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A critical review on environmental impact assessment of highway development in Himalayan region

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Abstract
The environment is severely degrading globally by many factors, one of which is highway development. EIA is the starting point in the process of implementing sustainable development agenda and most effectual tool for integrating environmental concerns in development planning and implementation. Transportation plays a vital role in the development of a country's economy; citizen's quality of life, access to goods and services and also the pattern for distribution of economic activity. This paper reviews the direction of a research study conducted to understand the quality of air, soil and water as well as impacts on socio-economic conditions of local habitats from highway and road construction activities.

Keywords: EIA, highway expansion, environment degradation, ecosystem fractured

Introduction
Environmental Impact Assessment (EIA) is an activity to assess the environmental outcomes of any project and design proper alleviation plans to diminish the possible unpropitious impacts (Sadler and Verheem, 1996) [63]. EIA is to identify, assess, predict and alleviate the environmental, social and other potential impacts and consequences of projects preceding to major decisions being taken, to recommend suitable mitigation measures and to reduce possible adverse impacts (Kaya and Kahraman, 2011) [44]. To predict the kind, magnitude and probability of environmental as direct or indirect result of a plan or policy and to decrease adverse effects, EIA is a good management tool Momtaz *et al*. (1998) [54]. EIA process and execute antecedent to any developmental project in order to make certain that no inauspicious effect will be on the environment. EIA provides a monitoring programme which is designed to measure the uncertainty of impacts. A well timed and suitable modification in the project can be included which ultimately help the project itself by conducting an early EIA (Anjaneyulu, 2002) [6].

Major environmental impacts of development projects are habitat destruction, loss of arable land, loss of biodiversity, waste disposal, pollution, desertification, soil erosion and material wastage Puri *et al*. (2015) [60]. Human activities are both beneficial and harmful for environment such as biological, cultural, social, economic impacts and so on and they must be taken into consideration when the development projects or plans are evaluated (Dutta and Sengupta, 2014) [22]. Ecological balance is of global prime concern for the environmental planners due to resulting consequences like global warming, acid rains and depletion of ozone layer (Canter, 1996) [14].

Highway projects are generally undertaken to improve the efficient connectivity, economic and social welfare of the people. Highway network is one of the important components of transportation system at the National, State and local levels. In the words of an economist, Jerrmy Bentham: "Roads are the veins and arteries of a country through which channels every improvement circulates". Assessment of impact on ecological attributes is one of the main components of EIA for highway project (IRC, 1989) [38].

Road construction has wide range of impact on the water resources, arising from activities such as earth moving, removal of vegetation, vehicles/machine operation and maintenance, handling and laying of asphalt, sanitation and waste disposal at labour camps. These mentioned activities lead to siltation, loss of water bodies through filling as well as alteration of drainage, flooding, water logging and contamination of water bodies through solid and liquid wastes. Highway development and operations should therefore, be planned with careful

Consideration of the environmental impact (Fig 1). In the recent years, the need for developing adequate road transportation infrastructure has been realized by Government of India and various state Governments. Various State Governments have also started projects for upgrading some of the state highways. All these efforts are intended to provide improved road transportation facilities for passenger and goods traffic. Highway development projects cause ecological destabilization and habitat disturbance of the surroundings. Ecological balance is of global prime concern for the environmental planners due to resulting consequences like global warming, acid rains and depletion of ozone layer (Canter, 1996) [14]. The conservation of biological diversity is an important global environmental concern (Diamantini and Zanon, 2000) [20]. Roads are long and linear structures and therefore, road development projects are more susceptible to ecology as compared to other types of development projects Byron *et al*. (2000) [13]. The effects of highway activities have been depicted in Fig 2.

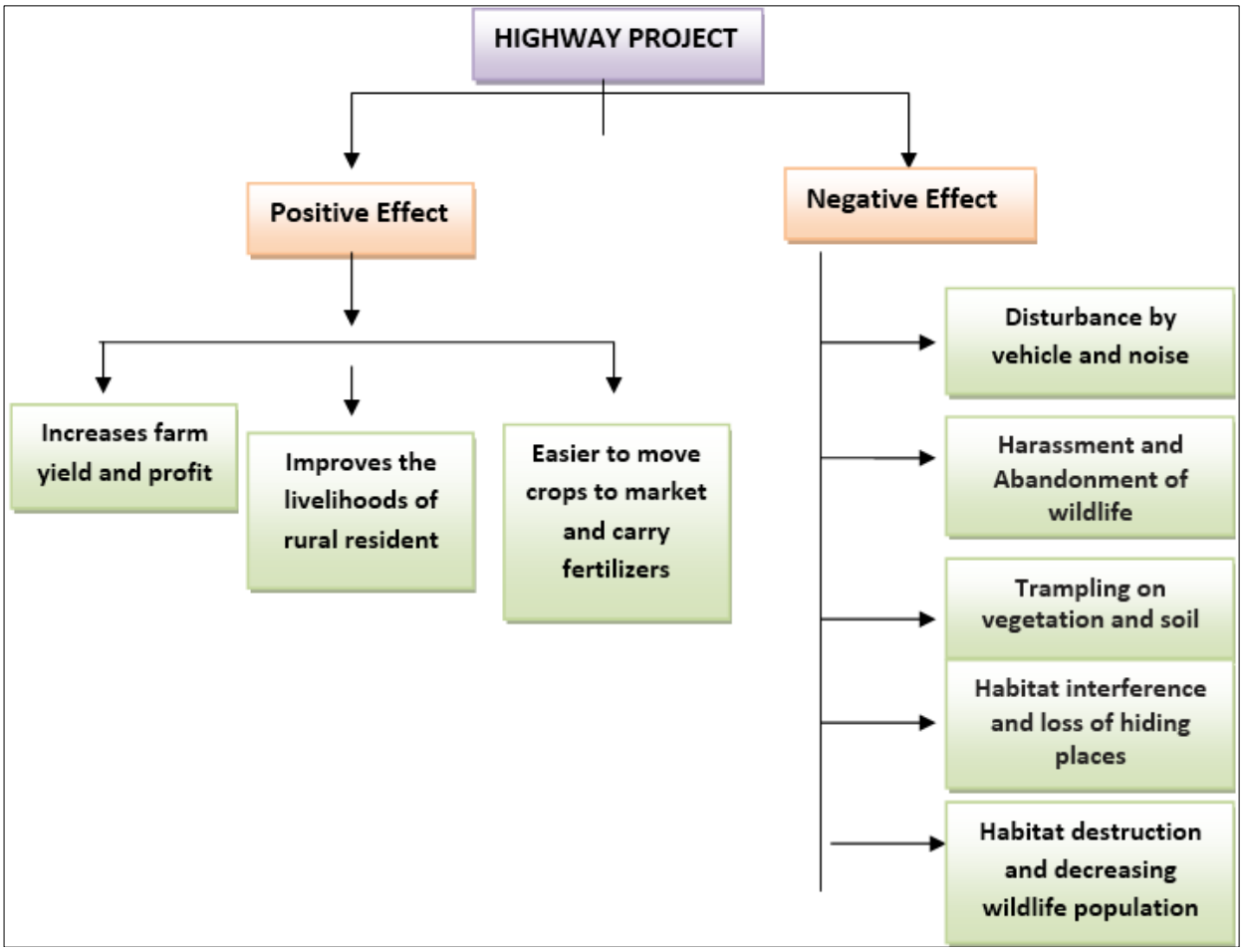

Fig 1: Impacts of highway development on environment

Development with environmental protection and sustainability are the main goal of the policies of Government of India. In India, Ministry of Environment, Forest and Climate Change (MoEFCC) has made it mandatory to conduct Environmental Impact Assessment (EIA) for major Highway projects (MoEFCC, 1994) [53].

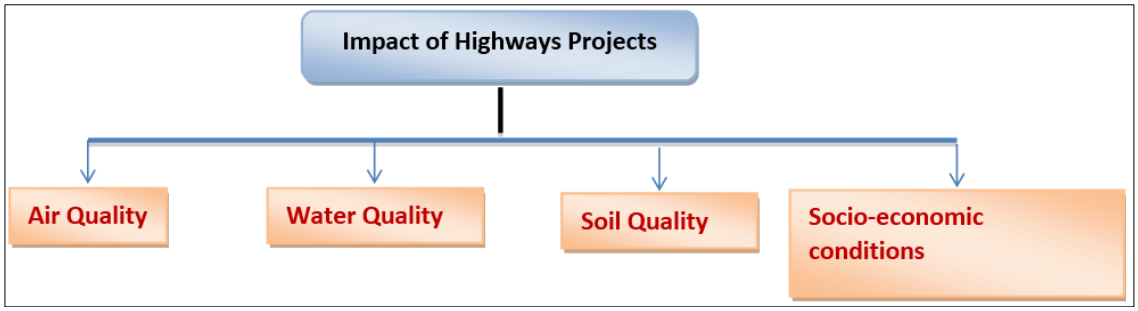

Fig 2: Effects of highway activities

Effects of highway development on environment

Positive side of transport is undeniable. However, despite the wide range of benefits Agrawal *et al.* (2014) [2] transportation activities bring variety of adverse impacts to the degradation on environment qualities and human health (Button and Rothengatter, 1993) [12]. The forest roads expansion impacted the water, air, soil and biodiversity (Thakur and Sar, 2012) [70].

Air quality

Rapid growth in road transportation sector may leads to increased emission of vehicular exhaust, resulting in deterioration in the quality of ambient air. Several pollutants are emitted by automotive vehicles depending upon the type and quality of the fuel consumed by the vehicle. The release of pollutants from vehicles may include fugitive emissions of the fuel, therefore, the source and level of these emissions depending upon the type of vehicle as well as its maintenance, etc.

Several columnist agree that air pollution affects growth adversely (Bhatia, 2006) [11]. Industrialisation with increasing energy demand, expansion of cities and rapid economic development are said to cause increase air pollution Oliva *et al*. (2007) [59]. Studies also showed the impacts of air pollution on the Chlorophyll content Flower *et al*. (2007) [25], Ascorbic acid content Hoque *et al*. (2007) [37] and pH in plants. The dust released from tear and wear of tires contains Cd^{2+} that is deposited on leaves which ultimately leading to blockage of stomatal gas exchange also culminates in reduction of the photosynthetic activity of plants (Hedaya, 2008) [35].

Traffic emission and automobile exhaust particularly from lubricant oils, leaded gasoline and motor vehicle tires leads to increasing levels of elevated lead (Pb^{2+}) and cadmium (Cd^{2+}) in urban areas (Sharma and Prasad, 2010) (Table 1). The ascorbate and glutathione dependent oxidative potentials of PM2.5 and PM10 at AQMS-S over the pre- and post-road widening scheme were assessed and were sensitive to regional particulate matter components (Kelly and Fussell, 2012) [45].

Dhyani *et al.* (2014) [19] recorded the concentration of carbon monoxide on 6 lane NH-2 along the Ashram chowk CRRI road of 2.8 Km under prevailing meteorological conditions and traffic by running CALINE-4 model using emission factor specified by ARAI for Indian vehicles. It was concluded that impact of vehicular emissions on air quality was confined to 160 meter on both sides depending upon traffic as well as meteorological conditions.

Font *et al*. (2014) [26] also recorded that after the completion of the road widening or construction activity, there was an increase in all the pollutants from the road during rush hour: 1 $\mu g\ m^{-3}$ $PM_{2.5}$, 2-4 $\mu g\ m^{-3}$ for PM_{10}, 8 and 40$\mu g\ m^{-3}$ for $NO_2$and NO_X, respectively illustrating a notable deterioration in residential air quality.

Amin *et al.* (2017) [4] also estimated air pollution from the additional traffic during as well as after the construction activity of A-25 extension project. The levels of NO_2 were spatially interpolated during peak and off-peak hour traffic and traffic density simulated on the road network for four scenarios. It was found to be the levels of NO_2 concentrations were reduced at neighbour areas due to less traffic during the construction period whereas, levels of NO_2 after the construction were higher than those in the year 2008.

Table 1. Key pollutants and their effects on human health (Colin and Michael, 2005; Amer, 2007)

Name of pollutant	Effects on human health
Heavy metals	Exposure will lead to irreversible brain damage and also lead to premature deaths.
Nitrogen dioxides	Linked to a wide range of respiratory problems; sore throat and cough
Particulate matter	Acute exposure will lead to death, decreased lung function, pulmonary inflammation and increased respiratory symptoms, Chronic exposure will increased mortality
Carbon monoxide	Have great effect on the oxygen delivery to the body's tissues and organs, and may cause death.

Soil quality

Soil is an vital component of the natural environment, as well as a primary medium for many biological and human activities, mainly including agriculture. Its conservation in relation to road development deserves considerable notice. In the road itself, there are many places where damage might occur, such as in borrow pits, or around rivers and streams. For the road agency and others, losses can be considerable, which includes farmers losing land and crops, because of sedimentation in rivers and lakes, fishers losing income, therefore, road users being delayed when the road structures or embankments collapse Manta *et al*. (2002) [52]. The costs of correcting these problems are often many times greater than that of costs of simple preventive measures.

Metals such as lead, chromium, and zinc, remain in the soil for hundreds of years. Emissions from heavy duty and commuter vehicles on the roads were reported to contain cadmium (Cd), lead (Pb), nickel (Ni), zinc (Zn), and Copper (Cu), which are present in fuel as anti-knocking agents leads to contamination of soils and air Bai *et al*. (2009) [8].

Forest soils can suffer from number of threats, some of which are human induced. Although mechanized harvesting allows for high productivity, it may also solemnly damage forest soils. In recent decades, the use of heavy and powerful machinery in forest management has increased exponentially. The degree, extent, and duration of undeviating and deviating effects of heavy traffic on soils depend on various factors, such as moisture, soil texture, slope of the terrain, organic matter content, size and type of vehicles, tire shape, wheel inflation pressure, and number of vehicles trips. The alteration of ground morphology and topsoil compaction are crucial straight effects of forest harvesting carried out using heavy equipment Shuqing *et al.* (2007) [67]. Soil compaction results in porosity reduction, which implies limitations in oxygen supply and water supply to soil microorganisms and plants, with negative consequences for forest productivity and soil ecology. Compaction, especially when confined in ruts, also has dramatic ramifications in terms of erosion and runoff of the most fertile soil compartment that is the top soil. In compacted soils, forest regeneration can be prevented for long time periods.

Some points related to soil impact on nature

- Dislodge and compressed soils resulting in loss of biomass productivity.
- Altered conditions that change plant growth, soil pH, and the vegetative community structure (i.e., water retention and light levels; temperature, soil displacement, and compaction; and dust).
- Increased erosion leading to nutrient and sediment delivery to wetlands and streams, which results in adverse impacts to aquatic species (e.g., fish, their prey, and other species) and habitats.

Ndiokwere (1984) [56] investigated that the effect of automotive emissions of Cu, Cd, Ni, Cr, Pb and Zn on soil along a highway with heavy traffic density. The decrease in concentrations of the metals with distance was found and high accumulations of the metals on soil samples near to the highway than from sites at a greater distance was also noticed.

In the United States, about 19% of the total land area has been directly or indirectly affected by public roads system (Forman, 2000). These effects mainly resulted from habitat degradation, sedimentation, changing of leaf processing and inputs of toxins from construction materials (Eldin, 2002) [23]. The sources of heavy metal accumulation in soils were industries and traffic emissions (Wei and Yang, 2010) [72] therefore, decreased with increasing distance. On very busy roads (over 20,000 vehicles per day) soil contamination can arise from daily traffic operation. Naser *et al.* (2012) [55] found that heavy metal content with that of the distances from the road in the order of Ni>Pb>Cd at 0m >50 m>100 m>1000 m distances, respectively. Excess of metal pollutants deposited on soils gets transported and transformed to vegetation and then from plants they passed on to animals and human beings and thus, affects the quality of food and safety. Food chain contamination is a fundamental pathway for the entry of many toxic pollutants into the human body. The heavy metal pollution in soil at Motorway (M-3) in Nigeria was found to be in permissible limits but it slowly passed to the food chain, which if not monitored would result as a terrible menace for all living beings as well as for environment Chamen *et al*. (2003) [15]. Researches may have their application as bio-indicators to detect the presence of various atmospheric pollutants on plants for prediction and identification of environmental pollutants.

Water quality

Historically, construction activities have identified as a main source of pollutants to natural water bodies such as lakes, rivers and streams. The sources of water pollutants at construction sites primarily include soil erosion, oil and diesel, solvents, paint, cleaners and other harmful chemicals and construction dirt and debris. Pollutants generate from these sources are added to the water bodies through both direct discharge by workers at the sites and as well as non-direct discharge, which results with the storm water runoff leading to physical, chemical and biological degradation of quality of water. As well as when urbanization progress, new highways are constructed for development and transportation, and hence, stream ecosystems within highway corridors are highly susceptible to impacts from construction projects. As one of the major nonpoint pollution sources, the construction of new highways can have short- and long-term effects on biotic and abiotic conditions of stream (Barton, 1977; Chisholm and Downs, 1978; Cline *et al*., 1982; Taylor and Roff, 1986; Anderson and Potts, 1987; Stout and Coburn, 1989; Wellman *et al*., 2000; Hedrick *et al*., 2007) [9, 16, 17, 69, 5, 68, 73, 36]. These effects mainly resulted from habitat degradation, sedimentation, changing of leaf processing, and inputs of toxins from construction materials (Barton, 1977; Chisholm and Downs, 1978; Stout and Coburn, 1989; Eldin, 2002) [9, 16, 68, 23]. However, few studies have also reported the effects of highway construction on biotic and abiotic conditions in the highlands. One section of a new four-lane paved highway, the Appalachian Corridor H, was constructed from June 2000 to August 2003 in the Lost River watershed, north eastern West Virginia. Gillilan, (2003) [31] investigated that the West Virginia Division of Highways (WVDOH) implemented sedimentation ponds, silt fencing, mulches, and grass seeding as BMPs to mitigate possible environmental effects from the Corridor H construction. Hedrick *et al*. (2007) [36] also found no remarkable effects of the highway activities on benthic macro-invertebrate metrics and fine sediment in two tributaries of the Lost River neither during construction nor 1year after construction activities from 2002 to 2004. However, longer-term effects of highway construction activities on biotic conditions and water quality at the watershed level are still unclear.

Some major points related to water quality which effect ecosystems

- Reconstructed landforms can result in changed hydrologic regimes such as altered water table position; increased water temperatures; interrupted groundwater flow diverted to surface systems; changes in the timing of runoff; drained natural wetland habitats; unintentional artificial wetlands; and altered or restricted channels which can result in altered streambed materials)
- Altered stream flow, mainly the timing as well as intensity of low and high flows
- Reduced size, number, and depth of stream pools, which hence, diminished the habitat for fish and other aquatic organisms
- Drastically altered large organic debris input to streams, which can ultimately affect channel morphology and alter habitat
- Diminished stream bank vegetation where roads are located in riparian areas

Trombulak and Frisell (2000) [71] investigated that 14,108,812 km of road lanes of all types in conterminous United States, with an average width of 3.66 meter per lane, have demolished at least 4, 351, 784 hectare of water bodies and land that especially supported plants, animals and other organisms. Abewickremal *et al*. (2013) [1] also studied impacts of Highway construction projects on natural water bodies in Sri Lanka. The baseline data was collected before the construction activity to study the impact from four major Highways. Water samples were collected for analsis of Electrical Conductivity (EC), pH, Total Suspended Solids (TSS), *Escherichia Coli (E. coli*), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD). The results showed the higher variation in total suspended solids due to higher runoff rate because of larger slopes of the road surfaces. Increase in BOD and *E. coli* were attributed mainly due to uncontrolled runoff and discharge from the site as well as the reason for increase in DO was unclear.

Shridhara *et al*. (2014) [66] assessed the potential impact upgradation from Padubidri to Karkala of 2-laning of State Highway. Loss of cultivation land also resulted from the formation of labour camp, construction camp and concrete batching plant. The concentration of PM i.e., less than 10µ for 24 hours was found to 65.26 µg/m^3 in construction site and NO up to 12.82 µg/m^3 duration. The potential impacts of dust and air pollution on construction site minimized at source by proper handling and maintenance of construction equipment, plantations of trees on road side and evolution of green belts. However, Wu *et al*. (2014) [75] have conducted interviews, to analyse the effects of Highway-6 construction on Puli Township, and revealed that both socio economic and biophysical factors were the main forces driving land-use change along major roads. Specifically, highway construction and successive urbanization under various land-use policies resulted in varying degrees of disintegration and isolation of habitats in the overall landscape pattern in Puli Township.

Socio-economic condition

Highway development has its impact on poverty status and socio-economic conditions of well-being of the people living

in its proximity, through greater transport mobility and connectivity. Major import and export of goods communication services and transportation within a community as well as between communities take place through roads Lalnundanga *et al.* (2015) [46]. The construction of roads not only improves the livelihood of the community but it also increases the number of educational institutions as well as health centers. Most of the people are also engaged in certain jobs such as handloom and carpentry as they can now easily export and import their goods due to better roads. Being a hilly state with difficult climatic conditions and terrains, transport infrastructure is essentially road-based for most community, personal purposes and business as well as being the only principle means of communication (World Bank (1994) [74]. A well maintain road network is essential for cost effective movement of people and material, without which trade and industry not maintain a competitive edge. Researchers have sought to link transportation improvements with economic growth and development and have shown significant and positive correlations between highway transportation infrastructure and economic activity (Gibson and Scott, 2003) [30]. Kamboj and Kumari (2017) [43] reported that the highway development enhances mobility and was critical to the economic growth of a community and a country as a whole. Unfortunately, inappropriately planned, designed and constructed highways can aggravate the conditions of the poor and harm the natural and socio-economic environment. The common adverse impacts of highway development include damage of natural landscape, habitat and bio-diversity, destruction of cultural and social structure of affected communities, creation of air and water pollution and generation of noise and vibration.

Ingle *et al.* (2005) [39] reported that the shopkeepers working at the highway sides are at high risk of exposure to the air pollution caused by heavy highway traffic. The lung function test of the shopkeepers showed significant decrease in forced vital capacity, forced expiratory volume in one second and peak expiratory flow rate as he observed the inferior ambient air quality near highway passing through Jalgaon urban centre during May 2003 to April 2004. Growder *et al.* (2009) [32] investigated that a major public sector investment project like road infrastructure development directly or indirectly improves socio-economic well-being of the society in close proximity to the highway, with greater transportation mobility, increased access to the various economic opportunities, connectivity with surrounding areas and appliances of life. Dissimilarity does exist between the positive and negative impacts effects of highways on rural areas. Evidences recommend that road infrastructure have an influence on rural economic development.

Biodiversity

Biodiversity is mainly threatened by rapid infrastructure activities and its associated ecological effects (Forman, 2003; Laurance and Balmford, 2013; Laurance, 2015) [28, 47, 48]. Infrastructures leads to alter the ecological conditions, cut through highly suitable habitats, and more over reduce the populations of many species of wildlife (Fahrig, and Rytwinski, 2009; Benítez-López, 2010) [24, 10]. Anthropogenic modifications and urbanization cause extent of habitat fragmentation and mainly lead to decline in the local biodiversity. As a result of which more species, including alien and native plants, halophyte and non- halophyte species, cosmopolitic and threatened species, were found prosperous at roadside. The growing anthropogenic modifications frequently disturb and alter natural regimes in every ecosystem and also cause extent of fragmentation and habitat loss (Davies and Pullin, 2007) [76], which can be highly detrimental to the persistence of species, leading to decline of local biodiversity and alternation of ecosystem process (Flory and Clay, 2009). On one hand, isolated habitat can no longer support viable populations in the long-term (Davies and Pullin, 2007) [76]. On the other hand, a reduction in landscape connectivity decreases the probability of individuals successfully moving between habitat patches (Klein, 1989; Baguette *et al*., 2000) [7, 51]. Therefore, in the conservation of biodiversity, connectivity of habitat patches within a landscape has become a key issue (Klein, 1989) [7].

Forest roads are termed as "ecosystems" as they occupy ecological space Hall *et al.* (1992) [34] and provide habitat for associated plants and animals (Lugo and Gucinski, 2000) [50]. Road infrastructure causes indirect and direct loss to forest ecosystem. Direct loss may refers to the reduction of forest area and indirect loss of roads may refers to degradation and fragmentation of the ecosystem (Geneletti, 2003) [29]. One of the major effects of roads relates to its edge effects, which can be defined as the alternation to habitat quality due to proximity to edge. It can cause indirect loss of habitat by changing temperature, moisture, species composition, wind speed and light availability and, therefore, leads to alteration in original biodiversity (Gysel, 1951) [33]. Roads are the most widespread forms of the natural landscape during the past century, correspondingly, the value of road as a corridor, changing the degree of isolation of animals and plant populations in fragmented landscape, should be also considered (Ojha and Bhattarai, 2001) [58]. The use of road to preserve local biodiversity has been an area of considerable debate over the past two decades. Proponents argue that roads act as conduits, facilitating the movement of individuals between isolated patches of remnant habitat, thereby promoting gene flow, reducing population fluctuations and decreasing extinction risk. Therefore, roadside is sometimes regarded as the last favourable refuge for plant species in many fragmented agricultural areas.

Sheng-Lan Zeng *et al.,* (2010) [65] investigated that except for new roads group, roadside habitat harboured higher value of species richness than that of non-road disturbance areas Additionally, in total 100 species were identified, which include 33% alien ones and 67% native species. Amongst these species, 98% species were found at the roadside and only 20% in non-road disturbance areas, which meant that almost 80% of plant species only survived in roadside habitats.

KC and Gautam (2012) [40] were found that, 8 plant species including 5 tree species, 2 shrub species and 1 woody climber species in the study area. A total of 7 plant species were found in the effect-zone at 25 m distance while a total of 6 plant species were found in the effect-zone at 55 m distance. Three tree species, one shrub species and one woody climbers were common in both the effect-zones (Table 2). The difference in species richness between the two zones could be due to the edge effects, which often results higher species richness and greater numbers of exotic species at the edges Ranney *et al.* (1981), and potential ecosystem processes and productivity function alters Laurance *et al.* (1997) [49].

Table 2: List of plant species found in the two effect zones.

S. No	Local Name	Botanical name	25m distance	55m distance
1	Jamun (T)	*Syzigium cumini*	√	√
2	Sissoo (T)	*Dalbergia sissoo*	√	
3	Sal (T)	*Shorea robusta*	√	√
4	Ranisalla (T)	*Pinus roxbughii*		√
5	Bhorla (W)	*Bauhinia vahlli*	√	√
6	Latimauwa (S)	*Engelhardia spicata*	√	
7	Mainfalkada (S)	*Catuna regamspinosa*	√	√
8	Khannyu (T)	*Ficus semicordata*	√	√

In urban areas, contamination of vegetation by airborne trace metals is particularly massive, notably along highways. The pollutants released by the vehicular exhaust emission bring changes in the growth form of the plant species growing close to the busy roads as well as could involve in the extinction of some vital species Kabir *et al.* (2012) [42]. The discharge of various types of air pollutants affecting the vegetation, is the problem posed with increase in fleet of vehicles (Jyothi and Jaya, 2010) [41]. The study indicated that higher Cd^{2+} concentration was observed in *Nerium oleander* L. and *Platanus orientalis* L. in the roadside and urban plant leaves as compared to control, which was collected from the city. The plants have positive correlation with traffic density. The concentration of Pb^{2+} in *N. oleander* was 50.48 μg g^{-1} at a distance of 1 meter and 1.13 μg g^{-1} at a distance of 50 meter (Doganlar and Atmaca, 2011) [21].

Nergiz and Durmus (2016) studied the effects of restoration activities and road reconstruction on birds such as, European bee-eater (*Merops apiaster*), Sand martin (*Riparia riparia*) and European roller (*Coracias garrulus*) nesting at roadside in Van, Turkey. To determine the effects, a survey was conducted in year 2013-2015 along the 86 kms long Highway in Van and demonstrated that total population number of the species and nests decreased during and after the road construction and broadening efforts between the years 2013-2015. These three species failed to find alternative nest area affected by habitat destruction caused by road construction activity.

Conclusions

Large areas of forest are destroyed during road construction, which not only results in economic losses, but also changes the conditions of the environment. Forest road construction is a hazardous operation in hilly terrain and can inflict mark on the landscape and also cause substantial damage to the forest ecosystem. In mountainous terrains, to prevent soil erosion clearing of trees should be kept to a minimum. When working close to waterways, it is necessary to take preventative measures to prevent sediment from washing into streams. Precautions may include installation of silt traps or silt screens. Different environmental elements will be demeaned by the construction work like forest, wetland, hydrology, fisheries, soil, air, water, agricultural land etc. But, taking precautionary measures and adopting eco-friendly technologies can reduce these impacts. Also, the mitigation measures would be sustainable and long term durable of the proposed road construction project.

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Conflict of Interest

There is no conflict of interest for this manuscript.

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