ROAD NETWORKS AS ECOLOGICAL CORRIDORS: A CASE FOR SUSTAINABLE ROAD LANDSCAPES IN INDIA

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ABSTRACT

With over 3.3 million kilometres of roads across India (NHAI), roads and highways together form the single largest contiguous network of open space available in the country today. This transit network has 96,000km of national highways alone, set to increase exponentially to 200,000 km. Expressways, state highways, major district and rural roadways are also expanding rapidly.

During this phase of exponential growth, transport networks provide the opportunity to address landscape ecology at a vast scale, at multiple levels be it national, regional, state or local level. Road networks must be considered within the ambit of a larger vision for open space development with sustainable strategies for diverse landscapes and critical biodiversity hot spots.

Designing roads for speed and efficiency, the consequent deforestation, barriers to migration, wildlife fragmentation, loss of habitat and adverse impact to water and soils changes the regional landscape ecology. Attempts to mitigate the effects of particulate emissions, noise pollution and heat and glare too are lost when landscape development is addressed belatedly.

This paper advocates the need for a balanced approach towards the transit corridor planning in light of development pressures, climate change challenges, water management opportunities, need for disaster preparedness and wildlife migration corridor preservation in India. An integrated planning approach enhances and encourages local engagement, native plantation and regional ecological diversity. Whereas the economic impetus of road expansion is pressing, a comprehensive approach to transport corridor planning and design addressing the socio- cultural, ecological issues and long-term adaptation to changing climate is equally urgent.

INTRODUCTION

With over 3.3 million kilometres of roads across India (*1*), roads and highways together form the single largest contiguous network of open space available in the country today. This transit network has 96,000 km of national highways alone, set to increase exponentially to 200,000 km. The National Highways, 1.7% of the road network carry 40% of road traffic alone. Expressways, state highways, major district and rural roadways are also expanding rapidly.

During this phase of exponential growth, transport networks provide an opportunity to address landscape ecology at a vast scale, at multiple levels be it national, regional, state or local level. Road networks must be considered within the ambit of a larger vision for open space development with sustainable strategies for diverse landscapes and critical biodiversity hot spots. This is a unique opportunity for developing India and unparalleled in its scope of influence.

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landscape ecology. Attempts to mitigate the effects of particulate emissions, noise pollution and heat and glare too are lost when landscape development is addressed badly or belatedly.

This paper advocates the need for a balanced approach towards transit corridor planning in light of development pressures, climate change challenges, water management opportunities, need for disaster preparedness and wildlife migration corridor preservation in India.

TRANSIT CORRIDORS AS LANDSCAPE CORRIDORS

An integrated planning approach enhances and encourages local engagement, native plantation and regional ecological diversity. Whereas the economic impetus of road expansion is pressing, a comprehensive approach to transport corridor planning and design addressing the socio- cultural, ecological issues and long-term adaptation to global warming is equally urgent.

Reimagining highway corridors as landscape corridors, requires looking at the planning, design and implementation of highway corridors through various lens, towards creating myriad benefits. This will also address obligations made by the Government of India (GoI) to implement the UN Sustainable Development Goals- 3 (Good Health and Well Being), 13 (Climate Action) and 15 (Life on Land), the Paris Climate Accord.

SCOPE OF IMPACT

Indian roads today account for 65% of freight and 80% of passenger traffic across the country.

Distinct classifications of road systems include Expressways (200km), National Highways (96,261km), State Highways (1, 31,899km), Major District Roads (4, 67,763 km) and Rural and Other Roads (26, 50,000km) (*1*). Together they serve long distance cross country traffic, interstate, intrastate, connector and local traffic across the length and breadth of India.

This year alone, 1,627km of highway was added at an average of 26.3km per day alone. And the GoI plans to double the length of the National Highway network to 2, 00,000km, and build 50,000km of roads by 2022.

There are a number of other National Highways being developed across the country. Compilation of data by regional offices of sixteen (16) cities across the country identifies the average width of the ROW available for plantation. This varies from 0-62m available on the left and right hand side of the road, depending on area, land ownership, and other conditions. It also varies for different stretches.

With an assumption of an average of 0.5km width of area available for plantation across all country, for the 50,000km of additional roads planned by 2022, a minimum of 25,000sqm of area will be available for landscape development. Availability of land could increase this minimum consideration to a more robust regional landscape plan. Taking into account space available adjacent to the 3.3million kilometres of roads the same area could be as high as 1,650,000km.

One such national highway system is the Golden Quadrilateral- the largest highway project in India, and fifth longest in the world, begun in 2001. 5876km of 4-6 lane roads connect the four metropolitan cities form a quadrilateral. This system alone has the potential to respond to critical needs not only transport infrastructure, but climate change, preservation of water, biodiversity, and contextual ecological and social connections.

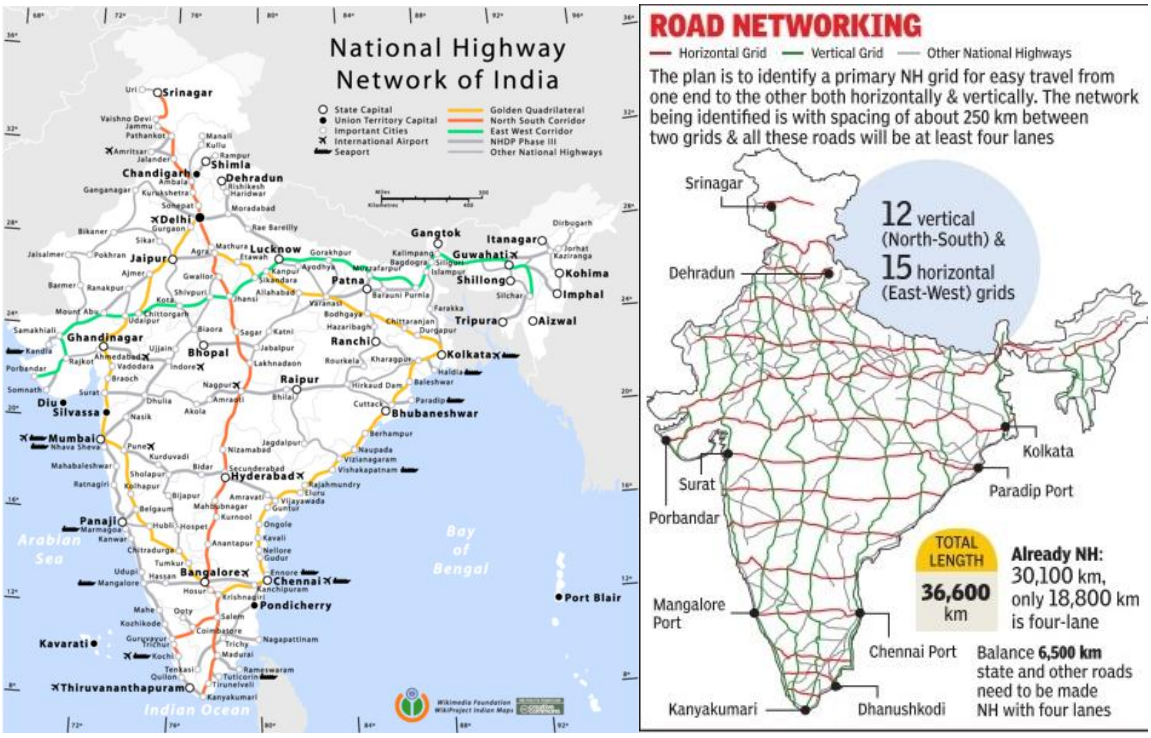

FIGURE (a) National Highways of India & (b) Proposed National Highway System

(Source: http://economictimes.indiatimes.com/news/economy/infrastructure/government-plans-national-highway-grids-for-smooth-travel-27-corridors-identified/articleshow/52723683.cms, http://www.factsninfo.com/2014/05/facts-and-information-about-indian.html)

BACKGROUND

One aspect of particularly high-speed expressways across the world is the focus on the commute, with lesser considerations to context- the surrounding habitat, vegetation, communities and cultural distinctions. In some cases, transport planners and engineers have addressed the context, particularly in the US highway systems through National Parks and across the countryside.

US Scenic Highway System

Initially developed in a piecemeal fashion, in the early 20th century, with four parkways in New York State, scenic routes were developed for economic growth and preservation of natural resources. Hailed then and thereafter as engineering and landscape feats, in 1964, a National program of scenic roads and parkways was authorized to increase outdoor recreation opportunities, exploration of scenic and natural beauty, substantial economic benefits of tourism and sightseeing and potential gains of aesthetic benefits. This was followed by the Highway Beautification Act of 1965, and the development of a National Scenic Highway System in 1973*(2)*. This system highlighted five issues-

- National designation of scenic roads
- Corridor protection and scenic enhancement
- Complementary facilities
- Urban emphasis and energy efficiency
- National connectivity

Their recognition and success as Scenic Highways are in large part due to their responses to the context. Exploration of mountains, grasslands, scenic ocean views etc. became part of the American transportation journey. India is at the same juncture of road infrastructure development that the US was in the 1930s, with the setting up of highways for employment and connectivity.

FIGURE: (c) Scenic Route along India- Myanmar Highway

(Source: http://www.egis-india.com/activities/roads-and-highways)

Travel of Indian Roads

In India, the rapid road infrastructure development taking place currently is unprecedented in scale and the footprint it covers. The only precedent to large scale infrastructure development at this scale is the Indian Railways in the latter half of the 19th century.

Travel in India has many cultural connotations. Due to the hardship involved, it was always seen with trepidation. Except for employment or commercial opportunities and freight, at the turn of the century, most of other travel was for pilgrimage, and social functions. Today, most trips are within a state, and those going out of state are for business, social, religious and pilgrimage, education and training trips. Bus is the dominant mode of travel with 70% trips in rural and 55% trips in urban areas (*3*). 23% of visitor trips are for holidaying in rural areas and 59% in urban areas. Medical trips account for 48% of rural and 25% of urban trips.

The ambitious road infrastructure development impetus has seen the road length in India increase over 11 times from 1951-2011 (60 years). And with it, cost and access to private modes of transport, public and semi-private bus operators and aggregators and increase in convenience, road travel for both for leisure and other activities is set to increase.

The potential in this case of developing the ROWs, neighbouring lands and shared landscapes towards enhancing the transit experience are immense.

CURRENT SCENARIO

Encouragingly, with the emphasis on reducing carbon emissions based on targets committed to the Climate Change Accord in Paris (CoP21 Summit), the need for planting does not need to be

stressed. The commitment made was to reduce emission intensity of its GDP by 33 to 35% of 2005 levels by year 2030 and the creation of an additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent through additional forest and tree cover by 2030. Planting 5000 million seedlings in over a decade will create a carbon sink of 2.1 billion tons of CO2 (*4*).

Green Highways Policy

Under the Green Highways (Plantation, Transplantation, Beautification and Maintenance) Policy 2015, the National Green Highways Mission was launched by the National Highways Authority of India. This has been created to

1) Develop a systematic framework for Integrated Green Corridor Development along National Highways,
2) Build a resilient ecosystem in the form of "Green Corridors" along National Highways for
    - combating global warming and climate change effects,
    - optimum GHG sequestration,
    - ex situ conservation of native RET species of the region,
3) Make Green Highways Mission self-sustaining,
    - develop unique green corridors with aesthetic appeal,
    - reduce the impacts of air,
    - noise pollution and dust,
    - provide shade on glaring hot roads during summers,
    - reduce soil erosion at embankment slopes and reduce the effects of wind and incoming UV radiation.

The Mission however focuses on the planting alone, and not the comprehensive landscape development requirements mentioned above. The focus is two-fold-Planting of new trees, post development of highways; and, Transplantation (*5*).

Planting

There are a few issues with this approach. Firstly, planting of new trees requires diversity in terms of region- species planting, structure of landscape or landscape massing to develop interdependent viable ecosystems, consideration of supporting insect, reptilian, amphibian, animal and avian fauna native to the place, and use of native plantation.

NGHM has developed a Plantation Species Matrix, a decision making tool for selection of suitable tree/shrub species for roadside plantation based on Ecological, Economic & Aesthetics considerations. Ecological considerations include- Pollution Attenuation Capability, Leaf Area, and Stomatal Index, Evergreen or Deciduous and Growth rate. Economic Considerations include Ease of Maintenance, Utility, Aesthetic and Road Safety (*6*).

Yet, a lack of understanding of species diversity required results in a common palette of 30-40 trees planted across the country, Pradip Krishnan stated at the Indian Green Building Council (IGBC) Summit held in New Delhi in November. 2016. Native and naturalized trees and plant material should be used as much as possible. Native plants are plants indigenous to a given area in geologic time. Removing a certain native plant from the landscape will likely remove the

insect that feeds on that plant, which in turn may eradicate the bird that feeds on that insect. The loss of a species can quickly escalate to affect an entire ecosystem (*7*). They also require less water, soil amendments and less maintenance. Non-native species including exotics (that do not replicate easily) and invasive should be avoided.

Consequently, the widespread planting of non-native, exotic species can be invasive and damaging to local landscapes. Prosopis juliflora, for example, today covers 1.8% of geographic land of India, since its introduction in 1877 by the British. It is responsible for loss of native biodiversity, productivity of arable lands, ground water loss and water loss in canals and reservoirs across the country. It requires aggressive eradication and replacement. The Madras High Court has mandated its eradication, Dr. C.R. Babu informed the Green Circle in New Delhi in April 2017.

The Indian Forest Service (IFS) has a strong presence across the country. Region specific plant species list should be sources and planted under their guidance to diversify species selection and give home to native trees and their supported ecosystem. Based on the road hierarchy and region, the preparation of diverse native and naturalized plant lists is required.

Further, availability of water, soil conditions, climate, topography, sun aspect and geographic region must determine the plantation and landscape development carried out.

Also, the planting of "open forest" regions which comprise of approx. 9.14% (30 million Hectares) of the total Geographical area of the country and, converting them into "Moderately Dense Forests" (*5*), must be assessed for its sustainability. Plantation in areas of scrub forest or grasslands, will require greater expenditure for irrigation and maintenance. Availability of water in a region must determine the plantation, based on its water requirements, rooting systems and pH requirements.

Further, not only trees, but shrubs, grasses, groundcovers and climbers need to be diversified. They play a significant role in binding the soil, reducing soil erosion, water run-off, creating buffers to and from the road, aesthetics and place making. Storm water management strategies to need to be incorporated.

Transplantation

Second, transplantation of mature trees has a low success rate, is time consuming and expensive. Typically, trees of greater girth are transplanted and succeed in 0-50% of the time. Smaller girth/ calliper trees are typically cut, which tend to succeed in 80% of the time (*5*). And the fragmentation of landscapes is inevitable in this case.

TRANSIT CORRIDOR PLANNING

Ecological Considerations

In vast areas of the country, the road infrastructure is on green-field land, through forests, uncultivated lands connecting cities, towns and settlements. The opportunity therefore to develop comprehensively not only the road infrastructure itself, but mould the entire regional landscape is available only if planned comprehensively to address the following-

- Topography and traditional drainage patterns
- Natural vegetation
- Critical biodiversity hotspots

- Forests – classified and unclassified
- Significant natural features
- Cultivation and agrarian economy
- Cultural and traditional practices related to the land
- Wildlife Migration

At present, road development does not take into account a holistic development strategy to address these critical issues. As a result, we are seeing bifurcations of forests and national parks (*8*) by roadways, thus fragmenting native forests and unique landscapes and altering the corridor migration patterns of wildlife.

Forest fragmentation

In effect, this fragmentation impacts existing matrices of the forest. A forest comprises of a core forest area with concentrated biodiversity at its core, a transition area between the core forest and habitation, which acts as a buffer between the two and is home to succession plantation, the edge which is the area adjacent to habitation and development. This structure- of core, transition area, edge and beyond, protect the forest and the habitation by maintaining a separation. Encroachments tend to blur this boundary and wildlife intrusions into habitation is due to this.

With road development through a forest area, the core area gets disturbed, encroaching on the biodiversity growth and movement. This is not limited to wildlife, but also the interdependency of trees, shrubs, groundcovers and other natural planting systems, water and drainage patterns and topography changes as well. Also, tree fatalities are 250% higher along roads than forest interior (*8*). Felling of trees bifurcates corridors. This reduces the core area of the forest, with the road edges into transition areas, and subsequently into areas of habitation/ development. The forest systems from a large green networks fragments into patches, limiting both the natural forests and habitation for wildlife.

Wildlife migration patterns

Protection of the immense and unique biodiversity of India (numbers), is important where development impacts are endangering species and some becoming extinct. Evidence of changing patterns of wildlife migration, loss of life of people and animals is already available. A wide variety of species are affected, ranging from invertebrates and herpetofauna, to many birds and mammals, including large mammals such as Asian elephants and sambar and carnivores such as tiger and leopard. A study from Mudumalai Tiger Reserve, found road mortality of 40 animal species, including amphibians, reptiles, birds, and mammals (*9*). Wildlife die from predation or the greater competition and less resources caused by shrinking forests. Preserving the ecological corridors therefore becomes more vital at the scale of development underway.

Watershed Impact

Similarly, the impact on watersheds needs to be mitigated, to avoid soil erosion, flooding, landslides and other adverse impacts. Integration water harvesting, ground water recharge, flood litigation and water retention strategies into the roadside landscape development can make highway systems the repositories and model of water management and conservation. This can be done by mapping regional, local and project level watersheds and managing the drainage of rainfall.

Cultural Connections

Also unique to India is the interdependency of regional cultures with the ecology of place. Traditional foods, medicines, building supplies and even religion are interwoven with local ecology. Wild herbs and leaves from native forests are integral components in Ayurvedic and other traditional medicines. Foods foraged from forests, local delicacies are tied to traditional diets and cultural occasions. Thatch, timber, fodder, saps are sourced from forests, fields and ravines, in so far India today has about 100,000 sacred forests.

Land Acquisition

Typically, highway projects are developed with planting and horticulture work after the road is complete or nearing completions. As a result, planting is accommodated in the space available and not ideal. There is always a balance between acquisition of land for landscape works, and particularly close to cities and towns, vacant land needs to be secured from encroachments.

COMPREHENSIVE PLANNING APPROACH

The development of road infrastructure involves government agencies, transport planners, engineers and contractors. Typically, horticultural contractors carry out planting. The lack of engagement during the planning, design and implementation of road systems with ecologists, landscape architects, regional planners, water specialists, zoologists and geologists, limits the ability of the aforementioned to holistically plan and anticipate long term issues and development.

Integrating the resources across agencies and diverse professionals with expertise is not the daunting task it appears. It requires a multi-disciplinary approach to planning ecological corridors with high domain expertise, some economic burden in the short run, and greater long term socio- economic and ecological benefits in the long run. Ecological parameters can be established within which regional, state and local agencies can provide specific inputs based on traditional and cultural wisdom and fragile environmental landscapes. The impact of this approach on the second largest road network in the world will be far reaching and timely.

In order to help in realizing the objectives of Convention on Biological Diversity (CBD) 1992 CBD, India has enacted an umbrella legislation called the Biological Diversity Act 2002 (No.18 of 2003) aimed at conservation of biological resources and associated knowledge as well as facilitating access to them in a sustainable manner. Environmentalists and ecologists can provide such expertise. Compensate for massive deforestation and fragmentation of biodiversity hotspots. Landscape Architects analyse, plan, design, manage, and nurture the built and natural environments. They are uniquely poised to provide valuable guidance in comprehensively addressing the needs of the built infrastructure, surrounding landscapes and planting requirements.

Regional Planners too, can help map out the required interventions addressing the diverse needs and qualifications of a larger region. Interconnected domains of sociology, horticulture, forestry, water management and public health also play a role.

These and other expert professionals can add value in through sustainable ecological development, economic benefits and aesthetic value.

- Decision making
- Design and Implementation

- Technical oversight
- Operations and Management
- Land costs/ value addition

BENEFITS OF THE APPROACH

Considering this integrated planning approach in India is path breaking in its intent, yet can be a model for sustainable infrastructure development. Comprehensively addressing a larger vision of the road landscape as a unified engineering system, within the constraints and opportunities of regional climate, terrain and ecology will avoid monotonous travel experiences for the 80% of passenger traffic on roads (*1*) too. Sensitivity towards terrain, climate and soils may also reduce the environmental damage caused during natural disasters and climate change.

Roads as 'Greenways' or 'Landscape Corridors' also bring to the wider populace equitable access to cultural landscapes, scenic tourism corridors and open space resources; so far limited to the developed parks and neighbourhoods of large cities. And will also provide psychological benefits, including equity of access to public open space 'commons', flora, fauna and scenic beauty inherent to places.

Commendably, the interrelationship of local communities engaging in landscape activities is being explored (Green Highways Policy, 2015). This includes creating nurseries, tree guard manufacturing and agro-processing sections during infrastructure projects (green highways). Further opportunities should be explored to develop scenic corridors with scenic vistas and supporting transit stops for recreation and leisure, commercial planting of orchards, agricultural produce and connectivity.

In isolation, these considerations are only one aspect of the larger regional landscape development. Another aspect of plantation and the development of landscape corridors is the role of landscape in place making. Cultural associations of place and memory are tied to the place. Legibility and wayfinding, with safe and comfortable access - from a thermal, physical and perceived sense- create a sense of place.

Typologies of space- forest, grasslands, open spaces, transition spaces, rocky terrains etc. create opportunities for different kinds of experiences. For both road users and the local communities. Needs of access, connectivity, screening, viewsheds, staging, emergencies, leisure, commerce, conservation, preservation, development and tourism should determine spatial planning priorities. Scenic vistas, historic- heritage, religious and cultural- corridors in semi- urban areas add immense value to the land.

Road construction is associated with increased frequency of landslides and erosion in steep forested landscapes. In forest areas, increased surface areas are prone to erosion, slashing of trees and saplings and removing overhanging branches results in tree canopy cover breaking over the road and colonization of weeds (*8*). Ensuring a comprehensive planning approach by mapping the natural resources available, highlight early on the pitfalls of this approach and can be mitigated by minor modifications in the road planning- roads along the edges of habitation and transition areas instead of through forests, navigating more stable, accessible slopes in steep forested areas and so on. The effects on indigenous and marginalised people, rural and forest-dwelling communities from infrastructure projects should also be considered.

Larger issues of biodiversity and shared resource management, emergency and disaster management are important planning considerations.

WAY FORWARD

Strategies on the way forward require a comprehensive planning approach to transit corridor planning, design and implementation at a regional level. This includes-

- Mapping of critical regional and local contextual conditions
- Impact assessment of development on ecological, economic, social and heritage of place
- Land acquisition strategy and regional planning
- Making adjustments to the road infrastructure based on contextual conditions
- Mitigation impacts of development
- Parallel development of landscape together with implementation of road infrastructure
- Community involvement and use of local expertise

To ensure this can be a viable strategy, keeping in mind the aggressive timelines and development goals, the following need to be done to ensure timely coordination and completion-

- Create guidelines at National, State and Regional levels
- Encourage research and collaborations with allied fields of botany, ecology, landscape planning
- Create a Natural Resource Management Reserve to address all components
- Use partnerships in the Public and Private Sector and CSR initiatives to support innovation and collaborations
- Engage with local community

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