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Significance of Comprehensive Studies for Sustainable Infrastructure Development of Nepal

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Abstract

This paper discusses the importance of comprehensive studies for sustainable infrastructure development through a systematic review and comparison with past development cases in Nepal. Nepal needs an expanded infrastructure network to foster economic growth by addressing its current infrastructure deficits. However, it is also essential to maintain a balance among social, economic, and environmental considerations. Sustainable infrastructure integrates environmental preservation, financial and economic viability, and social equity, which is critical for long-term progress. The absence of comprehensive planning-based studies on infrastructure projects has led to significant failures, delays, and inefficient use of resources. The practices of comprehensive planning involve infrastructure development studies, including feasibility studies, detailed designs, and specialized analyses—such as climate data, topography, geology, and socio-economic impacts, financial and economic analysis, and risk analysis—to ensure sustainability. By examining several Nepalese projects, this paper highlights the consequences of inadequate study and offers insights to address the existing gaps.

Keywords: Infrastructure development, comprehensive study, planning, sustainability

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Introduction

Sustainable Infrastructure is a cornerstone of development and an important indicator of the prosperity of a nation. For this purpose, sustainable infrastructure will be defined as those that are well-planned and designed technically, constructed with quality assurance, environmentally friendly, socially accepted, and operated with stable institutions with adequate resources for operation. Mainly, national-level infrastructure involves the development of roads, mega buildings, and energy and water systems that need to consider their technical, financial, economic, social, and environmental implications. These are essential for human life and the country's economy. However, the community faces several challenges that need to be considered while talking about sustainable infrastructure development; these are resource scarcity, environmental degradation, natural hazards, technological advancement, inequality, and so on. The infrastructures should be able to ensure long-term economic viability, financial stability, social inclusivity, and environmental, and climate resilience benefits. On the other hand, unplanned infrastructure development leads to irreparable damage to the environment, society, and natural resources. Therefore, comprehensive planning in infrastructure projects is essential. Planning is a systematic and transparent method for identifying local needs, establishing goals and priorities, and creating a plan of action. While preparing of comprehensive plan, the aspects of technical, political, and legal should be considered, though, it may vary from one community to the next (Chandler, 2000).

The well planning enhances the technical and institutional capacity of developing countries and economies in transition. This will enable them to adopt and implement integrated approaches to sustainable infrastructure, supporting the 2030 Agenda (UN Environment, 2021). Sustainable infrastructure development includes the strategies and planning framework, alongside portfolio and project design, construction, operation and maintenance, and decommissioning processes (IDB Invest 2018). Over the past decade, there has been increasing attention to innovative methods to meet infrastructure demands while effectively managing environmental and social risks (Watking, 2014). Likewise, the importance of effective governance and innovation cannot be forgotten, which is crucial for

achieving sustainable development, as governance, innovation, and sustainable development are interconnected (Chaudhary, 2023).

For economic growth and competitive markets in Nepal, the expansion of the infrastructure network is essential (Dhungel, 2020). The goal 9 target of sustainable development goal is to develop quality, reliable, sustainable, and resilient infrastructure to sustain economic development and human well-being for all by 2030. Nepal committed to the SDGs goal through policy and plan by 2030. Considering sustainability, the paper focuses on how an infrastructure project can be well planned, having clear social, economic, and environmental objectives, being technically and financially sustainable without overburdening governments with long-term debt, and ensuring institutional stability over the life cycle of the projects.

This study focuses on the practice and challenges of infrastructure development and emphasizes on comprehensive planning to make it more sustainable and reliable. For this, the literature is intensively reviewed to discuss the sustainable infrastructure development cycles. Some Nepalese infrastructure projects as case studies are also linked to support the research arguments to fulfill the objective of the paper.

Discussion on Comprehensive Planning and Analysis

Comprehensive planning and analysis are normally divided into two stages, namely: Feasibility Study and Detail Design study. During the Feasibility Study of the infrastructure projects, several options are studied in-depth regarding technical aspects, and financial, economic, environmental, and social points of view while determining the most viable among them. Feasibility Studies establish the basis to decide whether a project should proceed. The main aim of the study is to ensure optimum resource allocation for deriving maximum benefits. Detailed design refers to the advanced phase of project planning that transforms conceptual and preliminary designs into precise technical drawings and specifications for the most feasible ones, which serve as executable blueprints for construction. The detailed design is the implementable document that could provide a critical guide that contractors require in terms of accuracy and details necessary for mitigating risks, eliminating ambiguities in design,

and realizing the intended functionality and performance of the project. This will include in-depth analysis and design of all project components, including structural, mechanical, electrical, and geotechnical systems in conformation with regulatory standards and best practices. It consists of detailed engineering design, technical documentation, material specification, and methods of construction that make sure the work is done efficiently, safely, and sustainably. Detailed designs assure construction and operational efficiencies when their clear details translate into smooth implementation and functionality over the long run.

Such studies are important in mitigating risks through the identification of possible hazards that include geological instability, climatic vulnerability, and socio-environmental impact, economic and financial risks hence ensuring that the project is sustainable and resilient. Furthermore, these studies are instrumental in securing funds, avoiding design variations and time extensions during the execution of the project, and smoother progress of the project. Moreover, the studies are very important with respect to funding approval for the project.

Topographic Studies

Topographic surveys acquire information about terrain, land use patterns, natural features, artificial structures in the project area, accessibility, etc. It is one of the most important prerequisites to any project initialization like site suitability assessment, project layout design, mapping water flow paths, and further planning of construction activities. Moreover, these surveys also accurately outline boundaries for land acquisition which can minimize disputes, and avoid delays and conflicts during project implementation. Most infrastructure projects are plagued by a lack of adequate topographic surveys. For instance, in hydropower projects, inadequate topographic data leads to less-than-optimal project layout designs, affecting the efficiency of the reservoir, disturbing the flow of water, and increasing the volume of excavation. For example, improper placement of intake structures or tunnels due to inaccurate surveys can lead to increased construction costs and environmental damage. Also, improper placement of transmission towers and route alignment also delay the projects Besides, poor planning of land acquisition due to lack of survey

data can result in long disputes with local communities, thus substantially delaying project timelines.

However, survey work in Nepal is less given priority in terms of budget. Topographic surveying can be enhanced in the present context of sustainable infrastructure development by integrating modern tools and methodology in data acquisition and training of skilled professionals. Recent technology developments around LiDAR, high-resolution drone imagery, and advanced GIS have transformed and quickened data acquisition, processing, and application of topographic data. The tools will also enable planners to improve the accuracy of the project layout design, efficiency in land acquisition processes, and reduce environmental and social conflicts.

Geological studies

Geological studies give important information on subsurface conditions, soil and rock properties, and geohazards, which may affect the feasibility and sustainability of projects. This study is of paramount importance for ensuring that the infrastructure is designed to resist site-specific geological challenges such as earthquakes, landslides, slope instability, erosion, squeezing, and landslide dam outburst floods, particularly in geologically sensitive regions like Nepal. Geological studies in hydropower projects help in the selection of suitable sites for dams and tunnels, assessment of slope stability, and providing safety conditions to reservoirs and other related structures. The geological study also plays a vital role in road and transmission line projects, road projects, and building projects by avoiding unstable zones and reducing construction risks.

In many instances, Nepal failed to effectively use geological studies in infrastructure planning, which often caused delays, cost overruns, and safety concerns. Several publicized infrastructure failures have taken place in Nepal because of the inability to undertake proper geological studies. To illustrate this, the most awaited Melamchi Water Supply Project (MWSP) in Nepal has been facing significant challenges due to poor geological studies and planning. Tunnel squeezing during the construction and repeated damage of intake of the project due to floods and landslides, has been repeatedly damaged by floods and landslides, indicating its vulnerability to natural disasters due geologically unstable

region. A landslide dam outburst flood in June 2021, implicated server damage to the project indicating the inadequacy of prior regional geological risk assessment study. This incident underscores the importance of integrating comprehensive geological studies and climate resilience measures in large-scale infrastructure projects in regions like Nepal (ADB, 2021). Likewise, frequent slides take place alongside the Araniko Highway due to inadequate geological assessment and poor slope stabilization measures. Highways and linear structures in rugged terrain, such as deep river valleys and mountain ridges, are vulnerable to landslides (Deoja et al., 1991).

Geological studies in Nepal are usually insufficient; most projects are advanced based only on superficial investigations without considering subsurface geological information. Unforeseen subsurface surprises and geohazards come up frequently during the construction phase, causing delays and cost overruns. Besides, the lack of strict regulations that demand detailed geological investigations further aggravates this issue by allowing projects to be advanced without a full understanding of the geological risks at a site.

Infrastructure development faces enormous challenges in Nepal because of its complicated geology in the form of young mountain chains, active tectonic zones, and frequent geohazards. Some contributory factors for such conditions may include limited skilled resources, as well as underestimation of the importance of geological investigations. These are issues related to inaccessible field investigation areas, unavailability of underground high-depth geological data, adverse weather conditions, poor coordination within the multidisciplinary teams, and potential unforeseen complications in construction. For instance, in the tunnel segment of Chemelia HEP from chainage 3+100m to 3+900m, significant tunnel squeezing and instances of tunnel collapse were recorded, and the area's geology was significantly different from the calculation made during the feasibility and design phase (Shrestha, Panthi & Basnet, 2014).

It's now time for Nepal to improve pre-construction site investigation practices and analysis to achieve sustainable infrastructure development. So detailed geotechnical investigations and seismic hazard analyses should be incorporated in every step of feasibility assessment and

detailed design of the project as well. The consulting business of the country should also open its doors to sophisticated technologies such as LiDAR, remote sensing, and ground-penetrating radar (SRT, ERT, AMT) that yield high-resolution geological mapping, especially in remote and inaccessible areas. Furthermore, enabling multidisciplinary collaboration among geologists, engineers, environmentalists, and other stakeholders will be very important in helping to integrate geological assessments throughout the project-planning process.

Climate data analysis

Climate data analysis thus plays an important role in the planning and design of sustainable infrastructure projects, especially in countries like Nepal, where highly seasonal rainfall dictates water availability. The concentration of rainfall during a few months in the monsoon season creates a situation of plenty followed by scarcity, with extreme variability in river flow affecting project viability. Unpredictable rainfall, made even more so by climate change, rises with the risks of floods, droughts, and dry spells that projects relying on stable water availability face. Large sedimentation and structural damage can take place due to monsoon floods in hydropower projects. Similarly, the disrupted water supply due to sedimentation and siltation affects irrigation projects, and flood management initiatives are required to make flow predictions to reduce risks.

Bhattarai et al. (2024) emphasize the need for climate resilience in project prioritization during the project evaluation framework in Nepal as there are regional differences in hydrological responses and a need for atmospheric interaction with the complex topography of the Himalayan region. The effective analysis of climate data starts with the collection of long-term records of rainfall, temperature, and river discharge. Modern regression techniques can also be applied to complicated relationships in various multiple linear and nonlinear models. The integration of these coefficients with climate and historical data into forecasting models allows the simulation of different scenarios of variable magnitude, including extreme events. Models are continuously validated and calibrated to maintain reliability and adaptiveness to new inflow data.

Climate data analyzed, informing hydrological risk assessments and infrastructural designs, considers high-flow and low-flow conditions. Spillways, sediment traps, and storage reservoirs are designed in relation to the foreseen flow variation. With good forecasts of flow, mitigation measures against flood can be planned; on the other hand, the anticipation of low flows aids in better water allocation for irrigation, drinking, and industrial use. This, in turn, increases the predictability of monsoon intensities through better sediment management and erosion control, hence holistic climate resilience for projects.

Spatial analyses, including full Arc GIS, remote sensing, and hydrological modeling with HEC-HMS, SWAT, or MIKE 11, enable this. Regression analysis and visualization will have to be done with analytics software like R, MATLAB, or Python. Integration of such analyses within project planning yields more reliable forecasts, optimum design, and mitigation of risks associated with the monsoon-driven variability of water in Nepal.

Environmental and Social Studies

The environmental and social viability of the projects is crucial for the success of any infrastructure project. The Environmental and Social Studies identify potential environmental and social impacts and propose mitigation measures for such impacts. By integrating identified mitigation measures with the feasibility study and detailed design, the project can be developed with minimum potential environmental impacts. Furthermore, Social studies can be strengthened by identifying and integrating possible stakeholders into the study. This technique can also foster transparency and trust, thereby reducing possible forthcoming conflicts and enhancing social acceptance. The deficiency in such assessments has often led to project delays and, consequently rise in project cost and even cancellations due to stakeholder resistance.

The Budhi Gandaki Hydroelectric Project (1200 MW) is designed to submerge the biggest Arughat settlement, a culturally significant area in Nepal. This proposed inundation has raised opposition from local communities, stakeholders, and hydropower experts. Some of them are still arguing that the project could have been designed to avoid the inundation of Arughat. In addition, the Project Affected people are also complaining

about the compensation delays and the lack of adequate resettlement plans. They even express their dissatisfaction through strikes and road blockades. For instance, in March 2018, stakeholders obstructed the Kathmandu-Benighat-Gorkha road, demanding timely compensation and a proper relocation strategy. Additionally, in October 2017, locals in the vicinity of Arughat warned of boycotting elections if the government failed to provide compensation to ease their resettlement process. This project is challenging due to its social issues as around 24% of the total project cost goes to environmental and social costs (bgjcl.com/pages/salient-features).

Another example is the Arun III Hydroelectric project which was canceled in 1995 by the World Bank because of environmental and social issues. The environmentalist and local community activists gave the project a thumbs down for its potential to disrupt the Himalayas ecosystem and displace the indigenous hill people. EIA(Environmental Impact Assessment) has failed to provide a thorough analysis of social, socioeconomic, and environmental costs, which influenced the choice of the project as the preferred alternative (Smidt, 1994). In addition, the inadequacy of the resettlement programs for the displaced population and the project's failure to make sure that the benefits are fairly distributed among the resident communities were among the issues or possible problems encountered (World Bank, 1995; Dixit, 2008). The lack of consultation and inclusion of the community in the decision-making process was also pointed in the face of opposition to the project by advocacy organizations like the International Rivers Network and local NGOs (IRN, 1995).

With the success of social and environmental studies, Nepal can improve the long-term viability of its mega infrastructure projects, with less environmental degradation, and high social acceptance, Thus, it is high time for Nepal to accept that environmental and social studies are far from mere regulatory formalities; they are essential tools for ensuring that infrastructure development benefits both society and the environment, aligning with sustainable development goals. It can minimize costly delays and budget overruns.

Scheduling and Cost Estimation for Infrastructure Projects

Scheduling and cost estimation are major factors for successful implementation of projects in infrastructure. These are basically the base things for any planning of a project to get it done on time and within a proper budget for resource allocation. Scheduling indicates the path on which the sequence would be done, and cost estimation would work out the resources required financially to be adequate at every stage of the work. These two go hand in hand in the successful execution of projects, reducing the risk of delays, cost overruns, and mismanagement of resources.

In Nepal, poor scheduling and estimation of costs have been long-term issues and have caused huge delays and cost overruns for most of the infrastructure projects. Hydropower projects have not been any exceptions; they too have faced delays and increased financial burdens. For example, the Middle Marsyangdi Hydropower Project had to experience unprecedented delays because of poor scheduling and cost estimation. It led to a delay in completing major phases and required more financial resources than anticipated to overcome unforeseen difficulties. This was no different in the situation concerning the Upper Tamakoshi Hydropower Project, with delays in procurement, and geological issues, including underestimations regarding project terrain and climate conditions; significant time overruns and cost escalation also occurred in this case..

The Melamchi Water Supply Project (MWSP) in Nepal has been beset with poor scheduling and cost estimation which were chiefly responsible for delays in time schedule and increased budget. Initially, this project which was intended to supply water to Kathmandu Valley was expected to be finished in 2008 at a cost of $315 million (ADB, 2002). Nevertheless, delays in the procurement of the required materials, construction activities, and environmental assessments have caused the project to be postponed to different periods. By the year 2021, the project had gone past the original cost estimate hitting more than $500 million (The Kathmandu Post, 2021). The first stages of the project were confronted with the effects of low tunneling work estimation that caused such issues as tunnel squeezes to come up and hence money to be spent on them on the fly. Further, inadequate risk management strategies and project

management practices, for example, the slow acquisition of lands and clearance processes, only served to prolong time schedules (MyRepublica, 2020). There was a lack of adequate and realistic forecasting and proper schedule that resulted in criticisms from the Asian Development Bank, ADB, which was the primary financier of state-funded projects at the inception of the project.

The road infrastructure projects in Nepal have also been hit by inaccurate scheduling and cost estimation. Improper site assessments, unplanned rerouting, and delays in procurement of materials resulted in cost overruns and delays in the Prithvi Highway and Araniko Highway projects. For better project outcomes, all possible costs, including geological surveys, weather-related delays, local labor costs, and contingency funds for unforeseen issues like landslides or accidents, should be duly considered in the cost estimation process.

Financial and economic analyses

Another important element, not less basic, is the financial viability analysis of the project with a clear way towards revenue generation or cost recovery. Where it seems a project may be economically beneficial but not yield reasonable monetary beneficial returns, there is a need to look for other options for its financing, either with public-private partnership financing or through grant or subsidization., These projects may not generate immediate revenue but offer long-term economic benefits, such as increased trade or tourism, which should be considered for their broader economic contributions.

Financial analysis shall be majorly concerned with the estimation of accurate costs, funding sources, and strategies, risk assessments, and the clear outlining of the way to revenue generation or cost recovery to ensure that projects are viable financially and can meet their operational and maintenance costs targeting the return-on-investment goals. The absence of proper financial planning may lead to project disruption even after the construction of the projects. The Bhairahawa Airport project is now the white elephant for the country. Around NRs40 billion was spent on the construction of Bhairahwa International Airport, though it does not have any international scheduled flights (The Kathmandu Post, 2023). The huge investment of the country is in jeopardy due to a lack of proper financial

analysis and market evaluation during the study phase, leading to unsustainable investment without matching revenue generation.

Similarly, the Upper Tamakoshi Hydroelectric Project has faced significant challenges regarding its Power Purchase Agreement (PPA) rate, which has jeopardized the financial sustainability of the project. The initial PPA signed with the Nepal Electricity Authority (NEA) set a rate of NPR 4.8 per kilowatt-hour has been failed to cover the project's high capital expenditure involved, the operational costs, including debt servicing and maintenance, which is higher than anticipated, (The Kathmandu Post, 2020a). The low rate does not align with the actual cost of electricity production, putting a strain on the project's long-term profitability and raising concerns about the need for rate revision to ensure financial stability (MyRepublica, 2021a). Additionally, the slow pace of tariff adjustments and inflationary pressures have further exacerbated the financial challenges, affecting the project's ability to generate adequate revenue.

Likewise, Civil Mall, located in Sundhara, Kathmandu, has faced significant challenges due to low occupancy rates and poor revenue generation. Despite being one of the prominent shopping complexes in the city, a considerable portion of its retail spaces remain vacant. Over 50% of the 82 retail spaces on the ground floor are unoccupied, which has led to concerns regarding its financial viability (The KathmanduPost, 2020). Lately emerging, changing consumer behavior, particularly the rise of online shopping and a shift towards smaller, specialized retail outlets, has further reduced the charm of large-scale malls like Civil Mall. These factors collectively explain the challenges faced by Civil Mall, which could jeopardize its sustainability.

On the other hand, direct and indirect social benefits beyond financial returns can also determine the viability of the project. This includes job creation, social welfare, and multipliers that estimate how much a project will stimulate the wider economy. For projects with longer-term benefits that cannot be immediately profitable, economic analysis decides whether costs are worth the value to society. Comprehensive financial and economic analyses during the planning stages can ensure proper decisions are taken in terms of ensuring that the projects are viable

and of value to society in the long term. The dearth of comprehensive financial and economic analysis in Nepal has been associated with a series of failures regarding the investments made in infrastructure projects.

Therefore, feasibility studies should be conducted considering financial projections on capital costs, operation expenses, revenues expected, and break-even points to avoid such problems. Economic feasibility studies must also be conducted for national and regional level projects to gauge long-term social and economic benefits to ascertain whether the projects are in line with national and regional development objectives. Another important aspect is to ensure sustainable financing. The projects should be designed to have flexible, long-term financing arrangements, considering the projects' economic viability, through grants, loans, or subsidies. When project revenues are insufficient, government guarantees or long-term financing structures provide financial security. Besides, regular audits and economic evaluations during a project's life will facilitate changes in plans whenever necessary to keep projects on course and adapt to changing economic circumstances.

Risk Assessment

For successfully developing and operating mega infrastructure projects, risk assessment is critical for feasibility. These mega projects are intricately complicated by various kinds of risks from environmental, technical, financial, and socio-political perspectives. If the presence of risks is not considered and consequently not estimated in an economic and financial feasibility study, the ultimate drawback will be an underestimation of the costs incurred for the realization of the construction project, and it ultimately creates problems in the design phase (Canesi & Gallo, 2024). Many mega projects have failed due to these causes.

A comprehensive framework for risk assessment and management during the feasibility study is thus very vital to identify, analyze, and mitigate the risks for the long-term sustainability and resilience of a project. Such risks are triggered by many factors. Climate change is due to flooding, GLOFs, weather pattern variations, increased sedimentation processes, and drought. The studies required to address these deal with climate impact, adaptive designs, climate-resilient materials, and suitable technologies. Correspondingly, geological hazards such as earthquakes,

mass movements, or unstable ground conditions shall be preceded with detailed geological mappings, hazard zone mapping, and respective structural design related to seismic and geotechnical standards accordingly. Market risks, including overestimation of demand and changes in consumer behavior, can be minimized by conducting detailed market research, demand forecasting, and flexible operational models.

The second major challenge pertains to cost overruns. This could be driven by inflation, incorrect estimation, or other unexpected expenses. Time overruns, caused by poor planning or regular natural disasters, may be avoided through the establishment of realistic timelines with time buffers, effective project management, proactive engagement with governments, early processes for approvals, and transparent stakeholder communication may avoid Political risks, which include policy changes or bureaucratic delays, require, as a mitigation measure. Frequent Shortages in construction materials can be managed by securing contracts with various suppliers, stockpiling critical materials, and finding alternatives.

A good risk management framework can be developed by SWOT analysis, expert consultations likelihood and impact assessment, and development of actionable mitigation strategies. Responsibilities related to risk management need to be delegated to the relevant stakeholders or contractors, while continuous monitoring enables rapid adaptation during construction and operation. Proactive measures, including environment-friendly infrastructure, political consensus, and financial security, enhance resilience further.

Conclusion and Implications

The key development of sustainable infrastructure includes several important principles: comprehensive planning and design, taking into consideration long-term environmental and social impacts; the use of renewable energy; and eco-friendly materials and construction techniques that reduce carbon emissions. Considerable attention is given to resilience in the event of natural disasters, especially in regions highly exposed to climate-induced events have been extreme floods, landslides, and earthquakes. It further involves the needs, concerns, and interests of local

communities in its involvement in the attainment of inclusive development within sustainable infrastructure development.

A nation can prosper only with the development of sustainable infrastructures regarding accommodation, transportation, energy, water supply, agriculture, and waste management. For a landlocked country like Nepal, with tough topography, weak geology, and frequent natural hazards, limited resources, special planning as considerations are required for infrastructure development. Otherwise, hazardous development can lead the country to a dead trap.

International best practices, like the use of green infrastructure in China for flood management and resilient road networks in Switzerland, provide useful insights. Similarly, in Nepal's case, the development of sustainable infrastructure must be done in a very specific manner, considering the local conditions, and emphasizing overcoming geographical obstacles and socio-economic vulnerabilities for long-term development and resilience. From the perspective of the environment, Nepal should adopt policies that balance development and conservation by implementing sustainable practices, such as environmental impact assessments, strict regulations on resource extraction, and habitat restoration (Shrestha & Praveen, 2024). Furthermore, the participatory approach of local people in development enhances sustainability.

Lastly, learning from past mistakes through establishing a database of previous projects and their geological challenges will inform future planning to avoid similar failures. In sum, by prioritizing comprehensive geological studies and addressing the challenges in geological assessments, Nepal can significantly reduce project failures, enhance the safety and efficiency of its infrastructure, and ensure long-term sustainability in its development efforts. This will contribute to a more resilient and well-planned infrastructure system that can withstand the country's unique geological and environmental challenges. The technical aspects such as topography, geology, and hydrology, environmental and social friendly, and economic viability are more important when choosing hydropower projects that determine the highest level of feasibility of any hydropower projects (Chaudhary, 2024). These challenges can be overcome only with effective planning, community engagement, and investment in capacity

building. Effective comprehensive planning resembles an ongoing process, as feedback from monitoring the implementation of the plan's recommendations should ideally be used to initiate necessary adjustments to the plan (Chandler, 2000).

Therefore, comprehensive studies are critical for large and complex infrastructure projects consisting of topographic and geological, financial, environmental, and social studies that determine a successful completion and operation. Essentially, these are the basic means for recognizing all potential risks, optimizing available resources, and creating correct and feasible plans that guide project execution. Besides that, one usually doesn't notice the design phase, in which all these studies take place. While the focus tends to shift to implementation as the main challenge, it has to be remembered that the implementation phase is, in effect, the execution of the design. The design itself is more than a blueprint; it is a form of research, intangible, and often only seen in reports and documents. The sad reality is that sometimes, after years of hard-won design work, infeasible or unrealistic project delays and challenges seem to appear. This, though, is just the same design that may save considerable time, resources, and money from being irreversibly lost and may assure long-term success for the whole project. It is therefore important that studies related to design be prioritized and more investment be made to build and sustain efficient study teams. In fact, comprehensive and quality studies that would ensure the smooth and successful execution of the projects require a capable and skilled team with adequate resources. The value of design studies actually needs to be recognized in relation to sustainable development and avoidance of unnecessary setbacks in future projects. The failure of the project creates a negative impression on people towards the infrastructure project which is not good in light development. It may also help to erode the people's faith in their government.

Conflict of Interest: The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declares the absence of conflicting interests with the funders.

References

ADB. (2021). *Mapping Hazards in Nepal's Melamchi River Basin.* Retrieved from https://www.adb.org

ADB. (2020). Guidelines for Resilient Infrastructure Development.

ADB. (2002). Nepal: Melamchi Water Supply Project

Dhungel, B. (2020). Infrastructure Development and Economic Growth in Nepal. Management Dynamics(3). 10.3126/md.v23i2.35817

Bhattarai, U., Maraseni, T., Devkota, L.P. *et al.* (2024). Hydropower and Climate Resilience of Nepal Himalaya:A bottom-up Hydrological Approach. *Earth Syst Environ*. https://doi.org/10.1007/s41748-024-00529-3

bgjcl.com/pages/salient-features(Budhi Gandaki Hydropower)

Chandler, M. (2000). Ten Steps in Preparing a Comprehensive Plan. Planning Commissioners Journal, November 39, 9-11.

Canesi, R., & Gallo, B. (2024). Risk Assessment in Sustainable Infrastructure Development Projects: A Tool for Mitigating Cost Overruns. *Land*, *13*(1), 41. https://doi.org/10.3390/land13010041

Chaudhary, D. (2023). Governance, Innovation, and Sustainable Development. *Journey for Sustainable Development and Peace Journal*, *1*(02), 1–5. https://doi.org/10.3126/jsdpj.v1i02.58258.Dhungel.

Chaudhary, D. (2024). Hydropower Development and Economic Growth in Nepal: Challenges and Prospects. *Journey for Sustainable Development and Peace Journal*, *2*(1), 1–18. https://doi.org/10.3126/jsdpj.v2i1.63236

Deoja, B.B., Dhital, M. & Thapa, B. (1991). Mountain Risk Engineering *Valley*. International Journal of Water Resources Development, 24(4), 553–565. DOI:10.1080/07900620802127353

GoN(Government of Nepal), Ministry of Energy, Water Resources, and Irrigation. (2021). Hydropower Development Policy.

IDB Invest. (2018). What is Sustainable Infrastructure? A Framework to Guide Sustainability Across the Project Cycle. Inter-American Development Bank. https://publications.iadb.org/en/

IFC(International Finance Corporation). (2020). Performance Standards on Environmental and Social Sustainability.

IRN (International Rivers Network). (1995). *Arun III: A Case Study of Power Politics in Nepal*.

My Republica. (2022 Dec 11). Editorial: *Lessons from the Melamchi Project*

My Republica. (2021a). *The Financial Struggles of Upper Tamakoshi: Revisiting the PPA Rate*.

My Republica. (2020). *Why Melamchi Water Supply Project Took Longer and Cost More Than Expected*.

National Institute of Standards and Technology (NIST). (2023, March 7). *IoTAB sustainable infrastructure*.

Smidt de J.T. (1994). Advisory Review of the Environmental Impact Statement of the Arun III Hydroelectric Project, Nepal, Commission for Environmental Impact Assessment, Utrecht, the Netherlands

Shrestha, D. K., & Praveen, B. M. (2024). Policies and Practices for the Conservation of Natural Resources during Infrastructure Development in Nepal. *NPRC Journal of Multidisciplinary Research*, *1*(7), 1–19. https://doi.org/10.3126/nprcjmr.v1i7.72434

Shrestha, P. K., Panthi, K. K., & Basnet, C. B. (2014). Analysis of Squeezing Phenomenon in the Headrace Tunnel of Chameliya Project, Nepal. *Hydro Nepal: Journal of Water, Energy and Environment*, *13*, 44–51. https://doi.org/10.3126/hn.v13i0.10039

The Kathmandu Post. (2023 November 29). Businesses in Bhairahawa suffer as new international airport lies empty.

The Kathmandu Post. (2021). *Melamchi Water Supply Project: A tale of cost overruns and delays*.

The Kathmandu Post. (2021a). *Upper Tamakoshi Project: The Impact of Low PPA Rates on Profitability*.

The Kathmandu Post. (2020a). *Upper Tamakoshi Hydroelectric Project: PPA Rate and Financial Sustainability Challenges*.

The Kathmandu Post. (2020). *No takers for mall spaces, but financiers continue to pour money into shopping complexes*.

The Kathmandu Post. (2017). Locals affected by Budhi Gandaki Hydro Project warn to boycott polls. *The Kathmandu Post*.

UN Environment. (2021). Integrated Approaches to Sustainable Infrastructure. UN Environment Program

University of Cambridge Institute for Sustainability Leadership. (2018). *Sustainable Infrastructure: An Overview*. Retrieved from https://www.cisl.cam.ac.uk.

United Nations. (2015). Sustainable Development Goals. Retrieved from https://sdgs.un.org/goals

Watkins, G. (2014). Approaches to the Assessment and Implementation of Sustainable Infrastructure Projects in Latin America and the Caribbean. Inter-American Development Bank

World Bank. (2019). Enhancing Resilience through Sustainable Infrastructure. Retrieved from https://www.worldbank.org

World Bank. (1995). *Nepal - Arun III Hydroelectric Project: Management Response to the Investigation Report*.

World Commission on Environment and Development. (1987). *Our Common Future* (The Brundtland Report). Oxford University Press.