

TECHNICAL NOTE

A framework to identify macro-level renewable energy integration opportunities in the Hindu Kush Himalaya Region



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A framework to identify macro-level renewable energy integration opportunities in the Hindu Kush Himalaya Region

Despite its significant renewable energy (RE) potential, the Hindu Kush Himalaya (HKH) region remains trapped in very low level of RE uptake. While extant literature exploring the drivers and constraints of RE adoption follow two distinct strands of analysis pertaining to the demand and supply side factors, efforts to integrate both sides into a holistic framework for RE adoption are both new and rare. This technical note proposes a multidimensional approach of developing such a framework for identifying/ leveraging the RE opportunities specific to the HKH context.

Green Energy Paradox in the HKH

The Hindu Kush Himalaya (HKH) region abounds in renewable energy (RE) resources with an energy potential estimated at around 3,500 gigawatts (GW) (Rana et al., 2022). While this is an optimistic opportunity for the region with many of the countries having pledged net-zero goals focused on green energy transition in their (updated) Nationally Determined Contributions (NDCs), much of the region's RE potential remains untapped due to low production and consumption. The total installed productive capacity reported in 2022, is barely at 30 per cent of the estimated RE potential of the region, and for countries, namely, Afghanistan, Bangladesh, Bhutan, India, Myanmar and Nepal, reported production of RE is significantly below their respective RE targets by 2030 (Rana et al., 2022). According to International Energy Agency¹, the share of modern renewable energy in final energy consumption among the HKH member countries varies from 0.31% in Bangladesh to 18% in India. Bridging this disparity will require substantial improvement and wider implementation of RE solutions² across the region.

Drivers and challenges for RE uptake in HKH

Extant literatures on RE adoption, find that sheer availability of energy resources is not enough to ensure energy access and /or uptake. Rather quality, reliability and affordability of available solutions are critical drivers of sustained uptake (ESMAP, 2015). In tandem, HKH-specific studies identify a plethora of challenges to adoption and sustainable usage of RE solutions in mountainous regions. These range from geographical isolation, limited demand, poor market linkages, high upfront costs of adoption (ICIMOD 2019), to insufficient number of market players, dearth of financing options/ instruments, absence of champions for productive use of RE (PURE³) (Bloomfield 2023; ICIMOD 2019), to limited availability of diverse and innovative solutions suited to local needs, absence of reliable data, performance benchmarks, and after-sales services, and limited technical capacity of mountain communities (Bloomfield 2023).

1 International Energy Agency <https://www.iea.org/regions/asia-pacific/energy-m>

2 We define RE solutions broadly as technologies, tools, approaches, methods, and practices that, when applied, help improve livelihoods or increase income.

3 The concept of productive use of RE (PURE) builds on Kapadia's (2004) work.

Multisectoral assessment of RE opportunities

More comprehensive assessment of the demand and supply side factors for RE access, in simultaneity, is provided by the Asian Development Bank's Framework for Sustainable Energy Access Planning (SEAP) (ADB, 2015), and a more contemporary Comprehensive Energy Solution Planning (CESP) framework developed by Colombo et al. (2024). While both the frameworks mark significant contributions to the literature on energy access planning, CESP is deemed more practical for supporting actual planning processes. It uses resource and demand assessments to design a technical solution, and subsequently a business model to enable its implementation and sustainability. Complementary activities are also introduced to enhance the success of the intervention, while an impact analysis evaluates the outcomes and feeds back into the context analysis underlying the model in order to reassess the energy needs and ensure ongoing project effectiveness.

Drawing upon the CESP framework, the framework proposed in this document is developed for supporting wider implementation of RE solutions in the HKH region. Based on the findings from the existing literature of RE adoption in the HKH, this framework seeks to unlock opportunities of RE integration into vital economic sectors (e.g., agriculture and tourism) and for productive uses (e.g., in strengthening goods and services value chains for the mountain region), with the aim to leverage the region's huge RE potential not only for transitioning to low-carbon, sustainable pathways for mountain development, but also for expanding / diversifying livelihood options, augmenting income and bolstering adaptation and resilience-building solutions for the vulnerable mountain communities.

The feasibility of such opportunities, however, is driven by multisectoral factors, thereby calling for a collaborative, multidimensional approach of developing a framework for identifying / leveraging the opportunities. Both SEAP and CESP models having significantly addressed this multidimensionality criterion vis-a-vis conventional approaches, therefore, are precursors to our proposed framework.

Roadmap for productive use of RE in the HKH

After identifying the relevant parameters and sub-parameters based on the literature review, the authors consulted relevant agencies (governments, non-government organisations, banks, donors, private entities, and development partners) in Nepal. Bilateral consultations were conducted with these agencies for sector-specific inputs. Finally, a validation workshop was convened in Dhulikhel, Kathmandu, on 15 December 2023, which was attended by about 20 people from 19 agencies. The workshop saw extended deliberations on the essential pillars of a RE opportunities assessment framework and through a consensus-based approach identified eight parameters and corresponding indicators that could be selectively deployed to assess macro-level opportunities to integrate the RE (efficient) solutions appropriate for a given context. These parameters and indicators are indicative and can be applied flexibly to accommodate interventions at different scales across all dimensions as deemed appropriate.

Incorporating these parameters/ indicators the proposed framework is designed as sector-agnostic in order to enable the identification of macro-level opportunities. After these larger opportunities are identified, a more detailed micro-level assessment framework can be developed to dive deeper into sector-specific opportunities. Thus, the current framework will be flexible to continuous improvement based on experiential insights. This approach will be particularly valuable for development practitioners, partners and government institutions to quantify high-level opportunities and develop strategies for directing investments effectively.

Eight pillars of RE opportunity assessment for the HKH

The proposed assessment framework adopts a multidimensional and multi-perspective approach that considers eight interrelated pillars (Figure 1). Various methods could be explored to gain insights into these pillars as deemed fit for a given context.

FIGURE 1

EIGHT PILLARS OF THE RE OPPORTUNITY ASSESSMENT FRAMEWORK



PILLAR 1

Supply/demand situation and energy consumption patterns

This pillar is crucial for identifying the structural reasons behind RE adoption, areas of resource wastage, forecasting future demands (cross-sectoral, diverse / innovative solutions), and enabling informed planning to develop policies that ensure energy security, support economic

growth, and promote sustainability. Monitoring these patterns of consumptive and productive uses of RE will also help in assessing the environmental impact of energy use, making informed investment decisions, adopting cost-effective practices, and maintaining competitiveness in a rapidly evolving market. The assessment parameters and indicators for this pillar are shown in Table 1, which can be modified to fit specific contexts and scales of intervention.

TABLE 1

PARAMETERS FOR ASSESSMENT OF ENERGY SUPPLY, DEMAND, AND CONSUMPTION PATTERNS

SN	Parameters	Suggested Indicators	Rationale (Why)	Methodology/Approaches
1.	Energy supply and demand situation	Installed capacity (MW), kWh, and peak demand	To understand the energy consumption patterns and peak demand	Survey and literature review
2	Energy consumption trends	Quantity and types	To understand the quantum of energy based on types, seasonal variations, and historical trends	Data collection, analysis, and evaluation of impacts
3	Driving factors	Factors	To understand the factors driving current energy consumption trends	Literature review and focus group discussions (FGDs)

PILLAR 2

Policy and regulatory frameworks influencing energy supply and demand

What policies and regulations influence existing RE supply, demand, and consumption trends in the study area? Is the policy environment supportive or restrictive for RE integration? Is it conducive for large-scale adoption of RE solutions?

A strategic combination of policies and regulations is essential for effective deployment of RE solutions. For example, financial incentives can encourage consumers and businesses to invest in renewable projects (subsidies and tax breaks reduce the initial/ upfront costs of renewable technologies, or instruments like Feed-in Tariffs (FITs) provide guaranteed payments for the

energy fed into the grid), while interventions for stabilising RE supply and /or making RE solutions more efficient and cost effective (e.g., RE mandates, such as Renewable Portfolio Standards (RPSs), investments in infrastructure for grid expansion and energy storage, fostering innovation through research and development (R&D)) can strengthen sustainability and support long-term energy security.

Additionally, public awareness campaigns and education on the benefits of RE and energy efficiency encourage sustainable practices and informed decision-making. Together, these strategies create a comprehensive framework for accelerating RE adoption and achieving a sustainable energy future. The parameters and indicators identified in Table 2 for this assessment can be modified to meet specific contexts and scales of intervention.

TABLE 2 PARAMETERS FOR ASSESSMENT OF POLICY AND REGULATORY FRAMEWORKS

SN	Parameters	Suggested Indicators	Rationale (Why)	Methodology/ Approach
1	Relevant policies and regulations	Policy and regulatory gaps	To understand the policy strengths and gaps shaping the energy supply and demand scenario	Literature review of relevant policies
2	Fiscal incentives and support mechanisms	Scope, adequacy, accessibility, competitiveness, and stability of instruments	To understand the policy instruments and the supporting mechanisms	Literature review and FGDs
3	Regulatory framework	RE mandates, compliance, and enforcement	To understand the policy consistency and predictability of legal frameworks	Literature review and FGDs
4	The support infrastructure	Adequacy of the infrastructure	To understand the adequacy and stability of the infrastructure	Literature review and FGDs

PILLAR 3

Technology needs

Considering the current energy situation and the regulatory context, what types of RE solutions are the most suitable for the given context? The insights gained from such an analysis will help to align RE solutions with local needs

and opportunities and ensure that the chosen energy solutions are both relevant and feasible for the given circumstances. The parameters and indicators identified in Table 3 for assessing technology needs can be adapted to fit specific contexts and scales of intervention

TABLE 3 PARAMETERS FOR ASSESSMENT OF TECHNOLOGY NEEDS

SN	Parameters	Suggested Indicators	Rationale (Why)	Methodology/ Approach
1	RE solution needs	Need-based applications	To understand needs, preferences, and expectations	Literature review, survey, and FGDs
2	RE solution suitability	Affordability, accessibility, compatibility, and user-friendliness	To understand the suitability of technology based on factors such as affordability, accessibility, compatibility, user-friendliness, and life-cycle costs	Literature review
3	Technology scalability and upgradation	Vertical and horizontal scaling, and upgradation	To understand scalability, both vertical and horizontal	Survey and FGDs
4	Operation and management practices	Narratives	To understand aspects such as operation, acceptability, management culture, and practices	Survey and FGDs

PILLAR 4

Market conditions

What types of markets exist or could be developed to support the widespread adoption of RE solutions? Understanding market demand, emerging markets, growth areas, and business models is crucial for effectively integrating RE solutions. Assessing market demand, considering both the RE product and service markets, helps in identifying specific areas or value chains where RE solutions are the most needed and can make the

greatest impact. By analysing emerging markets, opportunities for positioning RE solutions and services strategically can be identified, which also helps in capitalising on growth areas before they become saturated.

Identifying growth areas is essential for planning strategic investments and developing targeted business models that cater to local conditions. This approach enables companies and investors to focus on regions with significant potential for RE expansion, thereby maximising both returns and impacts. (See parameters in Table 4).

TABLE 4 PARAMETERS FOR ASSESSMENT OF MARKET CONDITIONS

SN	Parameters	Suggested Indicators	Rationale (Why)	Methodology/ Approach
1	Specific energy needs and applications	kWh for activities	To understand the specific requirements for various applications, sector-wise	Survey and literature review
2	Emerging markets and growth areas	Size of the market and growth rate	To understand market size and growth rate, and energy generation for electricity, heating, and cooling, or other energy uses	Literature review
3	Sectoral industry trends and market dynamics	Industrial growth rate	To identify the drivers influencing the market demand for productive applications	Literature review
4	Customer awareness and preferences	Use of technology/ adoption of technology	To understand customer awareness and preferences	Survey and FGDs
5	Business models in use	Different business models and business principles	To understand different business models and their operating principles	Literature review
6	Opportunities for vertical and horizontal linkages	Connection/relation	To understand the connections and relationships between vertical and horizontal linkages	Market mapping through survey

PILLAR 5

Stakeholder analysis from a GESI perspective

A gender equality and social inclusiveness (GESI)-centric stakeholder analysis aims to answer the question about the key stakeholders of RE solutions. This requires a comprehensive approach, such as stakeholder mapping and engagement to ensure active participation of women, marginalised/disadvantaged communities, and vulnerable populations in the planning and decision-making processes. It is essential to understand how diverse groups are affected by energy poverty and how tailored RE solutions can address these disparities. Analysing access and affordability is crucial, as that would reveal the financial constraints and barriers faced by various social groups in accessing RE technologies, and thus help in planning

initiatives for enabling RE access for the last mile. Additionally, understanding migration trends and their impact on energy needs is vital, as that would shed light on the shifting demands and challenges faced by communities, particularly those that have not migrated.

Assessing the economic opportunities that would be created by RE projects is also important. This involves examining how such projects can improve livelihoods, reduce migration pressures, support local economies, and produce social and economic benefits for disadvantaged groups. Ensuring that capacity-building and skill-development initiatives are accessible to all promotes broader participation in the RE sector. Policy and institutional analyses are also necessary to evaluate the support for GESI in RE integration and to advocate for reforms that create a more inclusive environment. (For parameters and indicators, see Table 5)

TABLE 5 PARAMETERS FOR ASSESSMENT OF STAKEHOLDERS

SN	Parameters	Suggested Indicators	Rationale (Why)	Methodology/ Approach
1	Stakeholder mapping and interests	Stakeholders and role matrix	To understand the different stakeholders, their interests, and roles through a GESI lens	Survey and literature review
2	Economic opportunities	Economic opportunities	To understand the potential for job creation and economic opportunities resulting from RE projects	Survey and literature review
3	Capacity and training needs	Capacity gaps	To understand capacity development from a GESI perspective	Literature review
4	Outmigration trends	Percentage of outmigration	To understand the impacts of outmigration	Literature review

PILLAR 6:

Financing mechanisms to support RE opportunities

What are the prevailing financing mechanisms and how do they constrain or contribute to the wider adoption of RE solutions in the study area? Assessing the prevailing financing mechanisms for RE integration is crucial and requires a comprehensive approach. This involves evaluating the existing financing instruments, such as grants, subsidies, loans, and equity investments, in order

to understand whether they are accessible for different stakeholders, including individuals, small businesses, and larger enterprises. Innovative financing models, such as crowdfunding, green bonds, and pay-as-you-go schemes, could be considered to enhance financing accessibility. A detailed cost-benefit analysis is essential for estimating initial capital investment, ongoing operational costs, and the potential returns on investment, thereby ensuring that RE projects are financially viable and sustainable. (see Table 6 for parameters and indicators).

TABLE 6

PARAMETERS FOR ASSESSMENT OF FINANCING MECHANISMS

SN	Parameters	Suggested Indicators	Rationale (Why)	Methodology/ Approach
1	Financial viability	US Dollar (USD), net present value (NPV), internal rate of return (IRR), and payback period	To understand initial investment requirements, the cost-effectiveness of options, and the life cycle	Cost-benefit analysis
2	Cost-benefit analysis	Cost-benefit ratio	To understand where and why investment must be made	Literature review
3	Operational efficiency and productivity	Capacity utilisation and cost per unit	To understand where potential improvements can be made in terms of operational efficiency and productivity by using RE solutions	Literature review
4	Potential financing mechanisms	Equity, loan, FDI, grants, and interest rate	To understand financing options, grants, subsidies, and the incentives available for RE solutions	Literature review
5	Financial risk mitigation measures	Insurance, hedging cost, and loan loss guarantee	To understand the financial risks involved in RE solutions	Due diligence and literature review
6	Levelised cost of energy	USD/kW	To understand the levelised cost of energy and capital	Literature review and survey

PILLAR 7

Environmental Impacts

What environmental impacts could result from integration/ implementation of RE solutions?

To effectively assess the environmental impacts associated with integrating RE solutions, a comprehensive approach is essential to ensure sustainability while minimising ecological harm. This involves evaluating the potential effects on local ecosystems, biodiversity, water resources,

land use, carbon footprint of RE solutions vis-à-vis conventional energy sources, circularity aspects, climate resilience and the overall sustainability of these solutions.

This assessment can help tracking the long-term impacts of RE projects, thereby allowing for adaptive management and continuous improvement based on new data or changes in environmental conditions. (See Table 7 for parameters and indicators)

TABLE 7

PARAMETERS FOR ASSESSING ENVIRONMENTAL IMPACTS

SN	Parameters	Suggested Indicators	Rationale (Why)	Methodology/ Approach
1	Environmental regulations and compliance	Specific statutory requirements	To understand the statutory requirements and the compliance needed for promoting PURE programmes	Literature review and survey
2	Environmental sustainability commitments	Specific goals/targets	To understand if there are environmental sustainability goals and targets to support scaling RE solutions	Literature review
3	Mitigation measures	Environmental impacts	To understand the probable environmental impacts of RE solutions and identify mitigation measures	Literature review
4	Adaptation to climate change	Measures related to potential climatic hazards	To understand the resilience of RE infrastructure to withstand extreme weather events and climate change impacts	Literature review

PILLAR 8

Assessment of risks

What risks might arise in promoting RE solutions, considering the local context? The insights gained from this assessment is essential for integrating RE solutions as it identifies and addresses potential challenges that could impact project success and sustainability. By evaluating technical, financial, environmental, and regulatory risks early in the process, stakeholders can develop strategies to mitigate these issues, thereby enhancing project viability. This approach supports informed decision-making by highlighting the benefits and drawbacks of different RE solutions and ensuring alignment with long-term sustainability goals. Additionally, effective risk assessment helps secure financing by demonstrating to the investors that

potential risks have been identified for proper management, thereby facilitating access to the necessary capital.

It also improves project design and implementation by identifying the areas that require special attention, while ensuring regulatory compliance and enhancing the project's resilience to climate change, technological advancements, and market fluctuations. Overall, a thorough risk assessment exercise supports the successful and sustainable integration of RE solutions by optimising project outcomes and ensuring long-term benefits.

The parameters and indicators identified in Table 8 can be modified to suit the given context of the study.

TABLE 8 PARAMETERS FOR ASSESSMENT OF RISKS

SN	Parameters	Suggested Indicators	Rationale (Why)	Methodology/ Approach
1	Risk identification and categorisation	Risk profile	To understand the risk profile in terms of technical failure; social, financial, operational, market, and legal aspects; as well as by way of implementation	Field assessment, case study, and worst-case scenario risk assessment
2	Risk probability and impacts	Percentage of risk occurrence	To understand the probability of risk occurrence and its potential impacts	Field assessment, case study, and worst-case scenario risk assessment
3	Risk mitigation measures	Types of measures	To understand the types of risk mitigation measures required to tap RE solutions	Both quantitative and qualitative analyses

Way forward

The HKH region has substantial opportunities to leverage RE for economic, environmental, and social progress. The proposed framework aims to address the region's unique challenges while harnessing its strengths. Given the strong interconnectedness of the eight assessment pillars of the framework, the authors anticipate overlaps among them during implementation. Additionally, new indicators may emerge through primary surveys and focus group

discussions (FGDs) and should be incorporated as appropriate, based on the study context. The next step involves developing a practical toolkit to assess the parameters under each criterion with cost-effective, step-by-step guidelines. This toolkit, combined with the macro-level assessment framework, aims to identify and optimise opportunities for RE integration through detailed planning and appropriate resource allocation measures.

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