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Application of biodiversity offsets concept for sustainable road development in some hill roads in India

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ABSTRACT

Threats to biodiversity transport systems often cover large distances or form widespread networks, affecting biodiversity locally and regionally. Direct impacts include road kills (mostly mammals), disturbance (felling of roadside trees, increased noise, etc.), spills and contaminated runoff. Most such impacts occur during the construction stage, or result from vehicle operations. Indirect impacts are generally more critical for biodiversity, as improved access to remote areas frequently leads to unsustainable resource exploitation, and land-use and population change. In hill road construction biodiversity is affected by hill cutting, landslides, valley side slips and forest and agriculture land diversion. Strong efforts must be made to ensure sustainable road development with a aim to conserve natural resources which support rural livelihoods. In road development especially in hill road biodiversity conservation need to be planned based on biodiversity offsets with an aim of overall biodiversity gain. The central as well as state governments need to promote for biodiversity offset credit and bio-banking concept to implement biodiversity offset.

Key words: Biodiversity Offsets, Bio-banking; Habitat banking, Polluter pays,

INTRODUCTION

Transportation and the environment are strongly interlinked and dependent. Sustainable transport projects, such as more efficient rural road rehabilitation and clean urban transport systems, not only provide economic development but important social benefits. However, transport projects can have significant effects on the environment and local communities if not addressed explicitly in the design and implementation of projects and programs (Banerjee *et al.,* 2018). Moving beyond negative impact mitigation, toward more environmentally sustainable projects and programs, offers additional benefits, and project stakeholders are increasingly demanding and expecting environmental sustainability to be integrated into infrastructure projects. (Banerjee *et al.,* 2019).

An important element in improving the environmental sustainability of road transportation projects is the use of new technologies, processes, and products that directly enhance the projects' environmental, health and safety and economic sustainability through reduced consumption of energy and material. In addition, the use of environmentally sustainable technology can also enhance road project related activities such as vegetation clearing and slope erosion control and stabilization. While ideally these technologies and process are defined as part of the project design, they can still be identified and implemented during construction and operation and maintenance (Ramakrishna and Sapzova, 2012).

For hill road construction it may be stated that - new roads and upgraded roads bring enormous benefits to the people but creates a number of challenges in project implementation related to environmental and social issues important of them are - Stabilizing hill slopes, valley side slips, Disposal of debris , Protection of biodiversity, Air pollution, water pollution Maintaining the productivity of hill slopes , loss of land, loss of forest, loss of community structures , impact on local resources and community transmitted diseases (Geneleti, 2003).

Biodiversity loss may occur directly via road-kill events, disturbance or pollution, or indirectly by stimulating and facilitating loss of habitat, and forming barriers to dispersal and gene flow," Roads also affect biodiversity through reduction in habitat quality, facilitating human access to frontier landscapes, increasing opportunities for selective logging and bush meat hunting, increased risk of forest fires and the creation of edge effects at road-habitat boundaries. "Roads are not just a symptom of habitat loss in general; they seem to play a specific role, on their own, in reducing biodiversity by three mechanisms - fragmentation and creation of barriers for species movement; the precipitation of environmental changes such as an altered microclimate, and differing light and foliage levels; and finally, roads may serve as a proxy for damaging practices such as logging. (Ahmed *et al*., 2014). The construction and improvement of roads of all types sometimes leads, directly or indirectly, to significant loss or degradation of natural habitats and increased wildlife mortality (Forman and Alexander, 1998). As a result, road projects frequently pose conflicts with biodiversity conservation objectives. The challenge for people who plan, build, and maintain roads is to reconcile the improvement of transportation infrastructure with the need to avoid serious damage to natural habitats and biodiversity (Scott, 2015).

In considering the adverse impacts of road works (construction, improvement, rehabilitation, and maintenance) on biodiversity in most cases, it has been found that the induced impacts of road works on biodiversity are both more serious and more difficult to control than the direct impacts. Even where new or improved road access does not result in deforestation for new pastures or croplands, it may facilitate increased logging, mining, hunting, or other activities which often threaten biodiversity. Forested areas are typically more vulnerable to drastic, road-induced land use changes (such as deforestation) than are croplands, grasslands, or other non-forest areas. (Banerjee and Srivastava, 2019).

Biodiversity offset

Biodiversity offsetting is a system used predominantly by planning authorities and developers to fully compensate for biodiversity impacts associated with economic development, through the planning process. In some circumstances, biodiversity offsets are designed to result in an overall biodiversity gain. Biodiversity offsets are measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts arising from development plans or projects after appropriate prevention and mitigation measures have been taken (IUCN, 2016)

The goal of biodiversity offsets is to achieve no net loss and preferably a net gain of biodiversity on the ground with respect to species composition, habitat structure, ecosystem function and people's use and cultural values associated with biodiversity. Biodiversity offsets thus require a new development activity (e.g. road construction, railway construction) to provide for "no net loss" or a "net gain" in biodiversity. In other words, biodiversity offsets demand at minimum a like-for-like compensation for residual biodiversity impact through a direct compensation or the acquisition of biodiversity credits in a regulated market. An alternative version of "compensation" involves the definition of an economic value of the biodiversity impact or a set rate fee calculated as a percentage of the development project's value (OECD, 2016).

MTERIAL AND METHODS

Methodology adopted to achieve biodiversity offsets goals in construction of the hill road considered for study

Project location

The project roads are located in the state of Mizoram, a state situated in North – East of India. Within India, the entire North-East region, in which Mizoram is situated, represents the transition zone between India, Indo-Malayan and Indo-Chinese geographic regions. (Figure -1)

Mizoram is a part of the Eastern Himalayas which is hottest of the 34 biodiversity hotspots of the world. It comprises of a mountain range in South Asia which is youngest of all mountain ranges existing on the face of the earth. It is still in an evolving state. The ecosystem of the region, therefore, naturally exhibit great dynamism (Zobel and Singh, 1997). It also holds great significance from ecological and evolutionary point of view. This region is rich in biodiversity and harbours largest number of endemics and Schedule I species as compared to any other part of India (MacKinnon, 1986). It is recognized under the National Biodiversity Strategy and Action Plan to be an eco-region. Its unique location, topography with hills and valleys, and geology provide immense ranges of microclimatic conditions which support diverse gene pools of a variety of flora and fauna, making it a "biodiversity rich" area (Swamliana, 2013, Banerjee *et al.,* 2019).

For study about 115 km of state highway roads were considered for study. During the design period (2002-2003) considering the geological nature of the project area (soft rock and immature geology of the project area) and high rain fall pattern it was assessed that during construction period would require protection and management of landslides and valley side slips. Accordingly an environmental management plan for protection and management of landslides and valley side slips was prepared and implemented during construction period with the help of local people and indigenous technology of stabilization up to 2009 and stabilization and was monitored for 10 years , up to 2019. Side by side some environmental enhancement measures were also adopted and implemented up to 2009 and its status was also monitored for 10 years i.e. up to 2o19. (Plate -1).

Methodology adopted to achieve biodiversity offsets goals

prevent or minimize the loss of forests or other natural habitats and their biodiversity through induced impacts, road projects was designed and implemented according to the following considerations which moved the project towards biodiversity offsets goal in a short time -

Project Site Selection

To prevent biodiversity loss, new or improved road construction, to the maximum extent possible, natural habitat areas were avoided. Special attention was given to avoid damaging critical natural habitats. In inevitable areas special protection zones regulations were proposed to encompass the environmentally sensitive areas made accessible by the road.

Protected Area Establishment

Despite the best site selection efforts, some part of the project involving road construction or improvement inevitably passed through forests or other natural habitats, often with significant risk of adverse induced impacts on biodiversity was considered for standalone management plan with the help of biodiversity expert.

Establishment or strengthening of compensatory protected areas

Another approach for conserving biodiversity adopted was the establishment or strengthening of compensatory protected areas because compensatory protected areas are intended to partially offset the expected loss of natural habitats from a road project. The costs of establishing and managing compensatory protected areas considered part of the costs of the overall road project which provided an opportunity to turn a negative project feature (natural habitat loss) into something environmentally beneficial

Avoid fragmentation of natural forests

Fragmentation of natural forests were avoided because it is important for biodiversity and movement of forest-based animals across the roads.

Good Road Engineering

Sound road engineering and design work was introduced which significantly minimized harm to biodiversity. In particular, the natural water flows of streams, lagoons, and other wetlands need were maintained through adequate bridges, culverts, or other drainage works.

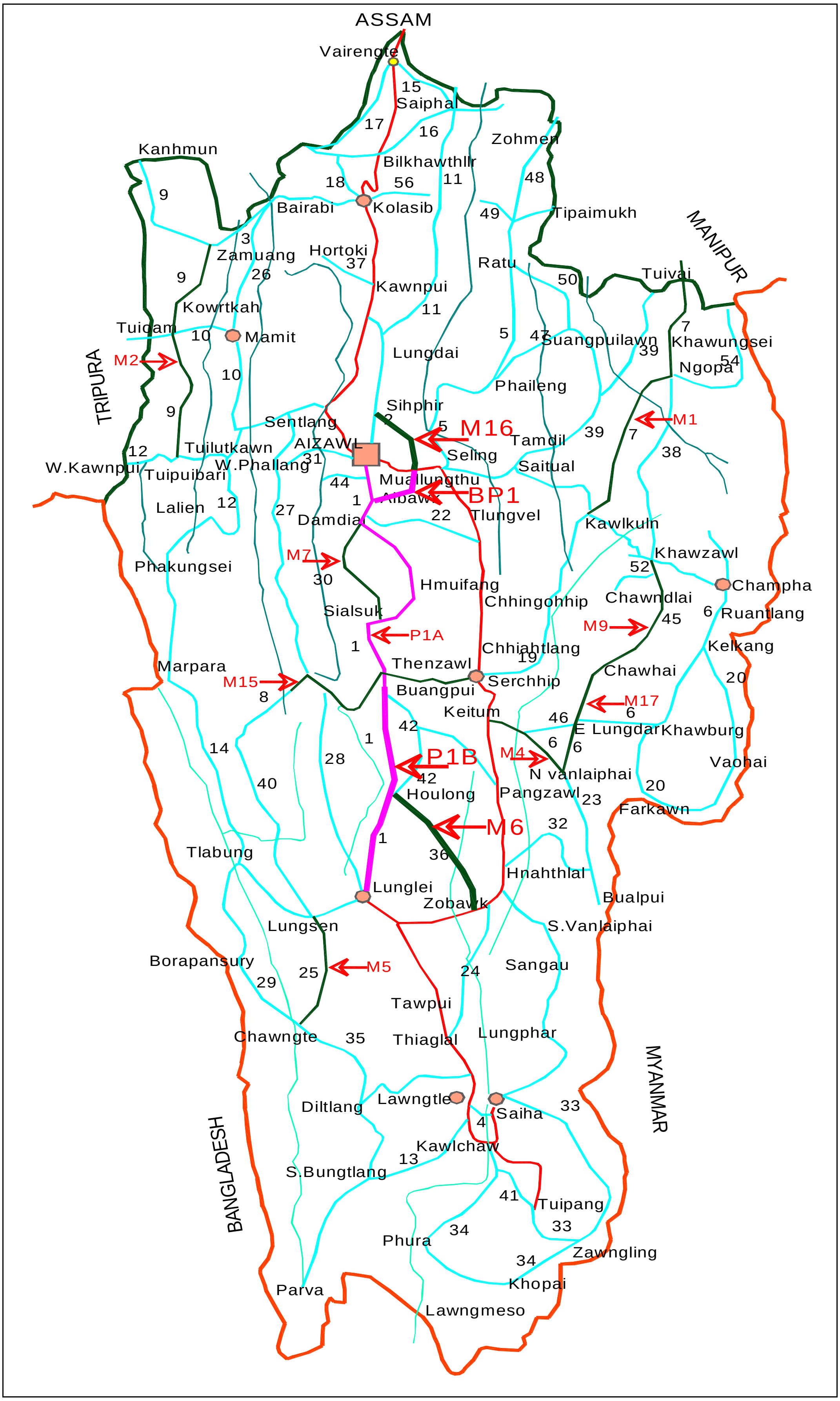

Figure 1: Map of Mizoram showing locations of project roads

Plate 1: Different Hill road construction activities in the project road damaged bio-diversity

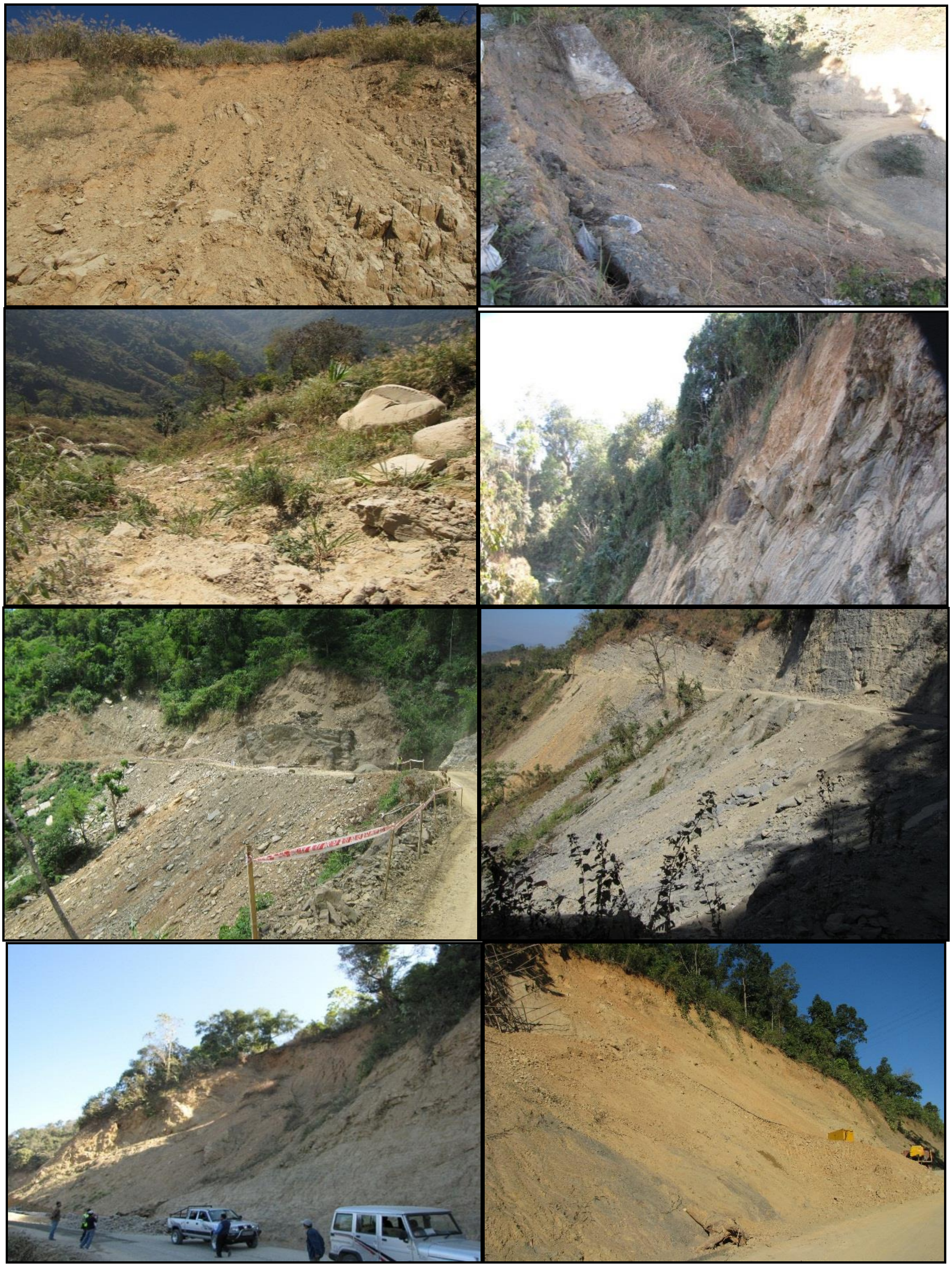

Plate 2: Different measures of bio-engineering in the project road

Tree canopy cover as arboreal bridge

In forested areas, many roads was designed to maintain partial tree canopy cover over them. In this manner, many animals could successfully cross the road over "arboreal bridges" and forest fragmentation was reduced and for maintaining tree canopy cover over roads deforestation activities prohibited in these sections.

Underpasses or overpasses - animal passage facilities

Animals crossing were identified in consultation with forest officials and local people data were collected on wild animals (especially threatened species) being killed by road traffic. Animal passage facilities were incorporated in the design, with adequate studies of the natural (pre-highway) movements of the species of special concern. Additional means of minimizing wildlife road kills included strategically-placed speed bumps, caution and animal crossing signs, broader educational programs, strict enforcement of speed limits, and prohibiting driving at night.

Plate 3: Stabilisation of spoils and Restoration of damaged area by bioengineering approach

Plate 4 : Environmental & Social enhancement measures

Creation of new ponds - Enhancement of aquatic biodiversity

Stabilized dump site as new playground

Stabilized dump site as road side village market

Stabilized dump site as agriculture land

Stabilized dump site as graveyard

Avoid hunting and quicker access to wildlife

Previous experiences revealed that animals are commonly hunted near construction camps or maintenance facilities, and are hunted/trapped wherever improved transport systems provide quicker access to wildlife habitats and markets. In projects design all these factors were taken into account, and focused on careful siting of transport routes as a preferred way of reducing mortality.

Invasion of alien species

Monitoring of invasion of alien species, which is common in transport corridors was adopted through forest department and educational institutes. Introduction of alien species in afforestation and camp restoration was avoided.

Siting the construction camp and other facilities

To the extent feasible, these facilities proposed be sited away from forests, wetlands, or other natural habitats. In areas that were natural habitats prior to camp establishment, the natural vegetation was proposed to be restored as part of camp removal. It is important for the native species and ecosystems that no invasive exotic species be introduced.

Good Construction and Maintenance Practices

During construction, good environmental practices were proposed in the contractor's contract document for protecting biodiversity. Environmental Management Plan which included conservation and management of natural habitats and enhancement of environment was included as part of the contract document.

Proposal for Biodiversity offset credit and Bio-banking

It is a general rule in India that when a authority converting some natural habitat into a project (housing, rail, road etc.) the project authority will need to pay for the creation or protection of a comparable habitat to compensate for the residual loss of biodiversity after all possible mitigation actions are undertaken.

Biodiversity offset credit Bank need to be established with in the state so that in future in an area where there are offset credit banks, the sponsors can buy offset credits for the purpose. An offset credit can involve habitat expansion (creation), habitat restoration measures, and habitat protection when the habitat was previously under threat. Offsets are different from natural resource damage assessments that arise from unplanned damage to the environment and are based on the cost of remediation (IUCN, 2016). Other concept was proposed considering the future projects is bio-banking through which biodiversity offsets can be organized as one-off offsets, in-lieu fees and bio-banking (the contractor can purchase offsets directly from a public or private bio-bank that holds a repository of pre-certified offset credits). Biodiversity offsets can be voluntary or compulsory by law.

In the case of bio-banking, credits will be tradable units of exchange defined by the ecological value associated with changes in a natural habitat. Credits will be certified and monitored by a central regulatory authority. Bio-banking will share certain features with tradable permit schemes whereby a quantified objective for biodiversity conservation is set (i.e., no net loss /net gain). Most bio-banks must include a long-term management plan and a trust fund that guarantees the long-term financing of the management plan (OECD 2016).

Steps adopted to achieve biodiversity offset in the project area

i) Identification of land slide prone areas and hill slopes stabilization
ii) Identification of valley slide slips
iii) Identification and selection of debris disposal sides
iv) Modification of road design for maximum use of debris & reduce the volume of debris disposal.
v) Use of local indigenous technology for slope stabilization
vi) Compaction and Benching of embankments & dump soil at debris disposal sites.
vii) Identification local soil binders plant species and use of such plants for plantation on slopes and embankment benches.
viii) Use of local bamboo species for bamboo mating on the surface of the slopes and plantation with local soil binder plant species and bamboo plants.
ix) Use of local bamboo species for construction of bamboo crib walls
x) Plantation along the road with local tree varieties
xi) Identification & Conservation of rare, endangered and threatened plant and animal species
xii) Community participation in environment management approach was adopted by using local people with local technology for slope, embankment, valley side slips with local materials and plants.
xiii) Creation of two ponds for local community to be used as fish pond and enhance aquatic biodiversity status of the project area.
xiv) Conversion of disposal sites as recreation park and play ground
xv) Conversion of stabilized hillside slopes, valley side slopes and dump side slopes as additional agriculture area for terrace cultivation and fruit production.

RESULTS AND DISCUSSION

As discussed earlier an environmental management plan for protection and management of landslides and valley side slips was prepared and implemented during construction period with the help of local people and indigenous technology of stabilization up to 2009 and stabilization and was monitored for 10 years, up to 2019. Side by side some environmental enhancement measures were also adopted and implemented up to 2009 and its status was also monitored for 10 years i.e. up to 2019.

Table 1: Activity wise biodiversity offset achieved in the project

Measures adopted	**Biodiversity offset achieved**
Project Site Selection	To prevent biodiversity loss, new or improved road construction, to the maximum extent possible, natural habitat areas were avoided.
Tree canopy cover cum arboreal bridge	This initiative increased the tree outside the forest (TOF) in the area by 2% and canopy cover by 20%.
Good Road Engineering	Large hair pin bends were developed in to ponds an enhancement of aquatic eco-system
Measures adopted	**Biodiversity offset achieved**
Avoid hunting in project area & construction camp	No hunting and wild animals' road killings.
Proper siting of construction camps	Saved the biodiversity of forests, Wetland and agriculture lands. Plantation around the camp enhanced the green cover of the area
Indigenous technology of bio-engineering	- Plantation of 50,000 sapling with survival of 22,000 trees with good canopy cover at the end of 10 years about - Increased the tree outside the forest (TOF) in the area by 2% and canopy cover by 20%. - New green cover area of about 1153,000 sq.m due to plantations on slopes and disposal sites. - No introduction of alien species in afforestation and camp restoration - Stable hill side slopes and valley side slips with plantation for last 10 years - Shannon Weiner index - increased for trees from 2.78 to 3.10, for shrubs 3.35 to 3.46 and shrubs 3.11 to 3.26 - Stable sites used as agriculture land - Stable large disposal sites are being used as schools and village markets. - People participation in environment management, employment generations and improvement of livelihood
Use of local material ,survival of 22,000 trees with good canopy cover at the end of 10 years & New green cover area of about 1153,000 sq.m due to plantations on slopes and disposal sites	- Reduction of carbon emission - Reduction in carbon foot print of the project - Increase in Ecological foot print of the area.
Savings and diversion of fund for environmental enhancement	Huge savings were achieved and part of the fund was utilized for management of the compensatory afforestation sites and environment enhancement measures.
Proposal for Biodiversity offset credit and Bio-banking	- Awareness on Biodiversity offset credit and Bio-banking for future projects

Road side plantation was done for entire 115 km of the road with locally growing tree and shrub species. About 50,000 saplings were planted at the end of 10 years about 22,000 trees with good canopy cover was enumerated. This initiative increased the tree outside the forest (TOF) in the area by 2% and canopy cover by 20%.

Using locally available bamboo to terrace the hillslopes for cultivation is a well-known and age-old practice in Mizoram. This new concept of using this bamboo to bind and stabilize the hill slopes on both the hill and valley side of the road, as well as on debris disposal sites was introduced. This combined the traditional techniques long employed by the local people with new ideas about how to expand their use. In Mizoram, given the local people's traditional know-how and ease in handling bamboo, the team adapted the techniques to suit local conditions by using the abundantly available bamboo. Bamboo terracing, bamboo crib walls, bamboo knitting and researcher's new technique of bamboo matting were developed to suit the slopes as presented in plate -2.

Soil binding, deep rooted, nitrogen fixing, bird feeds, ornamental from indigenous plants selected for slope protection and stabilization of disposal sites are - *Tephrosia candida, Abutilon rhombifolia* (Khingkhih), *Abutilon cordifolia* (Khingkhih suak), *Trema orientalis* (Belphuar), *Dysoxylum procerum* (Thingthupui), *Bischofia javanica* (Khuangthli), *Alstonia scholaris* (Thuamriat), *Artocarpus heterophyllus* (Lamkhuang), *Melocanna baccifera* (Mautak), *Gmelina arborea* (Thlanvawng), *Acrocarpus fraxinifolius* (Nganbawm), *Ficus benghalensis* (Hmawng), *Dendrocalamus hamiltonii* (Phulrua), *Thysanolaena maxima* (Hmunphiah), *Rhus semialata* (Khawmhma), *Dillinia indica* (Kawrthindeng), *Phyllanthus emblica* (Sunhlu) .

Implementation was assigned to local village councils. The local people had retained the traditional skills of working with bamboo; they also knew where to collect the raw material from as they knew where the bamboo forests were located. This promoted people participation in environment management (Plate -2)

Bioengineering measures for slope protection were implemented on 115 sites, covering an area of about 1153,000 sq. m., at a total cost of about US$98,000. The estimated cost of conventional civil works would have been about US$710,000 to US$1.0 million for the same area which was a huge saving for the project. Besides the restoration of slopes, valley side slips and management of dump sites some environment enhancement measures like creation of ponds by changing the road alignments (Plate -3). Biodiversity offset achieved in this project has been summarized in table -1.

CONCLUSION

India is a signatory to the Convention on Biological Diversity (CBD), and Article 14 of the CBD identifies impact assessment as a key tool for achieving the conservation of biodiversity and the sustainable use of its components. Biodiversity issues therefore need to be given more importance and should be included in transport policies, plans, program and projects.

There are many ways to avoid significant impacts on biodiversity, and mitigate adverse effects due to road development. If these are considered at the earliest stages in the planning and design processes, outcomes are likely to be less harmful and transport projects will help to achieve the commitment to ensure that the impact of transport networks must not threaten ecosystems, while supporting sustainable development.

Incorporating biodiversity conservation into the design and implementation of road projects will be an important example of how the goal of environmentally sustainable development can be translated into a concrete reality.

Many transportation planners, engineers, and environmental scientists worldwide recognize that roadway systems need to be more sustainable in light of finite natural resources, sensitive environmental conditions, and limited economic resources. Thus, transportation systems need to be planned, designed, constructed, and maintained in a fashion that properly manages the potentially negative environmental and social impacts and risks while attempting to promote directly and indirectly related positive impacts or benefits.

Nation's vision of road development should be - a world without poverty through a strategic and operational focus on the linkages between a healthy environment, sustainable use of natural resources, and poverty alleviation. The vision should include social inclusion and environmental sustainability to ensure that progress benefits the poor and does not come at the expense of future generations.

A national strategy or policy on biodiversity offsets can help to address issues of validation, market size, and coherence, thus realizing "aggregated offsets" - i.e. measurable conservation outcomes resulting from coordinated actions arising from more than one development project. The central as well as state governments need to promote for biodiversity offset credit and bio-banking concept to implement biodiversity offset. An offset credit can involve habitat expansion (creation), habitat restoration measures, and habitat protection when the habitat was previously under threat.

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Conflicts of Interest: The author declares no conflict of interest

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