder; and the variable contains NTFP (non-timber forest products; fruits, nuts vegetables, barks etc), timber (woods/logs used in buildings construction) and the pollution caused by various factors.

Descriptive statistics were employed to analyse the questionnaire responses, enabling a clear summary of participant perceptions across stakeholder groups (e.g., Government officials, local communities, and NGOs) regarding the ecological and social impacts of road construction. This approach facilitated the identification of patterns, trends, and differences in opinion relevant to biodiversity conservation in the North-Western Himalayan context.

Results

Potential Risks due to road construction

78% of staff and local communities believe that road construction has had low immediate impact on the biodiversity in the past. 40% respondents felt that the air, land and water pollution is least and 60% believe that the pollution is medium level and is growing rapidly. However, aligning with Kumar et al., (2015), the NGOs participants recorded a lack of public awareness on increasing pollution. The main cause of concern for the 60% GoI officials and 68% of local communities was the increased risk of landslides after the forests have been felled for road construction, agreeing with McAdoo et al., (2018). On the contrary, 14% of local community felt optimistic about the road construction which would open business prospects of local economic growth due to increased accessibility, which can further promote tourism, aligning to Gumus et al., (2008). 11% of staff expressed a minor discomfort for the duration of construction, however they also suggested that the construction risks can be reduced by planned reclamation activities and plantations as much as possible.

Human Interference and the nature of exploitation

For the issue relating to the depletion of natural springs caused due to road construction, local communities testify that most of the sources are depleting, similar to GoI staff. However, the GoI staff also indicate that 34% of water resources are unscathed. There is a minor disagreement between the two groups, with regards to pollution of natural water springs during road construction as the officials consider climate change and its impacts on water resources are higher than road construction, similar to a study conducted by Kuruppu and Liverman (2011). The 66% local communities attested depletion during construction, and 42% GoI staff believed the same, assuming a similar sample set for both the groups, there is a 24% opinion difference. The above observation aligns with a study carried out by Brown and Shogren (1998) as the local population fear that a decreasing water table caused due to road construction leads to a regression in food production.

NTFP incorporates diverse varieties of yields and production assisting ecological, social and economic perspectives (Belcher et al., 2005). There is a similarity in the opinion of both the groups accounting for the exploitation of NTFP produce, which is also an economic activity. Local Communities report that fodder is mostly exploited, similar to GoI staff testimony. Both the groups testified to have a symbiotic relation with each other to yield NTFP, which has considerable low impacts on biodiversity. NTFP species have a significant role in poverty alleviation around the globe (Yadav et al., 2021). However, if we consider Timber exploitation then there is a disparity between the two groups. The exploitation is unmonitored, unaccounted and hence local communities reap illegal benefits by exploiting 74% on average whereas GoI officials believe it to be 30.7%. As noted by GoI staff, guarding the dense forest cover in Himalayas is extremely difficult. The major impact of construction (pre and post) is pollution, caused during blasting, hill cutting, tree felling and air pollution. The respondents belonging to local communities believe that garbage disposal (29.6%) is the main reason for pollution, which can be reduced if authorities take strategic measures. Whereas other factors which contribute to pollution are forest fires (25.9%), suspension of dust during construction (11%) and the use of chemical fertilizers (33.3%). On the contrary, the GoI officials highlighted the lack of public awareness (7.6%) in solid waste management stating that the ignorance of local communities adds on to garbage pollution. The 46.1% officials were concerned about the forest fires, which act as Greenhouse gases in air pollution.

A significant relation was found between the group's assessment to the questionnaire based on their association with the government. The NGOs and local communities (42%) strongly agree with the disparity between the understanding and perspectives between both group sets. Similarly, the GoI officials also believe that there is a lack of communication between both group sets, which further adds to lack of public awareness with respect to issues pertaining to biodiversity conservation.

Wildlife Fragmentation

74% local communities were alarmed due to wildlife habitat fragmentation and 84.6% GoI Officials agreed. Both groups were optimistic about introducing such structures in the Himalayan region, as an anticipatory mitigation plan of wildlife habitat fragmentation. The analysis shows a mutual understanding of the habitat fragmentation as an impact of road construction. The local communities and GoI official aligned to this idea of conserving the wildlife habitat at an early stage, to avoid any future repercussions of economic developments as a direct impact of road construction.

Additionally, GoI officials were optimistic about the possibility of diverting sufficient funds to achieve a biodiversity neutral environment by building wildlife corridors along with road construction. The respondents also suggested measures to perform captive breeding to increase declining faunal population, further discussed in recommendation section.

Approaches to BCAP Regulations

30.7% of local communities had a primary focus on ecosystem services as an integrated approach to BCAP, considering the entire ecology with the purpose of sustaining an ecosystem in a nourishing, valuable and durable situation so that it can deliver the support people need (Grilo et al., 2010). However, ecological processes (19%) that produce the goods and services valued by people are different to the ecological processes which are vital for the biodiversity conservation (Keenan, 2007). Considering the difference between the biodiversity conservation practices within ecosystem services and ecological processes, the local communities are more inclined towards ecosystem services. 7% of local communities appreciate the traditional practices for conservation, whereas 23% of GoI staff value this approach.

As this case study evaluates the efficacy of BMPs, the local communities do not testify for such practices. There is a disparity between LC and GoI official (7%). A disparity was recorded between the understanding of legal rules/regulations and the implementation of those regulations to conservation practices. The outcomes display varying understanding and implementation of legal BCAP regulations. Additionally, there is active NGO and public participation in BCAP regulation. The approach directly impacts the unnatural transition (increase/decline) of floral and faunal population as a direct impact of roads construction.

Combined Participant's view (LC and GoI)

Participants identified key driving forces of Biodiversity Conservation and Action Plans (BCAP), with local communities placing particular emphasis on sustainability and the importance of conservation practices in addressing climate change. This aligns with findings by Kumar et al. (2015), who also highlighted a lack of public awareness about BCAP, often masked by the continued presence of green cover in the Himalayan region.

During discussions, participants were briefed on the components of biodiversity conservation and asked to reflect on associated challenges. A common concern raised by local communities was their dependency on ecosystem services without a proper assessment of the environmental impact, compounded by insufficient public awareness. This perspective echoes the findings of Sharma et al. (2008), who noted limited realisation of the need for biodiversity conservation in the forest-dense western Himalayas.

Government officials cited the absence of clear standard operating procedures (SOPs) and regulatory oversight as key issues. Institutional challenges, including corruption and a risk-averse approach among some officials, were also identified as significant barriers to effective conservation enforcement. Both groups recognised that while regulations exist, their implementation and monitoring remain inadequate.

Participants agreed that incentivising BCAP activities could enhance community engagement and participation in biodiversity conservation efforts. Overall, visible forest thinning associated with infrastructure development has heightened national awareness of the need for robust conservation measures in the Himalayan region. Importantly, participants across both groups identified educational needs as a critical area for intervention. These include increasing public awareness of biodiversity impacts, improving stakeholder understanding of conservation regulations, and strengthening community knowledge of sustainable practices. The findings suggest a clear requirement for targeted educational initiatives, such as training workshops, environmental literacy campaigns, and school-based biodiversity education, to enhance stakeholder capacity, inform sustainable behaviour, and support the effective implementation of BCAP across the region.

Discussion

A case study was carried out in the north-western Himalayan region of India to determine the factors that influence the efficacy of Biodiversity Mitigation Plans (BMP). Data from field interviews and questionnaire responses revealed a consistent disparity between formally stated mitigation strategies and actual monitoring practices on the ground, particularly in remote or forest-adjacent communities. Interview responses from forest officers and local committee members concurs with the research conducted by Boruah (2021), stating that Indian National Biodiversity Targets have missed the association between biodiversity conservation mitigation and implementation that was established by the Aichi Targets, noting a similar lack of coordination between Forest Departments, State Biodiversity Boards, and Biodiversity Management Committees (Boruah, 2021). This study established that the Himalayan region is visibly dense and diverse, still the region is overlooked in scientific studies on the area's response to the changing regional and global climate (Telwala et al., 2013). This study appreciates the mitigation measures introduced at national and international level; however, the results show a clear disengagement between field level implementation of those regulations. Nonetheless, the purpose of biodiversity conservation gets lost in the way to implementation. The reason to that is the detachment induced by lack of public awareness. This gap underscores the need for structured environmental education and outreach strategies to empower local communities with the knowledge required to engage meaningfully with biodiversity mitigation efforts. Without improving the public's understanding of the scientific and policy rationale behind mitigation plans, compliance and engagement are likely to remain limited.

The outcomes of this case study in Himalayan region also concur with the global literature as none of the Convention of Bio Diversity (CBD) targets for 2010 were met and ecosystems are declining more rapidly than ever (Ingram et al., 2012). Ecosystem services approaches have the potential to contribute significantly to achieving many conservation goals. The data analysis also agrees with the literature in that the population is also a burden on ecosystem and economy (Hussain et al., 2020). One of the reasons of ecosystem imbalance is population explosion of the 21st century and overconsumption of natural resources; the WWF and Zoological Society of London (ZSL)'s Living Planet Report 2020 testified that worldwide wildlife populations have dropped by two-thirds as a direct result of human overconsumption (Greenfield, 2020). In other research, around 6,800 ecological communities were analysed, and it was suggested that relation between human development and biodiversity loss has direct consequences to a pandemic such as COVID-19 (Gleditsch, 2021). Himalayas are intricate and delicate ecosystems, hosting 12% of human population (Sharma et al., 2010). This study suggests one of the ways to tackle the monitoring of Biodiversity Mitigation plan is by decentralising these practices at the community level. Large areas of degraded forest are being monitored under community management decentralised natural resources governance systems (Sharma et al., 2010). These findings suggest that community-level decentralisation should be accompanied by tailored educational programs, fostering capacity-building in biodiversity monitoring, reporting, and sustainable land use practices. Educational interventions aimed at local governance bodies can bridge the knowledge-action gap, ensuring that conservation efforts are grounded in both policy and local understanding.

As far as ecosystem services and ecological approaches are concerned, Indian forests produce two trillion worth of NTFP annually, approximately 90% of the 104 million people of rural areas depend on them (Yadav et al., 2021). The two approaches are compatible and mutually reinforcing, delivering positive results for conservation targets, even if biodiversity was not the original or primary objective, and vice versa (Ingram et al., 2021). The study reveals a mismatch between the two approaches. However, it is important to assess

the outcomes to avoid increasingly scarce resources for biodiversity conservation. This study maps out the challenges and the approach to Biodiversity Conservation attitude inculcated within the two study groups. The differing attitudes between the study groups also reflect varying levels of ecological literacy, reinforcing the need for sustained environmental education initiatives that are culturally and linguistically appropriate. Group A respondents (local community members) showed limited awareness of biodiversity policies, whereas Group B (NGO and consultancy participants) demonstrated greater familiarity with BMP frameworks. Such programs can help internalise biodiversity values, making conservation not just a policy obligation but a lived practice among local populations.

By validating the theoretical framework with the results data, the theoretical framework (Figure 3) shows the moderator variable is in fact the Consultancies as they are shown to directly influence the level of Stakeholder engagement. The Consultancies also inform policy for the Agencies. The aim of this study is to determine which factors influence the efficacy of BMPs in the North-Western Himalayan region of India. The results show that by the use of Consultancies to advise on policy and effective delivery, the efficacy of BMPs devised at a National and International level have greater influence on the regional flora and fauna.

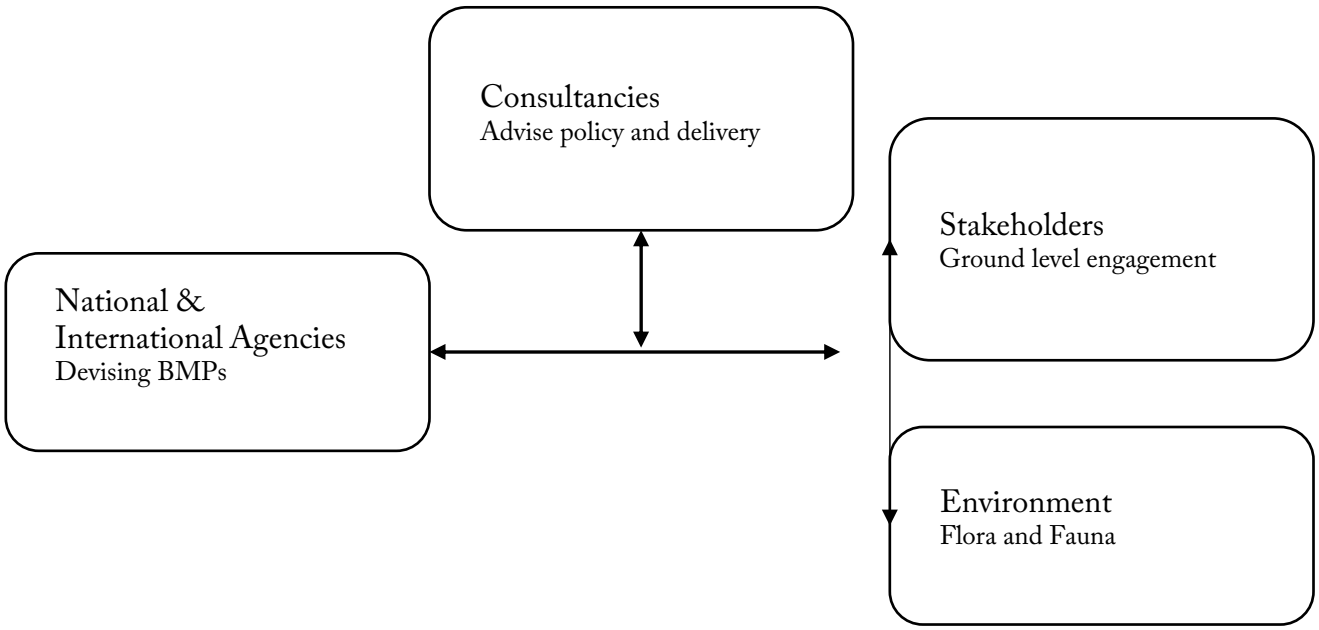

Figure 3. Theoretical Framework showing moderator variables

This study aligns with Tompkins and Amundsen (2008) in understanding the effectiveness of international legislation, where respondents suggested that there is a policy mismatch between the scale of the problem, the scale and design of the international regimes, and domestic policy agendas. Operational findings need to be incorporated in policymaking to develop an effective administrative procedure. Management plans based on scientific evidence will enable wildlife managers to select conservation measures that are the most likely to preserve biodiversity (Caudron et al., 2012).

Societal conditions may influence the behaviour of elected officials, who feel the need to provide positive economic news ignoring the biodiversity needs (OECD, 2017). Thus, maintaining the status quo becomes politically attractive. Political acceptance is also dependent on (among other concerns) the perceived effectiveness of the policy, the degree of fairness, and the degree of awareness of the problem (OCED, 2017).

One of the efficient moves is the EIA process; it has proven to be dynamic as it has integrated social concerns and audits of Non-Governmental Organizations (NGOs). NGOs carry out environmental audits to ensure that the construction industry has met the requirements of the EIA during the construction works of the pipeline project (Bataineh, 2007). In this context, education also plays a pivotal role in ensuring that both governmental and non-governmental actors are equipped with the interpretive skills to understand and enforce EIA standards. This includes training for NGOs, contractors, and community representatives, strengthening the communicative chain that supports environmental compliance and ethical accountability.

Overall, the findings highlight that educational interventions, whether formal training, public outreach, or community-led learning, are not peripheral but central to the successful implementation and monitoring of Biodiversity Mitigation Plans. In recognising education as a foundational pillar of conservation effectiveness, this study contributes to the growing discourse on sustainability literacy as a prerequisite for policy success.

Conclusions

The research aim was to determine which factors influence the efficacy of Biodiversity Mitigation Plans (BMP) in the North-Western Himalayan region of India. The novelty of this study is the location; this study is useful for future endeavours in this region. Western Himalaya was chosen as a study site as there is a general lack of scientific literature in the region, and there is an increased threat of biodiversity loss due to deforestation, extensive land use and exploitation and accelerated infrastructure development (Telwala et al., 2013). The case study has been carried out to substantiate ignorance of biodiversity conservation practices in the project influence area. Also, the public awareness towards the biodiversity conservation and to minimise ecosystem services exploitation was also reviewed. This points to a significant need for sustained environmental education initiatives aimed at enhancing biodiversity literacy among both local communities and policy implementers.

In 2020-21, the lockdowns directed in North India amid the Covid-19 pandemic imposed blanket lockdowns, shutting down public/private offices, schools and education institutes (Narula and Sharma, 2021) which became the most efficient in climate change and biodiversity conservation as compared to any biodiversity legislation. Lockdown prompted a short-term drop in pollution as economies faltered and people avoided travel and worked from home: emissions fell by about 7% in 2021 compared with 2019 (Cornwall, 2020). Martín-López et al., (2007) revealed a strong correspondence between human attitudes towards biodiversity and the progress made in biodiversity conservation. These findings underscore the crucial role of environmental education and awareness programs in shaping public attitudes that support conservation efforts. Environmental NGO, wildlife media, magazines and education programmes are the key drivers to human value consideration to biodiversity.

This study was designed to assess the awareness of biodiversity conservation among the local communities and the authorities along the Himalayan PIA. The analysis agrees to the scientific uncertainty; Xu et al., (2009) emphasises that the rural population of the Greater Himalayas are uninvolved in the BMP decision making process. The three critical gauges of successful BMP implementation are local community involvement, urban and rural participation, and transboundary engagement (Xu et al., 2009). During the investigation, this study's analysis agrees that main biotic exploitations in the forests include timer and non-timber forest produce, extensive fuelwood collection and livestock feeding (Sultan, 2017). The study establishes lack of government's Biodiversity Mitigation plan monitoring capacity, hence suggests a regionalized governance systems for biodiversity conservation (Sharma et al., 2010). This further highlights the need for educational outreach that empowers local populations with the knowledge and tools to actively engage in conservation.

The analysis provides evidence of floral and faunal population decline caused throughout the construction duration of roads in Northern Himalayas. This study agrees with Telwala et al., (2013), as urbanisation is increasing, it is causing species geographic range shifts and extinctions. Furthermore, the literature in this study analysed the efficacy of BMP recommended on global platforms. The present studies have revealed that biodiversity conservation should not just be seen as a token regulation, but it should be inculcated as a part of pro-biodiversity behaviour, which can be cultivated through continuous environmental learning among local communities and the governance authorities. As a result of this case study, if Consultancies are employed at the local level and communities are involved in biodiversity conservation decision making procedures, ecosystem restoration can certainly increase. The use of Consultancies has a positive impact on the efficacy of Biodiversity Mitigation Plans when the Consultancies are used to engage with local Stakeholders. In this role, Consultancies may also act as intermediaries in delivering training and educational support, helping to bridge the gap between scientific knowledge, policy, and local understanding. The findings of this study consider that enabling regular and active participation of all the central agencies from Village and Municipality to the Centre is one of the key requirements for achieving adaptation impacts (Karki, 2017).

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Appendix

The population Demographics (जनसंख्याजनसांख्यिकी)

1. What is the population dynamics of the village/communities along the proposed road construction?
प्रस्तावितसड़कनिर्माणकेसाथगांव/समुदायोंकीजनसंख्याकीगतिशीलताक्याहै?
2. What is the base line data of the area- temperature, elevation, rainfall and snowfall, humidity?
क्षेत्रकाआधाररेखाडेटाक्याहै- तापमान, ऊंचाई, वर्षाऔरबर्फबारी, आर्द्रता?
3. Are there any resource groups like SHG, JFMC, NTFP user groups and its role etc.
क्याकोईसंसाधनसमूहहैंजैसेएसएचजी, जेएफएमसी, एनटीएफपीउपयोगकर्तासमूहऔरइसकीभूमिकाआदि?

Floral and Faunal Diversity (पुष्पऔरजीववविविधता)

4. What kind of animals, birds and aquatic species exist?
कसितरहकेजानवर, पक्षीऔरजलीयप्रजातियांमौजूदहैं?
5. Which type of trees, herbs and shrubs are found and its extent of distribution?
कसि प्रकार के पेड़, जड़ी-बूटियाँ और झाड़ियाँ पाई जाती हैं और उसका वितिरण क्या है?
6. Which of the flora and fauna is rare, threatened, or extinct?
वनस्पतियों और जीवों में से कौन सा दुर्लभ, संकटग्रस्त या वलिुप्त है?
7. What are the names of invasive alien species and extent of its distribution and magnitude?
आक्रामक वदिेशी प्रजातियों के नाम क्या हैं और इसके वतिरण और परमिाण की सीमा क्या है?

Habitat Fragmentation (पर्यावास वखिंडन)

8. Is there any possibility of migration of wildlife on account of habitat fragmentation and corridor restriction?
क्या आवास वखिंडन और गलियारे प्रतबिंध के कारण वन्यजीवों के प्रवास की कोई संभावना है?
9. Is there any information on the animals and traffic conflicts along the road? If yes, what are the impacted animal species?
क्या सड़क पर जानवरों और यातायात संघर्षों के बारे में कोई जानकारी है? यदि हां, तो प्रभावति पशु प्रजातियां क्या हैं?
10. How many livestock predation events have been recorded in the past 3 months?
पछिले 3 महीनों में पशुधन शकिार की कतिनी घटनाएं दर्ज की गई हैं?
11. Has any Bear with cubs been reported during the past 12 months?
क्या पछिले 12 महीनों के दौरान कसिी भालू के शावकों के साथ होने की सूचना मलिी है?
12. In case Bear are known to be present in the beat, but no sign was obtained during the sampling period then mention on what evidence was this conclusion made (pugmark, direct sighting, scat, another sign)
यदि भालू को बीट में उपस्थति होने के लिए जाना जाता है, लेकनि नमूना अवधि के दौरान कोई संकेत प्राप्त नहीं हुआ था, तो उल्लेख करें कि यह नष्किर्ष क्या था (पगमार्क, प्रत्यक्ष दृष्टि, स्कैट, एक और संकेत)
13. Has any leopard with cubs been reported during the past 12 months?
क्या पछिले 12 महीनों के दौरान कसिी तेंदुए के शावकों के साथ होने की सूचना मलिी है?
14. In case leopards are known to be present in the beat, but no sign was obtained during the sampling period then mention on what evidence was this conclusion made (pugmark, direct sighting, scat, other sign.
यदि तेंदुओं को बीट में मौजूद होने के लिए जाना जाता है, लेकनि नमूने की अवधि के दौरान कोई संकेत प्राप्त नहीं हुआ था, तो उल्लेख करें कि यह नष्किर्ष क्या था (पगमार्क, प्रत्यक्ष दृष्टि, स्कैट, अन्य संकेत।

Project Influence Area (परियोजना प्रभाव क्षेत्र)

15. Does the area fall under any national park, sanctuary, buffer zone, conservation reserve or a biosphere reserve?
क्या क्षेत्र कसिी राष्ट्रीय उद्यान, अभयारण्य, बफर जोन, संरक्षण रजिर्व या बायोस्फीयर रजिर्व के अंतर्गत आता है?

Mitigation measures (शमन के उपाय)

16. What is the extent of the forest land diverted for the proposed road and the provision for compulsory afforestation?
प्रस्तावति सड़क के लिए वपिथति वन भूमि की सीमा और अनविार्य वनरोपण का प्रावधान क्या है?

17. What is the quantity of forest produce extracted from habitat, its evaluation and verification methodology?
पर्यावास से निकाली गई वनोपज की मात्रा, उसका मूल्यांकन एवं सत्यापन पद्धति क्या है?

Potential Risks of road construction (सड़क निर्माण के संभावित जोखिम)

18. Identify the potential risk due to the construction of the road to habitat and biodiversity.
आवास और जैव विविधता के लिए सड़क के निर्माण के कारण संभावित जोखिम की पहचान करें I
19. What is magnitude of pollution of air, water, land, and sources of pollution viz. mobile, stationery and mobile sources?
वायु, जल, भूमि और प्रदूषण के स्रोतों के प्रदूषण का परिमाण क्या है। मोबाइल, स्टेशनरी और मोबाइल स्रोत?
20. What is the nature of exploitation of natural resources by local/right-holders and its quantum?
स्थानीय/अधिकार-धारकों द्वारा प्राकृतिक संसाधनों के दोहन की प्रकृति और इसकी मात्रा क्या है?
21. Are there any natural water resources available and are these depleting?
क्या कोई प्राकृतिक जल संसाधन उपलब्ध हैं और क्या ये घट रहे हैं?

Possible Mitigation measures (संभावित शमन उपाय)

22. What type of interventions and probable mitigation measures for biodiversity conservation that are required for pre and post construction of the roads for the stakeholders?
हितधारकों के लिए सड़कों के पूर्व और बाद के निर्माण के लिए आवश्यक जैव विविधता संरक्षण के लिए किस प्रकार के हस्तक्षेप और संभावित शमन उपाय?
23. Is there any suggestion for development of habitats to support biodiversity conservation?
क्या जैव विविधता संरक्षण का समर्थन करने के लिए आवासों के विकास के लिए कोई सुझाव है?
24. What tree and plant species you suggest raising in forests/along roadside?
आप जंगलों में/सड़क के किनारे किस पेड़ और पौधों की प्रजातियों को उगाने का सुझाव देते हैं?