Leading the Future:
Sustainable Roads for Poverty Alleviation in Nepal

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A Study Report on Leading the Future: Sustainable Roads for Poverty Alleviation in Nepal 2022, prepared by Isha Gharti on behalf of the National Planning Commission.

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Executive Summary

Nepal continues to grapple with the consequences of a significant proportion of the population living in poverty, despite consistent efforts. And as the government programs designed for poverty alleviation in the past has yielded mixed result, the study explores a more effective route to poverty alleviation. Based on extensive reviews of government documents, development partners' reports and academic literature on poverty alleviation, sustainability, road infrastructure, climate change, the study examines Nepal's experience with poverty alleviation, identifies challenges to sustained poverty reduction and recognizes the prioritization of road development as one of the fastest routes to poverty alleviation. Building on global as well as national experience, the study argues that poverty alleviation programs in Nepal could benefit substantially by focusing on programs that have multiplier effects like the development of roads. To provide a more comprehensive picture of links between roads and poverty alleviation, the study is based on an extensive study of the economic growth of two of the fastest-growing economies in the world namely China and India, in addition to relevant experience from around the world. The review reveals that roads are known to positively affect economic growth by increasing connectivity, increasing private sector investments, facilitating, and expanding trade, accessing, and generating employment, making necessary services like education, health etc. accessible, and complementing other infrastructure developments like communication, electricity etc. Reconceptualizing roads as a direct contributor to poverty alleviation can thus prove a game-changer for Nepal.

However, the growing effect of road development on the environment, ecology and communities outweigh the economic and social benefits of roads. Thus, the study suggests adopting sustainable roads such as green roads in place of conventional roads could prove highly beneficial. Green roads mitigate soil, water, and noise pollution; reduce risks to biodiversity and calamities such as soil erosion; can contribute to water management and recycling; reduce landfills and reduce risks to communities. The study presents some of the innovative ways in construction, maintenance and use of green roads and provides a brief description on how green roads mitigate environmental, social and ecological risks.

To provide a general picture of the feasibility of green roads in the Nepalese context, the study examines major planning and visions set out by the government precisely the 15th planning and Sustainable Development Goals, and the current state of the road in Nepal. The study finds that green roads not only complement the national planning it can provide

additional economic, environmental and social benefits when compared to conventional roads. The study then assesses the constraints and challenges to green road investment, identifies investment gaps and outlines possible opportunities to fill the gap.

There is a substantial gap between major national planning and investment requirements on the road. The more traditional forms of resource management that relied on loans and donations can no longer support ambitious national goals. In such a case road development in Nepal can increase through the involvement of the private sector, for which increasing the tolling system, BOOT, bond financing and removing policy constraints, good governance, stable political structure, and removing bureaucratic hassles can prove beneficial. Additional benefits can be availed through green roads by mobilizing carbon finance reflated funds. Despite its benefits, due to a lack of information and manpower relating to green roads, Planners have not prioritized green roads. To fill the void, extensive research, feasibility studies and the creation of adequate manpower for green road development are suggested.

Abbreviations

ADB	Asian Development Bank
BOOT	Build Own Operate Transfer
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GoN	Government of Nepal
LDC	Least Developed Countries
LLDC	Landlocked Developing country
LRN	Local Road Network
MDG	Millennium Development Goals
MPI	Multidimensional Poverty Index
NPC	National Planning Commission
NRS	Nepali Rupees
PPAct	Public Procurement Act
PPP	Public Private Partnership
SDG	Sustainable Development Goals
SRN	Strategic Road Network
UN	United Nations
USD	United States Dollar
WFP	World Food Programme

1. Introduction and Background

Poverty alleviation in Nepal has remained a priority since the beginning of planned development. National planners including the National Planning Commission (NPC) recognize poverty alleviation as continued importance for national development and have accordingly designed and implemented various programs. Consequently, Nepal has been making progress in poverty reduction and the progress is considered one of the most encouraging stories the world over (Uematsu, Shidiq, & Tiwari, 2016). Between 2015 and 2019 reducing poverty by 1.1 % each year and has also improved its per capita income (NPC, 2020). Since 2020, while battling COVID-19 related health and economic issues, poverty reduction has slowed down and 18.7 % of the population continues to live under the margins of poverty. Building on its commitment to reducing poverty, Nepal has been a partner to many global initiatives like the Sustainable Development Goals (SDG) (2015) which puts ending poverty in all forms everywhere as its very first goal. In accordance, the national planning since the 14th plan has been incorporating these goals with the national developmental programs. The Government of Nepal (GoN) has been keen on accelerating the economic growth of Nepal and graduating from the status of a Least Developed Country (LDC) by 2022 and attaining the vision of becoming a middle-income country by 2030 and graduating to the status of rich nations by 2043 (NPC, 2019). Despite persistent attempt, attaining these ambitious goals is proving quite a challenge as the country continues to grapple with poverty and the continued effects of the pandemic that are exacerbated by rising inflation and the effects of the war in Ukraine.[1] Government initiatives in the past have yielded mixed results. Additionally, remittance, liberal policies, and developing private sectors are widely reported (Dixit, 2017; IIDS, CNI, 2019) as important contributors to poverty alleviation in Nepal. This is corroborated by the experience of rapidly developing economies in the world including China and India, that have invested in industrialization and infrastructure as the most rapid way out of poverty. In this regard, the paper explores the potential of sustainable infrastructure precisely, roads in poverty alleviation of Nepal. The study focuses exclusively on road infrastructure as Nepal's transport infrastructure is dominated by road networks, which provide for the movement of approximately 90% of all passengers and freight (IIDS & CNI, 2019).

[1] World Bank. *Understanding Poverty*. Available at https://www.worldbank.org/en/understanding-poverty

Increasing studies have suggested that the development of infrastructure together with investment in industry, and commerce contributes to rapid poverty alleviation (see, for instance, Calderon & Serven, 2003) (Yan & Hua 2004) (Sahoo, Dash &Nataraj 2010) (Aggrawal, 2013). Current thinking on poverty alleviation has focused on the promotion of opportunity (access to resources, services, and productive employment), enhancing security (reducing vulnerability to shocks), and facilitating empowerment (increasing the participation of poor people in decision making), all of which are directly or indirectly affected by road infrastructure. Nepal's lack of proper infrastructure can thus be linked to persistent poverty. The WEF Global Competitiveness Report (2013) ranked the quality of overall infrastructure of Nepal 132nd out of 142 countries and the status of roads as 117 out of 142.[2] However, despite these ranking, the GoN since the 1970s has invested significantly on roads considering the meager budget that government has at its disposal. Nevertheless, lack of transportation infrastructure in Nepal is linked to increasing costs and inflation of goods and services, especially in the rugged hilly and mountainous regions. Even these numbers do not fully encompass the dire situation of infrastructure in Nepal and its hindrance to Nepal's development. Nepal being a landlocked developing country (LLDCs) with poor infrastructure has compromised tremendous trade potentials with its neighbours and beyond. Nepal faces specific constraints imposed by geography and remains on the periphery of major markets. This has adversely affected the consumption as well as mobility of goods and services in and out of the country and constrained efforts to alleviate poverty. Nepal is highly disaster-prone and among the top-ranked climate change, vulnerable countries and is increasingly challenged by the impacts of climate change and environmental destruction. Furthermore, Nepal is highly stratified along caste, gender, geography and most importantly economic hierarchies which complicates the means to attain sustainable poverty alleviation.

The potential for Nepal's development and poverty alleviation through rapid road development has been long realized and the successive governments have prioritized road construction. And even though there is a political imperative to build more roads faster, agencies responsible for road construction have not been able to accelerate quality road construction as planned. And as roads are increasingly becoming temporary as they are chained to the election cycle, political biases and rampant corruption, their use is quite limited. Furthermore, road construction and planning in Nepal are known to violate multiple vulnerability protocols and have resulted in disastrous impacts on human communities,

[2] WEF (2013). *Nepal Infrastructure*. Available at https://www.intracen.org/country/Nepal/Infrastructure/

wildlife, ecology, and the environment which far outweigh the over-hyped benefits these roads are meant to provide. Hence transportation infrastructure is not only an issue of economic, social or environment it is also a political issue. However, infrastructure has largely been ignored in the assessment of poverty in Nepal. The paper will thus, explore the links between roads and poverty alleviation, its challenges, and opportunities to long term plans, precisely the 15th plan and SDG to attain sustainable poverty reduction.

The 15th plan and SDG recognize that sustainable development cannot be complete without social, economic, and environmental factors complimenting each other throughout and beyond the developmental process. As such they recognize that economic empowerment must be sensitive to and complementary to the social needs of people and the protection and rejuvenation of the environment (NPC 2020). This comes after the realization that economic development cannot overlook its consequences to the social system as well as the environment. Development projects in the past have been known to cause tremendous environmental degradation and are linked to climate change. It is also known to increase social stratification and adversely hamper lives and livelihood of many sectors of society most prominently the poor and other vulnerable populations including women, children the indigenous peoples. In this regard, any development must incorporate programs and initiatives that are mindful of its social and environmental implications. And although Nepal is gradually adapting and incorporating these aspects within its development initiatives, the pace and extent are rather sloppy and often unidirectional and non-integrative, where various programs are not complementary to each other. Within this, rather than designing multiple programs for one or the other aspect of development, projects designed to tackle multiple aspects should be embraced. As such research explores the prioritization of roads development as both means and an end to poverty alleviation. Further, keeping in view the global crisis of environmental depletion and alarming consequences especially to Nepal, new approaches to development that encompasses environmental protection and advancement to achieve sustainable growth as such green road is explored as an alternative to the traditional infrastructure designs.

2. Methodology

The Paper intends to achieve two objectives-integrate roads with poverty alleviation and further include the need to prioritise green roads as primary forms of roads in Nepal for sustained poverty alleviation and development. To do so, it provides an in-depth description

of the poverty alleviation efforts made by the government and bottlenecks to poverty alleviation efforts; explores how road development can contribute to substantial poverty alleviation, it then provides a description of the concept of green roads and how it could replace the conventional roads. It then comprehensively explores road challenges and opportunities for road construction: investment needs in Nepal and possible ways to avail them, available resources of funds, policies and processes while highlighting their links to poverty alleviation.

This research is based on the study of periodic government documents (Ministry of Finance, NPC, Department of Roads, Ministry of Physical Infrastructure etc.), five-year plans, Annual Plannings, MDG reports, SDG reports, periodic national surveys, reports from development partners (World Bank, UN agencies, ADB) including Economic Survey Reports, Publications from NPC, and various government agencies related to infrastructure and development were also reviewed. Literature regarding new and innovative ways to limit environmental degradation and sustain and multiply biodiversity and ecosystems without compromising developmental and economical necessities such as Green Road initiatives has been explored. Several cases from around the world have been examined for their relevance to Nepal's unique challenges. These are investigated keeping in view the distinctive and integrated multiple vulnerabilities that Nepal possesses.

3. Importance of study

The proposed research is a fresh attempt of its kind to investigate the causal relationship between road development and poverty reduction in Nepal which incorporates social and environmental sustainability at the core of the study. The purpose of this study is to present an approach for incorporating environmental issues into road conception and execution to promote a new era of more environmentally friendly and subsequently sustainable road projects that facilitates rapid poverty alleviation. Studies reveal, that one of the promptest ways of poverty alleviation is through infrastructure development especially the development of infrastructure related to transportation, which in Nepal’s case remains much relevant. As such the paper's research will contribute to the area by exploring the potential of roads for poverty alleviation. Furthermore, keeping in view the lurking dangers of climate change and the environment globally and especially in Nepal, the need for sustainable and green infrastructure is the way for the future. As such, the research will contribute in two broad ways. First, contribute to the understanding of the importance of sustainable roads in poverty

alleviation of Nepal and secondly, contribute by exploring the relevance of eco-friendly sustainable and green infrastructure to the overall development and poverty alleviation of Nepal. In doing so it will also address the issues related to the feasibility of such a project in financial, social, political as well as environmental and geographic terms.

4. Limitation of Study

Research is primarily exploratory research carried out based on literature reviews which possess several limitations. There is a gap between onsite and off-site exploration as the challenges can only be best understood in the field. However, the research is meant to serve as a reference to planners in the initial stages of planning and not a guide or a tool kit. Future research must go beyond secondary resources and into the actual sites to fully encompass the many obstacles and opportunities that are present in planning as well as the implementation of such mega projects. Generally, economists and urban planners distinguish two types of infrastructure, namely, economic infrastructure and social infrastructure. Economic infrastructure is defined as the infrastructure that fosters economic activity such as the construction of roads, highways, railroads, airports, seaports, electricity, telecommunications, water supply, and sanitation. Contrastingly, social infrastructure is distinguished as the infrastructure that promotes health, education and cultural standards of the population through activities that have a direct or indirect impact on the welfare such as schools, libraries, universities, clinics, hospitals, courts, museums, theatres, playgrounds, parks, fountains, and statues.[3] Although the importance of social infrastructure cannot be overstated for wellbeing and growth in standard of living the research will largely focus on economic infrastructure which limits its generalizability and reliability.

The study is also mindful that poverty alleviation is a multidimensional phenomenon that requires multi-level intervention and although infrastructure development is known to significantly contribute to poverty alleviation, it is not the only contributor. Structural reforms, industrialization and job creation, social infrastructures, diplomatic and bureaucratic efficacy, political and social stabilities, complementary infrastructures etc. also drive poverty alleviation. However, as the focus of the study is the contribution of green transportation infrastructures, discussion on the other factors will be limited. Further, although it is acknowledged that environmental and social issues are intertwined, complex social issues

[3] "Infrastructure Development in Nepal", New Business Age, 15 December 2014. Available at. https://www.newbusinessage.com/MagazineArticles/view/1030

such as indigenous people, physical cultural resources, resettlement, gender, child labour, and so on are only peripherally addressed here. The naïve calculations made in the paper are based on few reports and research which limits its predictability capacity. Future research may thus conduct a wider and more comprehensive analysis on the subject.

5. Nepal's experience with poverty alleviation

The government has been initiating several programs and projects that have been targeting poverty reduction since the early 1970s to mixed results. Notable among these programs is the Subsidized Ration Distribution Program, the Production Input Distribution Program, the Integrated and Community Development Projects, Food and Feeding Programs, the Food for Work Program, Garib Sanga Bishweshwar Karyakram (Bisheshwor Among the Poor Program), the Western Terai Poverty Alleviation Project, the Jagriti Women Income Generating Program, Enhancing Swabalamban for Poverty Alleviation in Arun Valley; Poverty Alleviation Fund (2010/11), and the Micro-Enterprise Development Program (Thapa, 2013). Although the successes of these programs are widely debated, Nepal has performed exceptionally well in terms of poverty reduction. The unprecedented poverty reduction in Nepal is reflected in many achievements that have far surpassed the projection made by aid and financial institution for Nepal. For instance, Nepal's first comprehensive poverty assessment published in 1991 based on the Multi-Purpose Household Budget Survey conducted in 1984/85 showed dismal living standard of people in Nepal Nepal with at least 40 % of the population deemed poor and projected poverty incidence to remain flat at 40 % by 2010 (World Bank 1991). Contrary to the prediction, while the poverty headcount rate had remained virtually unchanged at approximately 40 % until 1995 (World Bank, 1999), it declined to 31 % by 2003 (World Bank, 2006) and as low as 12 % by 2010 (World Bank 2013). However, in the revised estimation poverty increased in its real value by 35 % from the previous line and the poverty rate in 2010 was estimated at 25 % (World Bank, 2013) which still far exceeded the predictions made by financial institutes. These figures point to unprecedented achievement in poverty reduction and put Nepal in the 96th percentile of all available country episodes (Uematsu, Shidiq, & Tiwari, 2016).

The earlier calculations of Nepal's poverty were based on income-based poverty measures. Since the mid-90s the government began revising these measures and incorporated socio-political aspects and conceptualized poverty as a multidimensional aspect. These resulted in the Ninth Plan including programs that endorsed the concept of human development which

accommodated ideas of capacity building, health, education, accessibility, sanitation, housing drinking water and social services. (NPC, 1997). This understanding of poverty is now an official understanding of poverty in Nepal and line to the Multidimensional Poverty Index (MPI) published by the UNDP's Human Development Report Office and tracks deprivation across three dimensions and 10 indicators: health (child mortality, nutrition), education (years of schooling, enrollment), and living standards (water, sanitation, electricity, cooking fuel, floor, assets). [4] The deprivation in a third or more of ten (weighted) indicators, the global index identifies them as 'MPI poor', and the extent or intensity of their poverty is measured by the number of deprivations they are experiencing. In addition to absolute poverty measures, Nepal is also making progress in those indicators. For instance, life expectancy at birth was 68 years as of 2011, an improvement of 18 years since 1985. Nepal's infant mortality rate (per 1,000 live births) congregated to the world average by the late 2000s. Access to improved sanitation facilities is still low at 40 % and ranks 154th out of 195 countries in 2011, but a considerable improvement from 4.5 % in 1990. Nepal's primary completion rate exceeds the world average in 2014. The adult literacy rate tripled from 21 % in 1981 to 60 % in 2011.

According to the MPI report (GoN, 2021), in 2019, MPI dropped from 0.133 to 0.074, nearing being cut by nearly half in a mere five years. In human terms, it means that 3.1 million people left poverty in a mere five years, with only 5 million left to exit. The intensity of multidimensional poverty also significantly decreased from 44.2 % to 42.5 %. Nepal's results are also striking on the international stage in comparison to other countries; according to the 2020 global MPI trend data, no country with a similar starting level of poverty reduced MPI or its incidence faster than Nepal (NPC, 2021). Despite these spectacular achievements, 17.4 % (almost 5 million) of Nepalis are multidimensionally poor. Across indicators, the highest number of people are deprived of housing materials, clean cooking fuel, years of schooling, assets, and nutrition. Considering the indicator weights, years of schooling and nutritional deprivations contribute most to ongoing multidimensional poverty in Nepal (NPC, 2021). The true multidimensional poverty headcount ratio is estimated between 15.8 % and 19.1 % of the population. The average intensity of poverty, which reflects the share of deprivations each poor person experiences on average, is estimated at 42.5 %. That is, each poor person is, on average, deprived of less than half of the weighted indicators. In 2019, 16.2 % of the population is multidimensionally poor and are deprived of housing and live in

[4] UN Multidimensional Poverty Indicator. Available at https://indicators.report/indicators/i-3/

households that cook with dung, wood or charcoal. Over 11.6 % of people live in households that have no member who has completed six years of schooling and are multidimensionally poor, and nearly 10.3 % live in households that are deprived of assets and are poor (NPC, 2021).

Apart from the government initiatives including programs and policy reforms, remittances have been largely credited for this commendable achievement. A study (Dixit, 2017) suggests that more than 50 % of the observed decline in poverty can be attributed to growth in labour incomes, non-agricultural income. Remittances accounted for 27 % of total poverty reduction between 1995 and 2010. In addition to households directly benefitting from remittances sent by migrant members, non-migrant households also benefitted from the spillover effects. Population decline is another factor that is credited to substantial poverty reduction. The number of births of an average Nepali woman declined from over 6 in the 1970s and over 5 in the 1990s to around 2 in 2014. The decline in fertility rate is considered to have contributed to the spread of mass education, increasing female labour force participation, and the mechanization of agriculture (Bhandari & Ghimire 2013). The growing private sector, modest attempts at industrialization, and liberalization policies are also attributed to some decline in poverty. This suggests that rather than the government interventions directly aimed at poverty reduction, it is the spillover effect of other interventions such as liberal policies, encouraging the private sector etc. that contribute to poverty reduction. Even the planners identify key drivers of the growth for the next 15 years as agriculture and small businesses, physical infrastructure, tourism, energy, and services like finance and retail trade (NPC, 2015). As such, it is important to reconceptualize poverty reduction efforts and planning incorporating ever-evolving financial, social and environmental changes and challenges nationally and globally.

6. Challenges to sustained poverty alleviation

A clear understanding of the challenges of poverty reduction is particularly important in Nepal not only because of the mixed performance of the government's previous programs but also because of the uncertainty pertaining stability and security of the achievement so far. Government programs although bringing changes to many poor people’s lives, have also been criticized for their performance. Thus, the programs could benefit from conceptualizing poverty reduction beyond distribution and lending schemes, by integrating various dimensions of poverty reduction into a single framework and efficiently accessing real poor.

For instance, the government continues to prioritise not so lucrative agricultural credits, policies that have low returns for farmers and overlooks industrial development when there is a trend of decrease in agricultural income, nonagricultural increase, and labour income increase. Agriculture accounts for a significantly lower share of the overall Nepali economy as well as employment in recent times (Dixit, 2017). Due to the rapid decline in the country's already weak industrial sector, dismal growth of domestic jobs, Nepalese are forced to find work beyond the country resulting in a massive brain and labour drain in the country. Further, in addition to consistently attempting to reduce poverty, sustaining, and securing the achievement so far is also extremely important to avoid the reversal of poverty. The remittance that amounts to about 8 billion USD per fiscal year, or 26% of GDP, and is the most effective driver of poverty reduction in recent times is going through a steady slump. Because of Covid-19 related economic issues remittance shrank 7.5% in the first four months of 2021, against an increase of 11.2 % in the same period of the previous year (Kathmandu Post, 2021).

The 2019- onwards experience with COVID-19 and substantial slow down to poverty reduction also poses challenges to poverty alleviation. With almost all the economic and social sectors being hit, the World bank's Global Economic Prospects report said Nepal's economy may grow 3.9 % this fiscal year, ending mid-July 2022, unchanged from its June 2021 (Kathmandu Post, 2022). The poor economic condition will also be exacerbated by rising inflation and the effects of the war in Ukraine that has already posed multiple crises to the vulnerable population. Since the onset of war, the growing prices of fuel have triggered a domino effect in all sectors in Nepal. The World Bank said that global growth is expected to decelerate markedly from 5.5 % in 2021 to 4.1 % in 2022 and 3.2 % in 2023 as pent-up demand dissipates and as fiscal and monetary support is unwound across the world. In addition, a notable deceleration in major economies including the United States and China is expected to weigh on external demand in emerging and developing economies. The aid received from various countries is also declining post covid and global economic deceleration. These factors thus add to the multiple challenges to sustained poverty reduction in Nepal.

For a speedy poverty reduction enhancing in-country employment opportunities in non-agricultural productive sectors. Increasing and improving the domestic market could be one of the most effective routes to poverty alleviation. For this, the government may design ways to remove impediments to the factors that directly contribute to industrialization, labour

market and innovative enterprises. Experiences from around the world bear testament to the fact that durable socio-economic progress and the domestic labour market require a sound base of infrastructure. The World Development Report (henceforth, WDR) 1994, published by the World Bank under the title "Infrastructure for Development", rightly states that Infrastructure represents, if not the engine, then the "wheels" of economic activity. Infrastructure can deliver major benefits in economic growth, poverty alleviation and environmental sustainability (Mishra, Narendra & Kar, 2013). In such a case it will be worthwhile to explore how transportation infrastructure precisely roads, can contribute to poverty alleviation and sustained development in Nepal.

7. Road development and poverty alleviation

Recent studies on poverty alleviation increasingly stress the importance of road development in poverty alleviation and rapid development. Over the past 40 years, China has made significant progress toward its poverty alleviation goals. In China, the rural population under the current poverty line has decreased by739.9 million and the number contributes to more than 70 % of world poverty reduction. Scholars have noted that infrastructure has played a pivotal role in the overall development of the country. Demerger (2001) in exploring the links between infrastructure development and economic growth in China concluded that short- and long-run relationships exist between infrastructure development and the volume of GDP. He concluded that total length of road, economically active population, increase in tertiary education and gross capital development were interlinked. Studies have noted that China's growth has been investment-led with a major contribution from infrastructure stock, labour force, public and private investments unidirectional causality from infrastructure development to output growth justifying China's high spending on infrastructure development since the early nineties (Sahoo, Dash &Nataraj 2010). These findings are in line with the diverse body of international empirical evidence, which points to public infrastructure having a significant positive impact on output and the poverty-related outcome variables studied. China has invested intensively in the transport sector during the last 20 years which has provided access to markets, facilitated domestic market integration, lowered costs of production and transportation, and allowed China to compete both domestically and internationally. Besides contributing to growth, this investment has directly helped reduce poverty by increasing access to services and economic opportunities. Targeted infrastructure spending also has been part of national poverty-alleviation programs. Since the 1990s and

especially since the tenth five-year plan, with its proactive fiscal policy to spur economic growth and reduce poverty through better transportation the Chinese government's investment in transportation infrastructure has increased sharply (Yan & Hua 2004). Transport infrastructure investments have also been reported to benefit the poor as well as the nonpoor.

Similarly, Sahoo and Dash (2009) analyzed the impact of infrastructure on economic growth in India. Causality analysis found that infrastructure development makes a positive and significant impact on economic growth in India. The study suggests that India became the second-fastest growing economy in the world from 2003/04-2013/14 through large investments in infrastructure but its economic growth slowed down from 2012-to 2014 due to stalled infrastructure projects. Srinivasu and Rao (2013) stated that infrastructure was a prerequisite for the economic development of the nation. The descriptive analysis found that infrastructure has been playing an important role in promoting growth and in alleviating poverty, reducing disparity, and raising the health and education facilities within the country. A study (Aggarwal, 2013) on the impact of the program on rural households found that in Indian districts with greater road construction, there was a reduction in consumer prices. The study also found that roads led to an increase in variety in the household consumption basket, particularly of goods not produced locally. Hence the study concludes that roads lead to greater market integration and trade between urban and rural areas. The study also reports on the benefit to the agricultural sector with the improved accessibility of fertilizer and hybrid seeds increased. The same study also attributed the increase in school enrollment of younger kids and the increase in the number of women in the labour force to road accessibility. Road development also contributed to the selling of perishable goods and a decline in transportation costs (Aggarwal, 2013).

These studies acknowledge that roads and the services it provides significantly affect national economies and people's quality of life. As such, studies have suggested that, with the transformation of an economy from public sectors to private-sector involvement after the liberalization, infrastructure development leads to high economic growth (Calderon & Serven, 2003). More investment in the infrastructure development tends to boost output, private investment boosts higher return for investment, employment, economic activities, access to goods and services (Gautam & Tripathi 2010), public capital, trade facilitation economic performance, and growth of a nation (Munnel & Cook, 1990). However, it is important to stress the relationship between transportation infrastructure and economic

growth is based on the endowment of transportation, density, quality, and accessibility of transportation. Roads have a multiplier effect, apart from economic effects it also makes a significant social contribution. (Gautam & Tripathi 2010). It is reported to boost the local transport service supply industry, enhance the agricultural sector and contribute to the overall wellbeing of people. Roads are also noted to especially impact the poor, particularly the poorest and the bottom 20% of the population (Limi et al. 2015). It was reported that improved rural roads changed people's transport modal choice. People used more public buses and individual motorized vehicles after the rural road improvements. The paper also finds that the project increased school attendance, particularly for girls (Limi et al. 2015). The same study also indicates that the project contributed to increasing agricultural jobs and household income in certain regions and suggests that roads are even more critical for women and children, providing increased income and access to education and health services.

Although not extensively studied, roads are known to have socially and economically benefited local people in Nepal, especially in rural areas. Shrestha (2020) in his study based in Nepal identified the role of roads in improving agricultural livelihoods. His study suggests that a 1% decrease in distance to a road raises the market price of an agricultural plot from 0.1% to 0.25%. This increase in land value is underpinned by increased participation by households in agricultural markets and improved farm production and incomes. The paper also suggests that a decrease in the distance to a road contributes to the commercialization of agriculture and increases the use of fertilizer in agricultural production, thus reducing the unit cost of fertilizers.

The role of road in food security in Nepal has also been studied which suggest a positive correlation between roads and food security. The decline in agricultural output has resulted in increased reliance on the market for food accessibility in many rural areas. This has also resulted in a rise in the prices of goods in remote places with limited access to mobility. This is especially true for the cases of the Far and Mid-West region. In these places, food prices continue to rise reports have noted the market price for rice can be up to three times that of Terai (WFP, 2010). Furthermore, WFP cash for assets programmes in the Karnali region-Kalikot, Jumla and Mugu, noted that food-insecure communities build productive assets such as roads, trails and irrigation channels in exchange for a daily cash allowance, which has a positive impact on market development and household food security. With beneficiaries spending the cash overwhelmingly within the local economy, markets are stimulated, and food supply and diversity improved (WFP 2010). The impact study of the opening of the

Karnali highway in 2007 on Kalikot, Jumla and Mugu suggests an increase in the number, size and degree of integration of markets in the area notably in Nagma in Kalikot district and Raralihi in Jumla district, which have grown to become important market centres. Additionally, the study also suggests that most of the market centres along the road in Kalikot have increased in size. Smaller markets have also formed since the opening of the highway. The study also notes a trend of a decrease in the price of food (WFP 2010). Studies based in Nepal have also noted the multiplier effect of roads. ADB's support to construct 318 km of the rural road from 2006-to 2015 has increased in-vehicle operating cost savings by around 19% and a reduction in travel time by around 58%, (Pande, 2017). Similarly, UNDP (2011) assesses that the existence of the Mude-Deurali road in Dolakha reduces the cost of transporting goods by almost seven times.

Sudmeier-Rieux et.al (2019) noted that roads resulted in reduced travel time on foot, opportunities are opened for quicker transportation of goods and better access to employment, education, health care and markets. Roads also fuel migration and numerous social changes, both positive and negative. In Nepal, roads are also linked to the current boom in migration, facilitating easier mobility to both near and distant migration destinations (Jaquet et al., 2015; Upreti and Shrestha, 2016). A robust road infrastructure can provide vital corridors for evacuation and rescue in the aftermath of a disaster (Pande, 2017).

A 2010 Study (Gurung, 2010) citing cases of 18 districts suggested that 780,000 poor people have directly benefited from a wage income increase of around 25% over the subproject and supplementary investment construction period and that 200,000 people have uplifted out of poverty. A total of 34,700 person-years of employment are created by the road projects and significantly contributed to income restoration in conflict-affected districts. The skills training received particularly disadvantaged castes and ethnic minorities, and increased social capital, resulting in a decrease in social exclusion and vulnerability.

Studies have also noted the direct relation of road access to poverty reduction. For example, ADB’s project 34 aimed at providing all-weather access to 12 districts in Nepal and reduced the poverty rate by around 21% in the project area; especially in Ramechhap, Rasuwa and Taplejung where a high incidence of poverty had been recorded. In addition, the per capita income of the population in the project area increased by 102% with the introduction of access roads. Significant improvements in the education and health sectors have also been noted in the 12 districts because of an increase in access through road connections. An

increase in access to financial (banks, saving credit companies and cooperatives) and NGO activities in the areas are also credited to road construction has been observed with improved road connectivity. A surge in employment was recorded in the areas as the locals participated in the construction of the road networks. Similarly, it is reported the District Road Support Program (DRSP) was successful in providing 1.25 million person-days of employment to mainly the marginalized community in the project areas in its second phase of operations (Pande, 2017). In its third phase, the DRSP focused entirely on empowering both women and disadvantaged groups. In its four phases of road development, the DRSP continued to increase its efforts in providing employment opportunities to the poor and marginalized to enhance their livelihoods.

In 1997, 13 districts-Achham, Bajhang, Kalikot, Humla, Mugu, Doti, Jumla, Bajura, Rukum, Dailekh, Jajarkot, Rolpa and Baitadi were identified by an ICIMOD study as the worst-performing districts in 11 combinations of four dimension of development performance: namely, poverty and deprivation, socio-economic, institutional and infrastructure development, women's empowerment, and natural resource endowment and management. Out of those 13 districts, 10 districts-Achham, Bajhang, Kalikot, Humla, Mugu, Doti, Jumla, Bajura, Rukum, Dailekh, Jajarkot, Rolpa and Baitadi were not connected to National Road System at the time of the study in 2001. A comparative assessment of the Human Development Index of 2001 and 2011 revealed that surge in HDI with road connectivity. Thus, improved rural transport connectivity could be seen as one of the biggest factors in reducing the incidences of poverty (Pande, 2017).

A case study from Bhojpur found the impact of the road on the daily lives of people to be direct and tangible. The story reported subsistence farmers who worked on the road construction offered by ADB to have disposable income, teachers and health workers continued to stay in the village, school enrolment doubled, and the price of basic foods has come down by half. The story also reported that an average road builder could earn up to Rs 100,000 a year. This has reduced the number of people migrating to India or the Gulf for work. [5] Studies have also reported on the impact of the road in boosting tourism and the economy (Rossaminth, 2018; Manandhar & Singh, 2019)

[5] Available at http://archive.nepalitimes.com/news.php?id=18019#.YoSyldpBx1s\

8. Problems with rapid road development

Roads as explored earlier have tremendous potential for rural and urban poverty reduction and development. Nevertheless, the benefit is often outweighed by the many environmental, social, and even economic detrimental effects. Among its environmental effects alarming contribution to pollution, contribution to rising temperature, and ecological damages stand out most. Road construction, maintenance and use by vehicles affect physical and chemical soil conditions, water flow, air, and water quality, as well as plants and animals (TRBNRC, 2005). Between the pavement and sub-base, all the mining, transporting, heating, earthwork and paving work , the average single lane-kilometre of the freeway, will emit enough pollution to equal up to 750 tons of C02 (TRBNRC, 2005). It also dispels pollutants such as heavy metals. One kilometre of two-lane asphalt road requires 15,625 tons of aggregate rock. Roads are also known factors contributing to rising temperatures up to 15-10%.[6]

The ecological effects of roads include physical disturbance, loss of habitat, impediment to animal migration, vehicle-related death and possible extinction of populations and species including habitat fragmentation that can cause loss of population at the species and genetic level, posing a threat to the ecosystem; dispersal of wildlife along with road networks as they act as a barrier that cuts through animal ranges and creates a crossing hazard, further diminishing wildlife habitats, especially if trees were cleared to make way for the road. Roads are also known to cause sound pollution detrimental to lives around the road. Roads also disperse many species of plants and animals and insects which may cause an imbalance to the existing ecosystem. Roads facilitate more roads and there is an incremental and long-lasting effect. The detrimental effects of roads on nature by far outweigh any advantages to wildlife; both in the short-term and particularly in the long-term. Roads also have a detrimental effect on water (pollution, evasion) and soils (pollution, soil erosion, landslides). The increase in temperature or heat island effect is especially damaging to the lives of animals and birds along the road. The rise in temperature causes greater demands for cooling often compensated by electric means that contribute to increasing emissions of carbon dioxide and sulfur dioxide.

In case of Nepal, environmental impacts of roads have also been reported. These range from environmental degradation, erosion and landslides (Petley et al., 2007) to irrigation schemes, buried springs and contaminated water supplies (Singh, 2018). Haphazard road construction

[6] Available at https://www.climatecentral.org/

and poorly designed roads continue to threaten ecosystem, biodiversity. Rapid and ineffective road construction throughout the country, but particularly in the middle hill and mountain areas, is placing increasing pressure on fragile ecosystems, wasting government resources, and increasing risk to road passengers and roadside dwellers (DOR, 2013; Singh, 2018). Effects of climate change in daily lives of people including agriculture and looming dangers of natural and manmade disaster such as infrequent and unpredictable rainfalls (Petley et al., 2007; McAdoo et al., 2018) complicate the issue of construction and use of road (Sudmeier-Rieux, 2019).

Consequently, anthropologists and other social scientists have been known to adversely affect the socio-economic and cultural aspects of communities. Transportation infrastructure especially, the jerry-built roads has been associated with unequally benefitting various segments of society and detrimental to local customs and livelihood. While roads are critical for economic development, these ecosystems and the services they provide are vital for sustaining life. Roads are key drivers of land-use change and deforestation, threatening biodiversity. In Latin America and the Caribbean, commercial agriculture facilitated by transportation networks is a leading driver of deforestation (NASEM, 2005). Local and indigenous peoples, their culture as well as ecosystems and biodiversity depend on their livelihood as well as culture. Thus, transportation infrastructure building has long-term ramifications. As much as roads are important to the lives of people, so are the local ecosystem, biodiversity, water soil and air. Nepal with its rich biodiversity is among the few which sustain many of the planet's most biologically rich and environmentally important ecosystems (Laurance et al. 2015). Thus, keeping in view, the multiple needs of Nepali people, the challenge is for road development to proceed without having detrimental effects on the environment and local communities. In this regard, increasing studies suggest eco-friendly green infrastructures as a means to achieve a more sustainable infrastructure. This report explores ways to reconcile the different goals of road development and socio-environmental conservation. It identifies the social, economic, and ecological effects of roads that can be evaluated in the planning, design, construction, and maintenance of roads and offers several recommendations to suggest sustainable roads for sustainable development.

9. Sustainable roads

Brundtland Report published in 1987 defines sustainable development as development that "meets the needs of the present without compromising the ability of future generations to

meet their needs". Following this definition of sustainable development, the conventional forms of the road in Nepal are not sustainable as explored in the section above. As such a growing practice of sustainable roads is explored as an alternative to present practices in road construction, use and maintenance to mitigate the adverse effect of roads on the environment, communities, and ecology. Green road encompasses technologies and practices that use natural processes (or artificial systems that simulate natural processes) to improve the overall quality of the environment and provide social, ecological, and economic benefits. Green technologies for road construction are based on the idea that road and their possible benefits to humans are accelerated when processes integrate the protection of natural ecosystems and from the integration of these very ecosystems and natural processes into territorial planning and development. There are two prominent characteristics of green roads: interconnectivity and multifunctionality. The first term highlights the importance of linking natural and man-made ecosystems and connecting natural processes to human infrastructural needs. The multifunctionality aspect refers to the ability of green infrastructure to deliver multiple benefits, meaning that the adoption of a nature-based strategy can provide versatile solutions for decision-makers[7]. Green roads are thus mindful of optimizing environmental protection and using techniques and approaches that cause minimal damage to environmental and natural habitats based on the concept of moderation, coordination, and mutualism.

In the case of roads development, green roads and highways are roadways constructed per a relatively new concept for roadway design that integrates transportation functionality and ecological sustainability. As such green roads mitigate the adverse effects of conventional roads without compromising the quality and efficacy of conventional roads. The benefits of green roads encompass economic, social, environmental, and ecological benefits which are briefly explored below.

9.1 Optimizing environmental protection

Sustainable infrastructure like green roads combines several innovative techniques and approaches that replace or reduce the detrimental practices of the conventional road for instance in place of hot mix techniques, warm or cold mix technologies are used in combination with appropriate tailor-made soil bioengineering that mitigates the effect of conventional roads to lives and environment. It also minimizes cost and energy by making

[7] United Nation Environmental Protection Agency. Available at. https://www.epa.gov/green-infrastructure/what-green-infrastructure

maximum use of local resources. Some of the most common and increasingly used approaches to the green road are as follows.

- The conventional blacktop is widely replaced using asphalt, bituminous, natural latex rubber , wastes, etc. Asphalt when used in the construction or maintenance of the green road is usually a combination of recycled or reused or waste material with sand and bituminous are cost-efficient, durable, water-resistant and are studied to have outlasted conventional roads. They are also known to have noise reduction capacities and are easier to maintain (Pawar & Ambre 2021). And as they are built with permeable materials that provide superior watershed-driven stormwater management, the leaching of metals and toxins into streams and rivers is prevented.

- Eco-friendly manufacturing: Cold or warm mix Asphalt, bituminous or composite mixes are being developed that have less of an impact on the environment. In warm mix technology, temperature, smoke, odour, energy consumption and emission (up to 20% carbon footprint) are reduced in comparison to Hot mixes without compromising the specification of hot mixes. Similarly, cold mix technology, which is increasingly considered in countries like India, the US, and Germany eliminates the requirement for any heating and uses natural rubber latex blended with bitumen emulsion. Cold mixes are prepared by mixing aggregates (including wastes and recycled materials) with bitumen emulsion at ambient temperature compared to the hot mix prepared at a temperature of 155o C which leads to the emission of hydrocarbons and suspended particulate matters. Cold mix saves approximately 1500 litres of diesel per kilometre.

- Recycle, reused materials: One of the biggest contributions of green roads can also be in waste management. Green roads have tremendous potential for reusing and recycling waste materials and thus reducing landfills and pollution. The reuse of waste polymers is considered an attractive solution for environmental white pollution and reducing the costs of road pavement and maintenance. Recycling waste that cause major pollution like plastics have already been used in many countries including Bhutan and India. The Green Road project in Bhutan, is paving Bhutan’s roads using plastic which plans to consue and thus eliminate all of the country’s plastic waste by using it in road construction (Phillips, 2015). The project aims to reduce the amount of plastic waste which are going to 6 landfills by 30 to 40% (Galley, 2019). The technology used in the project mixes plastic waste with bitumen to create an aggregate compound called

polymerized bitumen that is used to pave roads. The technology can also significantly reduce the amount of bitumen and viscous petroleum product, needed for laying the roads. A report based on the project suggest plastic roads to be more durable than asphalt. Further it is reported that use of plastic can withstand greater extremes of temperature, ranging between -40C and 80C. Additionally, it is also worth noting than construction period can be reduced significantly while using plastic (Rolf Mars, 2016).

- Water-saving and recycling techniques: To avoid the concentration of water along the roadsides, green roads may be equipped with catchment areas or maybe built using porous asphalt or pervious concrete, that allow stormwater to drain through the surface into a catchment area below which can be reused.

- Flexible approach: One of the salient features of sustainable road is the flexibility in using. The conventional roads are increasingly studied to be disastrous to communities especially in the rural areas. In case of green road approaches, technologies and practices can be modified to suit the needs if urban areas, highways, rural road and even foot trails. For Urban settings and highways, the green roads can use a mix of conventional as well as green approaches. While for rural and foot trails it can largely rely on green technologies.

- For mountainous or rural areas, the green road can be modified to use techniques of lower slope cutting and vegetation protection, and mass balancing. The conventional ways of road widening by full cutting and throwing the excavated material downhill which the green road avoids by employing the cut and mill method of mass balancing. Rather than throwing the excavated materials down and possibly obstructing land and vegetation, these materials are reused, for instance in constructing a toe wall. The process can also be complemented by avoiding the use of heavy equipment such as bulldozers and proportionally cutting the slope height. A number of earlier arguments have already been presented to attest that labor-based methods are environmentally and technically better than using a bulldozer, for rural, non-surfaced roads. Using labor is a much more flexible and quality-oriented way to build rural roads, for example; material can be managed, cambers can be made accurately, slopes can be cut to the appropriate angle, drainage can be made as the road progresses, etc (Gurung 2010).

- Avoiding blasting techniques, or heavy equipment like a bulldozer, the risk of landslide and soil erosion is avoided. Deoja (1994) estimates that 400-700 cubic meters of

landslides occur per kilometre per year along the mountain roads and 3000 to 9000 cubic meters of landslide occurs per kilometre during the construction of mountain roads in Nepal. For instance an investigative study on a landslide incident in Bajhang for example in 2018 between April 27 and May 6, 10 people lost their lives in 10 days in multiple landslides in the district. The landslides collectively damaged nearly 320 hectares of land, turning them into river banks, destroyed property, local infrastructure, and nearly NRs 500 million worth of crops. The report found that roads built by rampant use of dozers in Bajhang had played a major role behind the devastation trail caused by landslides that year. In total, 165 roads were being built in a haphazard manner using 53 dozers around the time of the landslides in the district.[8]

Green roads thus reduce such risks. Blasting is replaced by simple methods like Chiseling and Hammering, Heating and Breaking and Drilling is done to cut the rocks. And as these methods require minimum technical skills, low skilled labourers can be employed. Additionally, green roads are based maximize the use of existing transportation infrastructure reduce the energy required to build the highway. Hence existing roads can be upgraded rather than constructed new ones.

- Environmental Impact assessments (EIA) are carried out as a construction protocol to access the environmental, biological and socio-cultural-economic impact so that projects can be designed to meet the specific needs of the place.

- One of the most innovative and distinct features of green roads is the use of bioengineering which alleviates the risks to critical habitats and ecosystems. Bioengineering is the use of living plants to reduce slope instability and soil erosion. In the process, local and indigenous people who have better knowledge of the local ecosystem and biodiversity are consulted and their knowledge is greatly integrated. Additionally, roads are engineered in ways that reduce disruptions to ecological processes by promoting wildlife corridors, passages, tunnels underpass etc., when necessary, loss of habitat can be compensated by resettling elsewhere (mitigation banking). When habitat fragmentation cannot be reduced road routes can be changed to reduce fragmentation (Spillberg and Morison 1998).

[8] Available at https://www.recordnepal.com/across-nepals-mid-hills-unplanned-roads-are-leading-to-more-landslides-%E2%80%94-and-more-deaths

- In recent times a rating system is being developed and tested to provide a rating for green roads in urban areas which has 61 credits, divided into mandatory (all projects must do them and these credits do not earn points) and voluntary (teams elect which to pursue and earn points). Voluntary credits track a variety of economic, social and environmental measures against specific performance targets and thresholds that are designed to encourage behaviours and performance above and beyond minimum compliance. These rating systems can monitor the efficacy of green roads.

9.2 Cost Efficacy

One of the most prominent features of green roads is their cost efficacy. Not just in rural construction, even during urban and major highway constructions costs are studied to have significantly cut down. A study conducted in India showed that there is a considerable difference between the cost of construction and overall maintenance of green roads and conventional roads. The study reported cost cuts of 16.36 % during the construction of a green road in comparison to the conventional road. Additionally, there will be a 26.50% saving in regular maintenance over the conventional road. There is up to an 11.80% difference in major repairs for the green road (Pawar & Ambre, 2021). Another study showed that fossil fuels (approximately 1,500 litres of diesel per km) can be saved with an overall savings of construction which are more than 35 % savings. Furthermore, cold mix roads are reported to have 50 years longer life than the hot mix. Similarly, the use of plastic waste and its flexible in using, increasing the stability, durability of roads and reduce the cost of construction of roads (blacktopping of road) by replacing some percentage of bitumen with that of the waste plastic (Lhamo & Norbu, 2020). A study suggests weight of 8% of plastic could save upto 0.4% of bitumen(Justo & Veeraragavan, 2002). Use of plastic with bitumen is known to increase binding property (Rajasekaran, Vasudevan, Paulreg, 2013 which adds to improving the durability of the road (Punith, 2010). Plastic further contributes to increasing the melting point of the bitumen which minimizes road damage due to heat. It is thus reported to be 60 percent stronger than bitumen paved road (Lhamo & Norbu, 2020).Use of green roads by recycling waste plastic could significantly cut down cost of road construction as well as cost for waste management. As much as 114.1304 tons of plastic can be used per kilometer of road construction (Lhamo & Norbu, 2020). Additionally, the cost saved by turning landfills into productive land could also be significant.

Even in the case of Nepal costs do reduce if the road is constructed using the green road concept and most importantly over 65% of the cost remains within the local economy. Cases in rural Nepal employing the green road approach are also known to enhance the local economy by raising skills and communal capacity as well as introducing economic activities like savings and credit operations and promoting off-farm income opportunities (during construction). These economic benefits are exacerbated by optimum utilization of local resources in the form of local labour, local materials, and local finance. By avoiding heavy and costly equipment and transferring it to human labour. For the purchase price of one bulldozer, it would be possible to use 120,000 person-days in labour-based road construction using the green road approach (equivalent to approximately 200. km of 1.5m wide trail, or .4 - 5. km of full-width earthen road) It is estimated that a labour input of 12,000 person-days per kilometre is required to construct a green road and payment to labour accounts for about 65 % of the total cost per kilometre (Mulmi, 2009) creating off-farm employment opportunities. Labor-based road construction are able address those issues of poverty orientation and inequitable distribution of wealth than building a road by bulldozer, as demonstrated in practice (Gurung 2010).

9.3 Ensuring Social equity and equality

Green roads are also mindful of the social implication of roads and are designed to mitigate possible consequences to the lives and culture of communities adjoining the road. As such green road considers equality in that it is mindful of benefitting as many locals as possible especially those at the lower socio-economic strata. By including maximum possible women and men in decision making, construction and maintenance process it also can accommodate gender balance. In addition, increasing local participation can improve local ownership. Green roads also consider historic and cultural landmarks during planning so as not to encroach or disrupt them.

As such there have been some small-scale attempts to green infrastructures in Nepal with varying results (GTZ, 2000). The attempts have been deemed appropriate for Nepal's fragile mountain topography that aims to be low cost and uses manual labour to generate off-farm employment. It was linked to some benefits to the local economy through region access to education, trade, hospital, local services etc. However, the effect was limited as most of them are not all-weather and had to be closed off during rainy seasons and limited to connecting the local economy with the region. However, a substantial move in poverty alleviation requires a massive investment in all-weather green transportation infrastructures that connects the locals nationally and beyond. And as a recent exercise on green roads in India in states like Tamil Nādu shows green roads can replace conventional roads completely without compromising any benefits of conventional roads. As such considering environment and rural poverty alleviation measures, the green transportation infrastructure approach will prove to be a sustainable way of constructing rural as well as urban roads.

10. Rapid road development and its relevancy to Nepal's overall development plan

This section deals with how developing sustainable roads links to national priorities and plans. To do so this section links sustainable roads to the 15th National Plan and sustainable development goals. It is especially pertinent as Nepal has not been able to meet the goals of the 15th plan or implementation of Sustainable Development Goals (SDGs) and is taking longer than many to come up with a comprehensive plan of action toward reaching those goals. GoN has stated 21 "national pride projects" of which 10 are directly related to

transport infrastructure, three aviation-related, one railway-related, one fast-track related and the remaining ones are about building highways. Nepal's transport infrastructure had mainly focused on roads and roads account for 90% of total transport mode. Nepal now is connected to 76 districts. By FY 2018/19, the total length of strategic roads was 13,448 KM. Of this, 6,979 KM is blacktopped; 2,277 KM is gravelled, and 4,192 KM is earth road. The total length of 80 existing national highways is 14,943 KM of which 6,000 KM is blacktopped, 1,150 KM is gravelled, 5,763 KM is the earth road and an additional 2,000 KM of road tracks need to be constructed. According to a survey conducted in 2018, 43 % of the strategic roads are in good condition, 42 % of roads are in average condition and the remaining 15 % of the roads are in a poor state. The road density is 9.14/sq km.[9] The present road system consists of 64% of SRN and 31.7% of Local Road Network (LRN) in paved condition (bituminous and gravelled). The rest is in earthen condition. Only 4% of LRN and 51% of Strategic Road Network (SRN) are bituminous pave. Out of the total SRN, around 53% of the roads are on the hill followed by 34% in Tarai and only 13% on the mountain. A significant proportion of mountain roads are in earthen or track condition. Only 33% of the total road network are all-weather roads, the rest fair-weather. 68 % of LRN is fair-weather, out of which more than 51% need major investment to make them operational. During the early years of planned development, (FY 2001/02 to FY 2006/07), road work grew by around 2.2% annually.

15th planning, poverty alleviation and sustainable road development

15th planning continues to prioritise poverty alleviation and among other factors recognizes the ack of integration between various poverty-related programs, inability to provide access to resources for the poor, lack of remittance and capital utilization and thus employment opportunities as a hindrance to more efficient poverty alleviation. The plan also states that a more effective way out of poverty would require gradually reassigning the surplus human resources from agriculture to nonagricultural sectors; modernization and commercialization the agriculture sector; generating new employment opportunities by creating an investment-friendly environment for the development of agriculture, industries and tourism sectors; and implement the poverty alleviation programs targeted to the poor by identifying the real poor among others. National and international practices of rapid development of roads as explored in earlier sections suggest that rapid green roads can significantly contribute to these efforts of the 15th plan. Additionally, the 15th plan recognizes the transport sector as a driver of

[9] https://ibn.gov.np/helpie_faq/what-is-the-status-of-domestic-transport-connectivity-in-nepal/

economic growth and development that has been making a significant contribution to physical and social infrastructure such as hydropower, industry, communication, tourism, agriculture, health, education, and urban and rural development and states governments commitment to encourage in transport infrastructure notably, road. In addition, the plan states the need for transport systems like roads to be safe, minimum transportation cost, and development of sustainable infrastructure and systematic maintenance are necessary. All these mentioned plans and priorities can directly benefit from investing in green roads.

15th plan also envisions maintaining a balance between technology, cost, and quality of construction of road infrastructure given the limited availability of investment and to build balanced, safe, sustainable, environment-friendly roads. In the real term, the plan envisions increasing the number of households with access to transport within 30 minutes from 82 to 95 %. Out of a total of 14,913 KM of national highways, an additional 7,500 KM of roads to be upgraded or improved and 13,474 KM of the road to be blacktopped. Likewise, a total of 1,078 KM of national highways including EastWest Highway, Kathmandu- Tarai Madhesh Expressway is planned to be upgraded to four or more lanes; Mid-Hill (Pushpalal) Highway, Postal Highway, and North-South Highway (Koshi, Kaligandaki, and Karnali Corridor) to be constructed and upgraded to two-lane highways; and standards for national highways, 308 provincial highways, and local road network to prepared and implemented.

Similarly, SDG that aims at lowering poverty levels by half by 2030 can also benefit by considering green roads. Goal 1: Poverty Reduction, Goal 2: Achieve Food Security Goal 3: Access to Health Goal 4: Access to education Goal 5: Gender Equality Goal 6: Access to Clean water Goal 7: Access to Clean Energy Goal 8: Economic growth Goal 9: Building resilient infrastructure Goal 10: Reduce Inequality Goal 11: Sustainable Cities Goal 12: Sustainable consumption & production Goal 13:Climate Action, Goal 14: Conserve live below Water, Goal 15: Conserve Life on Land, Goal 16: Peace, Justice and strong institution and Goal 17: Partnership for Goals[10]. Green roads can substantially and directly contribute to the proposed SDGs 1, 4, 5, 9, 10, 11, 14, 15, 17 For instance as noted in an earlier section, roads can contribute to poverty alleviation. A 2002 study conducted by ADB noted that given a sufficiently long period of employment on the road, the poor can accumulate significant capital to invest in alternative livelihood opportunities and thus move away from poverty (Pande, 2017). Similarly, access to health can be increased through sustainable roads. Nepal's

[10] Available at https://sdgs.un.org/goals

geographical complexities and poorly developed roads have tremendously compromised access to quality health. The delay and difficulty in treatment have resulted in many untimely deaths or an increase in the severity of the disease. The construction of roads as seen in earlier sections can significantly contribute to the matter. Similarly, as studies have shown, the road can contribute not only to access to education due to time reduction in travel but also to attendance and retention in school due to parents or guardians' access to employment due to road construction and use. Similarly, other goals of SDG including improving economic growth can be directly linked to roads. Roads increase access to the market, increase, employment opportunities, and expand the local economy. For instance, a study has noted an increase in and out trade from rural areas in terms of agriculture and dairy and an increase in food and other supplies in previously unconnected areas(Gurung, 2010).

Roads also directly contribute to SDGs 3,5,6,7,8. Evidence shows that investment in rural roads leads to greater food security. Improved rural transport infrastructure and services can make food more accessible and affordable for the poor by reducing costs of the agricultural products. Studies reveal that lack of proper transport facilities and road linkage results in a considerable proportion of agricultural products getting lost or wasted in rural Nepal. Due to a lack of proper access to the market via road as much as 30 % of food including agricultural products and dairy, on average is thought to be wasted especially in rural Nepal. Similarly, the estimated post-harvest loss of fruit and vegetable in Nepal lies in the range of 20-50 per cent (Pande, 2017). This loss is significant given the hunger, nutrition, demand for food supply as well as food security of Nepal is concerned. In such as case it is worthwhile to consider the road's possible contribution to access to market and food security (WFP, 2010). Accordingly, it has been noted that a safe, efficient and socially inclusive rural transport system opens new opportunities for women and girls that improve access to education, health care, markets, administrative and welfare facilities and employment opportunities. Additionally, as explored in the above sections, sustainable roads contribute to goals regarding responsible consumption. Green roads contribute to the management and conservation of life underwater as well as life on land. Roads also indirectly contribute to SDGs, 10, 12, 15, and 16 That relate to equality and justice.

Specifically in terms of road, the SDG has projected an additional construction of 120,000 km by 2030 to match the transport requirement for Nepal’s socio-economic needs. In addition, it also projects around 25,000 km of roads to be upgraded to all-weather standards. If the roads are to be built and upgraded to the DRCN standards, the government will have to

spend a minimum of NPR 440 billion (USD 4.40 billion) per year till 2030 (IIDS & CNI 2019). These are ambitious plans that require huge resources and will be limited by many challenges as explored below.

11. Challenges and opportunities

Even with substantial benefits, there are multiple challenges and opportunities for the road in Nepal these are explored in terms of resources, policies and regulations, and socio-political issues.

Financial challenges and opportunities:

Capital expenditure on transport infrastructure to maintain growth is estimated to be anywhere from 8.14% to 9.23% and the cumulative estimated GDP for the period 2019 to 2030 is anywhere between 365.13 billion USD to 490 billion USD. For the year 2022, the GDP is 21.34 billion USD and for 2030 the estimated GDP is USD 39.23 to USD 65.44 billion for the three GDP growth in 2022 is expected at 3.9%. The construction of an additional 120,000 km of road to meet the SDG target, and upscaling investment to meet the economic growth by 2030 is estimated to require an investment need of 84.88 billion USD (IIDS &CNI 2019). Based on the availability of funds, the investment gap estimated for the transport sector is 48.88 USD billion. Although some of the costs can be reduced by prioritizing green roads upto 15 million USD, a large number of funds would still be inaccessible.

Nepal's limited resources and a mammoth task set by 15th planning and SDG goals pose a substantial challenge to avail necessary resources. The major sources of funding for these investments at the present are the revenue it collects from the public, loans from public or international donor agencies, and aid from different countries all of which are neither sustainable in the present context nor dependable. Taxable revenue is already high compared to the living standard of an average Nepali; further increments will have disastrous consequences. Further, although some studies (Dixit, 2017) suggest the availability of some fiscal space for burrowing, as the current debt to GDP ratio (27%) is already high, higher borrowing leads to high debt and hinders capital accumulation and growth. Similarly, the transport sector receives one-third of the total capital expenditure allocation, of which approximately 40 % is attributed to contribution from development partners of which road transportation received more than half of allocated aid. However, post covid and rising

inflation due to the war on Ukraine are expected to further lower aid from development partners. This makes a strong case for the increasingly active role of the private sector in the country and also foreign investments.

Private sector participation in Road development: Since the 14th plan, the private sector has opportunities to be part of the road construction process. National Transport Policy 2001/2002 The National Transport Policy 2001/2002 encourages private sector participation in building roads and although the Government has provided space for private sector investment in the 14th Three Years Plan (2016/2017- 2018/2019), roads investment is not fostering. The estimated investment by the private sector in Transport and communication is NRS 365 billion, which is 56 % of the total estimated investment in the sector, road constructions have not generated enough private investments. In the present context, private investment in road projects is not so lucrative because of the long gestation period, multiple risks, the possibility of a longer period of debt repayment and limited return on equity due to the uncertainty of generating constant revenue streams. To overcome these issues, a tolling system, annuity mode of payment, and BOOT could be applied. Expansion in the green road will also create additional demand for construction materials, technical expertise, etc. which can benefit the industries manufacturing and supplying these resources. Similarly Banking sector, public savings (Citizen investment trust, Army Welfare Trust etc. can also be encouraged to be involved. In the process, the capital market, which has in the past year shown the tremendous possibility for public investment can also be made use of. In this regard transparency and openness of transaction, quality professional services, adequate corporate financial disclosures and improved legal regulatory and Supervisory are the urgent need of the Nepalese Stock Market. Additionally, bond financing including green bonds (bonds issued by companies, municipalities, etc. to procure funds exclusively for projects that address environmental problems) and diaspora financing can also prove beneficial. As government already recognizes the lack of proper utilization of remittance as one of the obstacles to poverty alleviation hence diaspora bonds, diaspora investment funds, diaspora insurance and pension funds, diaspora direct investment, securitization of future remittance inflows (where banks can be allowed to leverage future remittance receipts to obtain capital), etc. Are suggested ways of proper utilization of remittance. Additionally providing subsidies for green road construction can also encourage investment in green roads.

However, it is important to note that there is limited capability of private sector in terms of expertise and manpower related to sustainable roads. As it is there is a considerable hesitation

amongst the private sector to invest in transportation sector, which might have contributed to the dearth of adequate manpower, knowledge and understanding of sustainable roads and its benefits. To increase the willingness and capacity of private sector, the government could carry out research and feasibility studies and disseminate the knowledge and aid in creation of efficient manpower. Additionally, prioritizing sustainable roads and granting subsidies to technologies and goods related to sustainable roads may improve both willingness and capacity of private sector.

Mobilizing Climate Finance

Developing green roads can open up more avenues for road development. Due to the growing priority of climate mitigation initiatives globally, green roads can benefit from climate finance (carbon trade), tax concession on materials related to environmental protection, and reduced costs. As a Least, Developed Country, Nepal has substantial potential to leverage the finance from dedicated climate-related international funds established under the United Nations Framework Convention on Climate Change. Among many funds, Nepal has projects supported by Least Developed Countries Fund, Adaptation Fund and Global Environment Facility, Green Climate Fund as such low-carbon pathways such as green roads present a good possibility to access resource. By adopting green roads as an alternative to conventional roads, Nepal can align itself to low-carbon resilient development and increase resources for road construction. Encouragingly on February 26, 2021, GoN signed a landmark agreement with the World Bank's Forest Carbon Partnership Facility (FCPF), unlocking up to US$45 million to support Nepal to decrease carbon emissions from deforestation and forest degradation through 2025. With this Emission Reductions Payment Agreement (ERPA) in place, Nepal is expected to reduce 9 million tons of carbon dioxide emissions in the Terai Arc Landscape.[11] With this Emission Reductions Payment Agreement (ERPA) in place, Nepal is expected to reduce 9 million tons of carbon dioxide emissions in the Terai Arc Landscape. For each tonne of carbon dioxide emission reduced, Nepal will receive $5 in return. According to estimates, by adopting green roads, Nepal can reduce up to 260 tons of C02 per KM[12] (TRBNRC, 2005) and up to 31 million tonnes for planned 12000 Km by SDG.

However, green roads globally are at their primary stages of being fully utilized. As a result, there is a lack of adequate information, expertise and experience on the matter. However, in

[11] World Bank Press release (2021). Available at. https://www.worldbank.org/en/news/press-release/2021/02/26/nepal-and-world-bank-sign-innovative-financing-agreement-on-forests-and-climate-change-for-building-back-greener

[12] Subjected to technology used

addition to Some European countries and US, India is one of the foremost countries investing heavily in green roads with much success, which can serve as a reference for Nepal. Nepal must prioritise research, feasibility studies and further development of green techniques to fully unlock the potential of green roads in poverty alleviation. To that end, sensitizing and encouraging the private sector in climate-friendly investment is crucial. Financial sector regulation can be devised to encourage private investors and commercial banks toward green finance. In addition, when possible, subsidies on climate-friendly technology and programs must be exercised.

Effective project planning and development are also of critical importance to Nepal as the demand and supply chain for resources is very limited, as such prioritising projects based on a cost return basis, socio-economic spillover effect and need basis can prove beneficial. As the road constructions are increasingly subjected to political manipulation, numerous jerry-built roads of temporary nature take away scarce resources. Additionally making maximum use of existing roads and upgrading and maintaining them rather than constructing new roads will have further benefits. In the same line a study reports (Dixit, 2017) that by improving and adopting the best practices in selecting and delivering new infrastructure projects and by effectively managing the existing infrastructure, countries could obtain the same amount of infrastructure for 40% less investment. This arises from improved infrastructure productivity.

Instability and policy constrain

Even though over the past decades, there has been substantial policy reform to improve road development and increase investment and involvement of the private sector in it, several policies still contain the possibility of road development. Project selection based on the lowest bidder stated in Public Procurement Act is known to compromise quality and other financial malfunction. The lack of clear FDI regulation impedes foreign investment. Further, the absence of a single-window policy and multiple bureaucratic hassles discourage investment. Though even though government repeatedly states the importance of roads in development, the lack of favourable policies, bureaucratic inefficiency and competing acts, policies, and concerned ministries has resulted in the underutilization of the budget in recent years. Nepal has a range of acts, regulations, guidelines and directives that require proper road engineering practices, various levels of environmental assessments and approval. However, while funded by government budgets, a majority of local roads do not follow established government practices (ITAD, 2017). Hence, although the legal framework for

ensuring proper governance of infrastructure development is well developed with public bodies to monitor and enforce governance, the lack of political will and consensus among political leaders has undermined the impact of these bodies (Sudmeier-Rieux et al 2019).

Similarly, haphazard planning of roads and jerry-built roads on the basis of political interest has resulted in weak roads that do not withstand weather fluctuation and also cause road accidents. It has also been noted that duplication of roads and construction of numerous roads for a single region rather than strategic planning has caused wastage of valuable and scarce resources. Multiple roads for small communities have raised the debate of weather roads should be constructed around community or that communities should be moved to places with road connectivity so that resources can be used on upgrading roads rather than constructing new roads. In such a case planners must be mindful of economic, environmental and social return of roads planned.

Developing Complementary infrastructures

Recent reviews have shown that the impacts of one type of infrastructure (e.g., roads) on economic development, poverty reduction indicators, and other welfare measures can be significantly enhanced by coordinated investments in complementary infrastructure (e.g., telecommunications and power). Furthermore, it is becoming increasingly clear that unless the initial infrastructure investments (e.g., a new or rehabilitated road) is properly operated and maintained, the poverty and development benefits will soon vanish (Duncan, 2007). A very high rate of return due to its spill-over or externality effects is attributed to the complementary and mutually reinforcing nature of sectors namely, road construction, railways, electricity gas and water supply, communications, irrigation, storage, and ports (Mishra, Narendra & Kar, 2013). Hence the positive effects of roads are multiplied by the development of other infrastructure resulting in rapid development and poverty alleviation. Lack of complementary infrastructure not only reduces the positive effects of road, but it also contributes to further increase in poverty. For instance, in absence of proper agricultural infrastructure or water supply, health and education facilities, local resources will be transferred to areas of access, draining local economy.

Possible ill effects of road construction and its management on communities

As much as roads are a prerequisite for development, there have been many instances in Nepal where roads have limited contribution to poverty alleviation. In some instances, roads

have contributed to the unidirectional flow of goods, mostly from urban or resource-rich areas to rural areas. Local markets are also known to decline as the bigger markets are accessed by the local people. This results in further depletion of local resources and may increase poverty and dependence. For instance in Dailekh, district headquarters and Dadi Madi market (Bhari Kalikatum VDC) have both declined as people move towards the highway which skirts the district's western boundary, and the cheaper markets found along with it. In Kalikot, Padma bazaar in Chilkaya VDC has lost 75 per cent of its business to the Serrabada market in Pakha (WFP 2010). Similarly, in many cases, the road access has resulted in the movement of goods from urban areas or terai to lower and upper hills and commonly from south to north bringing little or no relief to the local economy. This is especially true for most economically backward places in the country like Karnali. Furthermore, the access to food after road construction has also been noted to be linked with lesser production of agricultural goods in shortage of mechanization or improvement in agricultural technology and necessities, especially in the Far and Mid-West.

The one-way transport or movement of food and goods also often increases prices. When good flow in only one direction, the transportation facility traders become responsible for two ways fees. Due to a lack of complementary interventions such as mechanization of agriculture, improved trade facility, social infrastructure development etc. most rural areas in Nepal connected to the south or urban centres by road are unable to fully utilize the benefits roads may incur. Similarly, traders cannot use destinations for back and forth of goods due to inadequate development of the supply-demand chain. Increasing two-way transport for export (i.e. generating a more substantial or marketable supply) would make more effective use of the roads and highways (WFP 2010).

Similarly, roads contribute to accidents and death. A report suggests that approximately 1.35 million lives are lost in road accidents annually, 37000 per day and over 50 million people worldwide sustain injuries due to road-related accidents(Pant et al, 2017) of which almost 90 per cent are recorded in low and middle-income countries. Quality of road, timely maintenance of roads, and abiding by traffic rules are some of the significant factors concerning road fatalities and injuries. The rate of road traffic crashes in Nepal is estimated to be 100 times greater than that in Japan and 10 times that in India (Adhikari, 2016). Global Burden of Diseases (GBD) estimates for Nepal, suggest that 6788 road traffic deaths occurred in 2017, of which 53% were pedestrians, 19% were motorcyclists, and 20% of people were in motor vehicles (Global Burden of Disease, 2017). Between 1990 and 2017, pedestrian road

injuries were the predominant type of transport injury leading to disability-adjusted life years in both sexes in Nepal (Pant et al., 2020). Construction of load must thus be mindful of possible hazards that can be caused by the road and efforts should be made to minimize road accidents.

Roads have also been studied to have contributed unequally to different sectors of society, often at the cost of economically and socially marginalized populations. For instance, a study noted that the tourism sector in Manang is profiting from and adapting to increased arrival numbers and a prolonged length of stay, while the lower parts of the region suffer from a significant loss of business. According to the government agencies and the project donors, low socioeconomic populations are expected to benefit the most from the road. Within Manang however, the livelihood strategies of these populations remain relatively unaffected. Therefore, it is concluded that building roads is not sufficient (Rossmanith, 2018).

Similarly, reports have also suggested the influx of negative changes in eating and lifestyle patterns of locals with road connectivity. For instance, in a story from the Karnali region one of the most food-insecure areas of the country, road connectivity has increased low nutrition as people abandoned traditionally grown and prepared food in exchange for packeted food mostly with low nutritional value. The report suggested that isolated villages can show better nutrition indicators than those connected to the road network because not having access to a market means people eat the nutritious food they grow rather than selling it for cash. [13]

However, this adverse effect of roads can be mitigated with effective planning, awareness, and building of complementary infrastructure strong education programmes and policies to regulate corporations that want to sell products all over the country to newcomer consumers.

Being mindful of these opportunities and challenges, Nepal may well be on its way to achieving SDG goals and other national planning goals through the construction of sustainable roads and the multiple benefits it incurs.

12. Conclusion

Nepal continues to struggle with the substantial population living in poverty despite many projects aimed at poverty reduction. Evidence from successful economic growth from around the world shows that rather than linear programs investing in labour market development

[13] Available at https://www.thenewhumanitarian.org/analysis/2013/06/20/why-roads-matter-nepal

results in accelerated growth in which the development of infrastructure acts as the backbone. A strong association exists between the availability of basic infrastructure such as roads and economic development measured in terms of GDP. This implies that a massive investment in infrastructure like the road would substantially contribute to sustainable poverty alleviation. Roads often have a multidimensional contribution to poverty alleviation which includes accessibility to employment opportunities, health, education, administrative services, lowered prices, higher consumption abilities and varying positive effects on improving the quality of life and reducing poverty.

However, as history has shown transportation infrastructure, especially roads are detrimental to the environment as it destroys ecosystems and hampers wildlife and natural resources and is known to have adverse consequences on societies often benefiting upper strata of economic hierarchy than those that depend on forest and ecosystems to sustain their life, that undermines the possibilities of road development. At the same time, developmental infrastructures are also known to have uneven effects on different levels of society. In such a state, keeping in the knowledge that any form of development to be sustainable must be attentive to economic, social as well as environmental needs; it is pertinent that future development projects including the transportation sector be mindful of these aspects. As such innovative techniques of sustainable roads like green roads are seen to be a better alternative for rapid road development. However, these efforts must be taken with caution that investment in infrastructure alone does not guarantee growth.

Additional as Nepal has set forth ambitious plans in the alignment of SDG, there is an urgent need to effectively manage and utilize necessary finances, and manpower and make necessary policy changes to unveil the full potential of green roads in poverty alleviation. In such a state, the planning must prioritize and encourage private sector partnership in road development, utilize the domestic resource, utilize remittance, encourage FDI, make necessary policy reforms, make use of carbon financing, develop complementary infrastructures, develop knowledge and necessary manpower on green roads and maximize current infrastructure, and developing complementary infrastructure.

Reference

Adhikari, G.P., 2016. Road traffic accidents (RTAs) trends on Kathmandu-Bhaktapur Road after addition of lanes. *Open J. Civ*. Eng. 6, 388–396. https://doi.org/ 10.4236/ojce.2016.63033.

Ali, Ifzal; Pernia, Ernesto M (2003). *Infrastructure and Poverty Reduction - What is the Connection?* Asian Development Bank. http://hdl.handle.net/11540/613

Bhandari, P., and D. Ghimire. 2013. Rural agricultural change and fertility transition in Nepal. *Rural Sociology* 78(2), 229-252.

Bougheas, S., Demetriades, P.O., & Mamuneas, T.P. (2000). Infrastructure specialization and economic growth. *Canadian Journal of Economics*, 33(2), 506-522

Calderon, C., & Serven, L. (2003). The output cost of Latin America's infrastructure gap

Chotia, V. and Rao, N.V.M. (2017), An empirical investigation of the link between infrastructure development and poverty reduction: The case of India, *International Journal of Social Economics*. 44 (12), 1906-1918. https://doi.org/10.1108/IJSE-06-2016-0154

De´murger, S. (2001). Infrastructure development and economic growth: An explanation for regional disparities in China.? *Journal of Comparative Economics*. 29, 95-117.

Deoja, B.B. (1994). *Sustainable approaches to the construction of roads and other infrastructure in the Hindu Kush-Himalayas,* International Centre for Integrated Mountain Development (ICIMOD) Occasional paper, 24, Kathmandu.

Dixit, A. M (2017). *National Study / Paper Infrastructure Finance Strategies for Sustainable Development in Nepal*. Kathmandu

DOR – Department of Roads: Nepal Road Standard 2070, Government of Nepal, Ministry of Physical Infrastructure and Transport, Department of Roads, Planning and Design Branch, Road and Traffic Unit, DoR, Kathmandu, 55 pp., available at: http://kec.edu.np/wp-content/uploads/2017/06/ Nepal-Road-Standard-2070-1.pdf.

Duncan, T (2007). *A Case Study from the 2007 Sector Assistance Program Evaluation of Asian Development Bank Assistance for Roads and Railways in the People's Republic of China*. ADB

Galley, K. (2019). An innovative way to pave roads using plastic waste practiced in daily Bhutan.

Global Burden of Disease, 2017. Global Burden of Disease Study 2017 (GBD 2017) Results. *Institute for Health Metrics and Evaluation* (IHME), Seattle, United States.

Government of Nepal (2021) *Nepal Multidimensional Poverty Index: Analysis Towards Action* https://npc.gov.np/images/category/MPI_Report_2021_for_web.pdf

GTZ (2000). *Green roads: Building environmentally friendly, low maintenance rural roads through local participation Frances Klatzel GTZ Food for Work*, Nepal FfW@gtz.org.np

Gurung, N.S (2010). Community-led rural road construction in Nepal. *Occasional Papers of the Future Generations Graduate School*

IDIIS & CNI (2019). *Nepal Infrastructure (2030) Investment and Financing Needs*.

ITAD (2017) Rural Access Programme Phase 3. *Monitoring, Evaluation and Learning Component Review of Rural Roads Maintenance Planning In Nepal*, Brighton, available at: http://itad.com/reports/nepal-rural-access-programmemonitoring-evaluation-and (last access: 24 March 2019).

Jaquet, S., Schwilch, G., Hartung-Hofmann, F., Adhikari, A., Sudmeier-Rieux, K., Shrestha, G., Liniger, H. P., and Kohler, T. (2015) Does outmigration lead to land degradation? Labour shortage and land management in a western Nepal watershed,. *Appl. Geogr.*, 62, 157–170.

Justo & Veeraragavan. (2002). Utilisaton of Waste Plastic Bags In Bitumenous mix for Improve Performance of Roads.

Kathmandu Post (2021b). Remittance falls for the fourth straight month. Available at https://kathmandupost.com/money/2021/12/15/remittance-fall-for-fourth-straight-month#:~:text=According%20to%20the%20latest%20central,migrant%20workers%20sent%20home%20Rs961

Kathmandu Post (2022). Covid surge threatens to hinder Nepal's economic recovery. Available at https://kathmandupost.com/money/2022/01/12/covid-surge-threatens-to-hinder-nepal-s-economic-recovery

Kumer, R. (2017, March 22). Challenges and oppertunities associated with waste management in india. *All Journal*.

Lhamo, S & Norbu, S (2020) *Potensial of Plastic waste reduction Through Green Road in Bhutan. Royal* University of Bhutan College of Natural resources

Limi, A, Lancelot, E; Manelici, I ; Ogita, S (2015). *Evaluating the Social and Economic Impacts of Rural Road Improvements in the State of Tocantins, Brazil*. World Bank, Washington, DC. World Bank. https://openknowledge.worldbank.org/handle/10986/22078

Manandhar, T & Singh, S. Impact of Road Network on Sustainability of Rural Community A case of Gorkha, Nepal. *Proceedings of IOE Graduate Conference, 2019-Summer* Peer Reviewed Year: 2019 Month: May Volume: 6 ISSN: 2350-8914 (Online), 2350-8906 (Print)

McAdoo, B. Quak, M., Sudmeier-Rieux, K., Gnyawali,k., Adhikari, B., Devkota, S., &Rajbhandari, P. Roads and Landslides in Nepal: How development affects environmental risk. *Nat. Hazards Earth Syst*. 18, 32o3-3210.

Mulmi, A.D (2009) Green Road Approach in Rural Road Construction for the Sustainable Development of Nepal. *Journal of sustainable development.* 2(3)

Munnel, A. H., & Cook, L. M. (1990). How does public infrastructure affect regional economic performance? *New England Economic Review*, September-October, 11-33.

Liu, M, et.al (2019). China's poverty alleviation over the last40 years: successes and challenges 2019 *Australian Agricultural and Resource Economics Society* Inc. 64, 209–228 DOI: 10.1111/1467-8489.12353

Mishra, A.K, Narendra. K, & Kar B.P (2013). Growth and Infrastructure Investment in India" Achievement, Challenges, and Opportunities. *Economic Annals*. 196 DOI:10.2298/EKA1396051M

MOF (2019) Economic Survey 2018/19. Singh Durbar. Available at. https://www.mof.gov.np/uploads/document/file/compiled%20economic%20Survey%20english%207-25_20191111101758.pdf

National Academies of Sciences, Engineering, and Medicine. 2005. *Assessing and Managing the Ecological Impacts of Paved Roads*. Washington, DC: The National Academies Press. https://doi.org/10.17226/11535

NPC (2019) Fifteenth Five Year Plan (2019/20-2023/24). Kathmandu, Nepal: National Planning Commission, Government of Nepal

NPC (2020). Government of Nepal National Review of Sustainable Development Goals. https://sustainabledevelopment.un.org/content/documents/26539VNR_2020_Nepal_Report.pdf

NPC (2021). Multidimensional Poverty Index Nepal: Analysis towards action Available at. https://npc.gov.np/images/category/MPI_Report_2021_for_web.pdf

Pande, K (2017). Improving Rural Connectivity and its Impact on SDGs –Case of Nepal. *United Nations Centre for Regional Development Intergovernmental Tenth regional Environmentally Sustainable Forum in Asia*

Pant, P.R., Banstola, A., Bhatta, S., Mytton, J.A., Acharya, D., Bhattarai, S., Bisignano, C., Castle, C.D., Dhungana, G.P., Dingels, Z.V., 2020. Burden of injuries in Nepal, 1990–2017: findings from the global burden of Disease study 2017. Inj. Prev. 26, i57–i66. https://dx.doi.org/10.1136/injuryprev-2019-043309

Pawar, T & Ambre, H (2021). Feasibility Study of Green Road over Conventional Road *International Research Journal of Engineering and Technology* (IRJET). 8 (7) e-ISSN:2395-0056

Petley, D., Hearn, G. J., Hart, A., Rosser, N., Dunning, S., Oven, K., and Mitchell, W.: Trends in landslide occurrence in Nepal, *Nat. Hazards*, 43, 23–44, 2007

Phillips. (2015). This Bhuddhist Kingdom is Paving roads with Plastic Waste. *Earth Project*.

Portal, W. (2012). Bhutan's First Waste Management Organization

Rajasekaran, Vasudevan, Paulreg. (2013). Reuse of Waste Plastic coated Aggerates- Bitumen mix Composite for broad Application-Green Method. *American journal of Engineering and Research*, 1-13

Rolf Mars. (2016). Sustainable Plastic roads is Future?.

Rossmanith, C (2018) *On the Road to Development: The Impacts of Road Construction on Livelihoods in Manang*. University of Innsbruck Institute of Geography Faculty of Geo- and Atmospheric Sciences

Sahoo, P & Dash, R.K (2009). Infrastructure development and economic growth in India', *Journal of the Asia Pacific Economy*,14(4),351-365

Sahoo, P, Ranjan, R.K & Nataraj, Geethanjali (2010) Infrastructure Development and Economic Growth in China Discussion Paper

Singh, B. P. S.: From nowhere to nowhere. Haphazard road construction is ravaging the Nepali countryside, Nepali Times, 6 July 2018, available at: https://www.nepalitimes.com/banner/ from-nowhere-to-nowhere/.

Shrestha, S.A (2020) Roads, Participation in Markets, and Benefits to Agricultural Households: Evidence from the Topography-Based Highway Network in Nepal. *Economic Development and Cultural Change* 68 (3), 839-864

Spellerberg, I.F & Morrison, T (1998). *The ecological effects of new roads—a literature review Science for Conservation*. 84

Srinivasu, B., & Rao, P.S. (2013). Infrastructure development and economic growth: Prospects and perspective. *Journal of Business Management & Social Sciences Research*, 2(1), 81- 91.

Sudmeier-Rieux ,K; McAdoo , B.G; Devkota, S; Rajbhandari, P,l; Howell , and Shuva Sharma, S (2019). Invited perspectives: Mountain roads in Nepal at a new crossroads Nat. *Hazards Earth Syst. Sci.*, 19, 655–660. https://doi.org/10.5194/nhess-19-655-2019

Thapa, A (2013). *Microfinance development as poverty reduction strategy in Nepal: a multidimensional analysis of the factors determining microenterprise performance*. PhD Dissertation. Graduate School of Public Administration National Institute of Development Administration.

Transportation Research Board and National Research Council. 2005. *Assessing and Managing the Ecological Impacts of Paved Roads.* Washington, DC: The National Academies Press. https://doi.org/10.17226/11535.

Tripathi, S & Gautam, V (2010). Road Transport Infrastructure and Economic Growth in India. *Article Journal of Infrastructure Development* 2(2) 135–151. SAGE Publications Los Angeles, London, New Delhi, Singapore, Washington DC 10.1177/097493061100200204 http://joi.sagepub.com Journal of Infrastructure Development

Uematsu, H, Shidiq, A.R & Tiwari, S (2016) *Trends and Drivers of Poverty Reduction in Nepal A Historical Perspective*. World Bank.

Upreti, B. R. and Shrestha, G.: Linking migration, mobility, and development for strengthening adaptation to climate and disaster Risks: Reflections from Nepal, in: Identifying emerging issues in disaster risk reduction, migration, climate change and sustainable development – shaping debates and policies, edited by: Sudmeier-Rieux, K., Jaboyedoff, M., Fernandez, M., Penna, I., and Gaillard, J. C., Springer, Switzerland, 146–160, 2016.

World Bank (1991) *Nepal: Poverty and Incomes*. Available at: http://wwwwds.worldbank.org/servlet/WDSContentServer/WDSP/IB/1999/09/17/000178830_9810190148263 7/Rendered/PDF/multi_page.pdf.

World Bank (1999) Nepal: *Poverty at the Turn of the Twenty-First Century Main Report and Background Studies.*

World Bank (2011) *Large-Scale Migration and Remittance in Nepal: Issues, Challenges and Opportunities.* Available at: http://ceslam.org/mediastorage/files/Large scale migration and remittance in Nepal issues and challenges - hissan.pdf.

World Health Organization, 2018. Global Status Report on Road Safety 2018: Summary. Geneva.

World food Programme (2010) More than roads Using Markets to feed the hungry in Nepal.

Yan, D & Hua, F (2004). *Infrastructure, Growth, and Poverty Reduction in China* Scaling Up Poverty Reduction: A Global Learning Process and Conference. Shanghai

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