Initial Environmental Examination

February 2014

NEP: South Asia Subregional Economic Cooperation (SASEC) Power System Expansion Project (SPEP) (Renewable Energy for Rural Energy Access Project (REREAP) Component)

Prepared by Nepal Electricity Authority for the Asian Development Bank.

CURRENCY EQUIVALENTS
(as of 31 Janaury 2014)

Currency unit	–	Nepalese rupee/s (NRs)
NRs1.00	=	$0.01043
$1.00	=	NRs95.91

Abbreviations and Units

ADB	Asian Development Bank
AEPC	Alternative Energy Promotion Centre
CDM	Clean Development Mechanism
CER	Certified emission reduction
CFL	Compact fluorescent lamp
CFUG	Community Forest Users Group
CFUG	Community Forest Users Group
COPB	Country Operation Business Plan
DDC	District Development Committee
DEEU	District Energy and Environment Unit
EA	Executing Agency
EARF	Environmental Assessment and Review Framework
EHS	Environmental, health and safety
EMP	Environmental Management Program
GESI	Gender equity and social inclusion
GoN	Government of Nepal
GRM	Grievance redress mechanism
GWh	Giga-watt hour
IA	Implementing Agency
IEE	Initial Environmental Examination
IUCN	International Union for Conservation of Nature
kW	Kilowatt
kWp	Kilowatt peak
MMH	Mini-micro hydropower mini-grid
MoE	Ministry of Energy
MoEnv	Ministry of Environment, Science and Technology
MoF	Ministry of Finance
MoWR	Ministry of Water Resources
MW	Megawatt
NGO	Non-government organization
NRREP	National Rural Renewable Energy Program
PIU	Project Implementation Unit
PV	Photovoltaic
RE	Renewable energy
REA	Rapid Environmental Assessment
RSC	Regional Service Centre
RoW	Right-of-way
SCF	Strategic Climate Fund
SPS	Safeguard Policy Statement
SWM	Solar and/or wind mini-grid
tCO_2e	tons carbon dioxide equivalent

UC	User Committee
UNNFCC	United Nations Framework Convention on Climate Change
VDC	Village Development Committee

NOTE

In this report, “$” refers to US dollars.

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1. INTRODUCTION

1.1 Background

1. This Initial Environmental Examination (IEE) has been prepared for the proposed Nepal Renewable Energy for Rural Energy Access Project (REREAP or the Project) which is the off-grid component of the South Asia Subregional Economic Cooperation (SASEC) Power System Expansion Project (SPEP)[1]. The Project is designed to improve access to small scale, off-grid commercial energy services through the installation of multiple renewable energy (RE) systems in areas that are generally unconnected to the electricity grid. The Project investment program aims to:

1 supply power to remote communities and institutional facilities;
2 improve the productive use of power; and
3 build the capacity of AEPC and other stakeholders.

2. The Project components include mini-micro-hydropower plants[2] on mini-grids (MMH), solar and solar-wind hybrid plants on mini-grids (SWM), and capacity development of selected stakeholders, including support for project implementation, and promotion of productive energy use activities. The community-initiated energy sub-projects will be progressively identified, screened and assessed during Project implementation. Only a small number of sub-projects have been proposed at this stage, with the remainder to be identified as the Project progresses.

1.2 Name and Address of the Proponent

Project Name: Renewable Energy for Rural Energy Access Project

Name of Proponent: Alternative Energy Promotion Centre (AEPC), Ministry of Environment, Science and Technology (MoEnv), Government of Nepal

Address of Proponent: Khumaltar Heights, Kathmandu, Nepal

1.3 IEE Preparation and Objectives

3. The IEE has been prepared by the Project Preparatory Technical Assistance (PPTA) consultant on behalf of and in close collaboration with AEPC. It has been prepared in accordance with ADB's *Safeguard Policy Statement* (SPS, 2009) requirements and aims to ensure good environmental practice. The specific objectives of this IEE are to:

(i) provide an environmental and social baseline description of the Project;
(ii) identify and describe the Project's potential environmental and social impacts;
(iii) design mitigation measures to minimize adverse impacts;
(iv) describe the Project's public consultation process and Grievance Redress Mechanism (GRM); and

[1] The REREAP and SPEP projects were originally conceived as separate projects, but have been combined into a single project. A separate environmental assessment report has been prepared for the SPEP on-grid components.
[2] "Mini" hydropower projects are between 100-1,000 MW; "micro" hydropower projects are less than 100 kW.

(v) provide Environmental Management and Monitoring Plans for the overall Project (including defining institutional responsibilities, capacity building and training, and the required budget).

1.4 Scope and Method of the IEE

4. The scope of the IEE is based on ADB SPS assessment requirements as the Government of Nepal (GoN) does not require the overall Project or the RE sub-projects to have an environmental assessment. Based on the likely types, sizes and locations of sub-projects, the Project has been classified as environment category B as determined by the Project's most environmentally sensitive component, the mini-micro hydro sub-projects.

5. The IEE consists of project description and assessment sections covering the overall Project plus separate sections assessing five representative sub-projects. Given that the Project consists of multiple RE sub-projects, most of which will only be identified and selected over the five year implementation period, five sample sub-projects (Table 1.1) representing the range of sub-project types and different locations where they are likely to be installed have been assessed (two MMHs and three SWMs). These assessments provide a good indication of the types and significance of the likely adverse impacts and benefits of the Project. The selected sub-project sites are located in the Siwalik, Middle Hill and High Mountain physiographic regions of Nepal, from elevations of 265 m asl up to 2,505 m asl. The example MMH sub-projects are similar in size to the likely average sub-project capacity (200 kW), located on small to medium sized streams. The SWMs range in size from 12.6-35 kWp, in the typical range for these sub-projects that are expected to average 20 kWp.

Table 1.1: REREAP Sub-Projects Assessed

Sub-Project	VDC and District	Capacity (kW)	Beneficiary Households
Sani Veri Micro-Hydro	Taksera, Kol and Rangshi VDCs, Rukum	300	2,034
Simrutu Micro-Hydro	Rugha VDC, Rukum	200	1,386
Chisapani Solar-Wind	Hariharpur Gadhi VDC, Sindhuli	20	66
Bhorleni Solar-Wind	Phaparbari VDC, Makwanpur	35	120
Kyangsingh Solar	Gumba VDC, Sindupalchowk	12.6	53

1.5 Structure of the IEE

6. This IEE is organized into (i) general sections that discuss the entire project, plus (ii) separate sections that assess the five example sub-projects, as indicated below. The assessment of each of the five sample sub-projects covers: (i) Sub-Project Description; (ii) Description of the Baseline Environment; and (iii) Impact Assessment and Mitigation Measures.

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II. Project Description
III. Policy, Legal, and Administrative Framework
IV. Summary of Project Impacts
V. Sani Veri Hydropower Project Assessment
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X. Environmental Management Plan
XI. Information Disclosure, Consultation, and Participation
XII. Grievance Redress Mechanism
XIII. Conclusion and Recommendation

2. PROJECT DESCRIPTION

2.1 Project Rationale and Objectives

7. In line with the Government's goal of increasing the share of renewable energy, Nepal has been selected as a pilot country for funding and technical assistance under the Scaling Up Renewable Energy Program in Low Income Countries (REREAP), a targeted program of the Strategic Climate Fund (SCF, a multi donor Trust Fund within the Climate Investment Funds), with the overall objective of supporting investments to increase energy access and accelerate economic growth through renewable energy.

8. Recent country diagnostic studies indicate that unequal access to infrastructure, including electricity, is one of the critical constraints to inclusive growth in Nepal[3]. The low coverage of the national grid, increasing demand for rural electrification, appropriateness of decentralized energy systems in sparsely populated rural areas, availability of renewable energy resources, and the need to respond to climate change are some of the key drivers for the promotion of renewable energy deployment in rural Nepal. In some regions grid connection of households is much lower. For example, just 22% of households in the Mid-Western Development Region (MWDR) are connected, with 50% of these residents reported to be living below the energy poverty level in 2011 (Parajuli, 2011)[4].

9. The Project will promote household, institutional, business and community access to energy through the installation of off-grid RE systems, and facilitate productive end use of clean energy. The Project is needed as rural consumers, comprising about 83% of the population, primarily rely on fuelwood and other traditional biomass for energy (the bottom of the energy consumption pyramid). Only 49% of the rural population is connected to the grid[5] (the last-mile consumers).

10. The main energy sources in isolated rural communities in Nepal are: fuelwood for cooking, heating and lighting; other types of biomass for cooking and heating (e.g. dung, crop residue); kerosene lighting; diesel to run a limited range of equipment (e.g. huller mills for husking grain); and dry cell batteries for torch light. Some off-grid households have home solar power systems primarily for lighting 1-2 rooms and charging mobile phones. Some households have bio-gas plants to supply gas for cooking. Diesel- and gasoline-fired generator sets are rarely used in off-grid rural areas due to the cost of fuel.

11. The focus of the Project is on the installation of a large number of small RE sub-projects across dispersed off-grid locations in Nepal (Table 1.1). Off-grid consumer access to a reliable and affordable energy supply will, by necessity, involve a combination of traditional biomass and

[3] Asian Development Bank, United Kingdom Department for International Development, and International Labor Organization. 2009. *Country Diagnostic Studies – Highlights of Nepal: Critical Development Constraints*. Manila London, and Geneva.
[4] Parajuli, R., 2011. Access to Energy in Mid/Far West Region - Nepal from the Perspective of Energy Poverty. *Renewable Energy*, 36, 2299-2304.
[5] Central Bureau of Statistics of Nepal. 2011. *Nepal Labor Force Survey 2008*, Kathmandu.

modern RE systems and services. There is no alternative to rural electrification with RE other than connecting isolated settlements to the electricity grid. Grid connection of small, isolated and dispersed settlements is not cost effective compared to village based RE facilities. In addition, grid connection by an extensive system of transmission lines would result in high transmission losses, would be expensive and difficult to maintain. Underlying this, grid connection would not address the existing shortfall in electricity supply in Nepal, particularly the seasonal supply shortfall that occurs when hydropower generation is low late in the dry season.

12. The reliance on fuelwood for cooking and heating has resulted in forest degradation and deforestation adjacent to hill communities over time. The supply of petroleum products is increasingly at risk as these fuels are imported via India and the Nepal Oil Company (which has a monopoly on fuel imports) is sometimes in arrears with Indian suppliers. The transport of fossil fuels to remote communities is usually by a combination of vehicle and foot transport, thus adding to the cost and unreliability of supply. The majority of consumers can only afford to use kerosene sparingly.

13. The conventional least-cost energy approach based on large-scale hydropower has failed to deliver sufficient power supply to meet demand. At present, installed hydropower capacity is around 700 MW, with an additional 592 MW under construction. Commercial hydropower potential is commonly noted as 42,000 MW, of which only 3% has been developed to date. Recognizing the challenges of large hydropower development, recent assessments have concluded that grid-connected solar PV potential is about 2,100 MW[6] and wind potential is about 3,000 MW. Assuming 15% and 30% load factors for solar and wind respectively, the combined potential output is more than twice the total electricity demand in 2010-11.Total solar potential may be much higher,[7] while commercial potential is difficult to estimate as PV system costs are dropping rapidly, and have already reached grid parity with [off-grid] petroleum-fired generation. Off-grid solar potential appears to be better at higher altitudes in the Western and Far Western Development regions. Wind appears to be better in the terai and hilly regions.

14. The Project will bring about transformational impacts by scaling up energy access using renewable energy technologies, poverty reduction, gender and social inclusiveness and climate change mitigation, and ensuring sustainable operations through capacity building. Expanded access to energy will far outweigh the associated negative project impacts. The primary Project benefits will be: improved quality of life associated with access to reliable electricity services (e.g. better lighting, refrigeration, computer use, telecommunications); reduced use of fuelwood and other traditional biomass for household energy supply (leading to reduced deforestation rates/forest regeneration); reduced use of kerosene for lighting; reduced reliance on petroleum-fueled equipment; reduced household labor demands (currently required for biomass collection). Secondary benefits will accrue from value-added economic activity enabled by access to energy, including agricultural processing (grain milling, poultry production, saw milling), social services (e.g. power for schools, health posts, and street lighting), and other small-scale enterprises such as cafes and carpentry shops.

15. It is conservatively estimated that the Project will benefit around 189,400 people through the provision of power directly to households, and in addition power around 100 schools, 30 health posts, small businesses and community facilities in villages such as street lighting.[8] This

[6] Concentrating solar thermal power potential estimated to be more than 1,800 MW (SWERA, 2008).
[7] UNEP/GEF. 2008. *Solar Wind Energy Resource Assessment*. Off-grid PV potential was not quantified, but GIS-based mapping suggests that theoretical off-grid potential is much higher than the grid-connected potential.
[8] These estimates are subject to revision.

power supply will improve the reliability and duration of power supply, and reduce greenhouse gas production. Rural-based enterprises that are also likely to benefit from the Project include grain mills, sawmills and carpentry shops.

2.2 Project Location

16. The Project is located in remote areas of Nepal, generally where there is no grid electricity connection in the Siwaliks, Middle Hill and High Mountain physiographic regions. The specific locations of sub-projects will only be determined as the Project is implemented, but they will generally range from 250-3,000 m asl. Sub-projects will potentially be in any District of Nepal where communities require an off-grid power supply.

17. The Project will scale up RE development in Nepal by delivering energy directly to many isolated, off-grid communities through the installation of dispersed, small-scale, community-based sub-projects. The Project objectives are:

- enhanced electricity supply to remote communities and institutions;
- productive end-use of energy in rural communities via RE development; and
- capacity development of AEPC and selected stakeholders, including support for project implementation.

2.3 D. Project Cost and Lending Instrument

18. The total project cost is estimated to be $25.0 million. A $5 million loan will be provided by the Asian Development Fund (ADF)[9] to finance the project. The Strategic Climate Fund (SCF)[10] will co-finance $11.1 million grant[11]. The Project will form part of the Government's National Rural and Renewable Energy Program (NRREP)[12], with NRREP co-financing project implementation and promotion of productive energy use activities. The remaining funds will come from the GoN's counterpart funds and contributions from community and participating financial institutions (PFI).

2.4 Project Implementation

19. The Project's Executing Agency (EA) will be MoEnv, with AEPC being the Implementing Agency (IA). The existing National Rural Renewable Energy Program (NRREP) Steering Committee will serve as the Steering Committee for the Project. Steering Committee members include representatives from MOF, MOE, MoEnv and AEPC. A project implementation unit (PIU) will be set up in AEPC, and will be supported by a consultant team[13] funded by the Project. The RSCs will provide implementation support at field level. The project will be executed over a period of approximately five years from the date of loan effectiveness.

20. All sub-projects will be community-driven, formally initiated by communities requesting assistance from AEPC via DEEU and RSCs in the form of development and financial support for

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[9] Nepal will not eligible for ADF grant from 2013 due to economic improvement.
[10] The SCF is to be administered by ADB.
[11] This amount includes PPTA of $580,000.00.
[12] NRREP is a governmental single window program in rural and renewable energy sector. The Joint Financing Agreement on NRREP has been signed by Norwegian Embassy and Danish Embassy recently, and is expected to be signed by DFID and KfW by middle of 2013.
[13] The consultants include full time and short term experts, to help PIU on project procurement, monitoring and evaluation. The consultants will have dual reporting function to both AEPC and ADB.

the installation and operation of RE installations. AEPC, through the PIU, is responsible for the design and environmental assessment of sub-projects, and monitoring their environmental management during construction and operation. AEPC staff expertise will be complemented by a network of qualified consultancies that will be utilized to assist in preparing the Project pipeline of sub-projects as required, including sub-project feasibility studies, safeguard assessments, environmental management plans (EMPs) and monitoring reports.

21. AEPC has been working as the implementing agency for various off-grid RE development programs over a number of years, and during this time has developed strong in-house capacity to identify, appraise, supervise installation, monitor operation and report on the types of small RE sub-projects that will be funded under the Project. AEPC follows well-established procedures for feasibility analysis, sub-project design, and environmental and social impact assessment, including procedures for vulnerable communities assessment.

22. Project-facilitated capacity development within AEPC will focus on managing, implementing and promoting RE development and, at regional level, gender equality and social inclusion (GESI)-based community participation and management of energy systems. Capacity development activities will be implemented through participation in relevant courses and seminars and through “learning-by-doing”, with technical backstopping by PIU.

2.5 Project Components

23. The Project consists of three types of small-scale RE sub-projects plus institutional support to AEPC in the form of capacity development to AEPC and selected stakeholders. The sub-projects are:

(i) **Mini-micro hydropower (MMH)** – run-of-river schemes located on small to medium sized streams and existing irrigation canals, typically with an installed capacity in the range of 100-1,000 kW. Each sub-project is likely to supply power to a number of villages. The total installed capacity of MMH sub-projects will be up to 4.0 MW, therefore based on an average sub-project capacity of 200 kW, 20 MMHs will be installed.[14]

(ii) **Solar/wind power mini-grids (SWM)** – these sub-projects will be configured as either a (i) solar, (ii) solar/wind hybrid or (iii) wind sub-project. A SWM solar/wind hybrid plant will typically consist of 36-72 solar PV (10-20 kW of solar PV panels plus 2-3 wind turbines with 5-10 kW capacity per unit, with a total installed capacity of round 20-30 kW supplying power a single village. The total installed capacity of all SWM sub-projects will be up to 2.0 MW, therefore based on an average sub-project capacity of 20 kW, an estimated 100 SWMs will be installed.

Table 2.1: Sub-Project Types, Estimated Installed Capacity and Beneficiaries

Sub-Project Type	Assumed Average Installed Capacity per Sub-Project (kW)	Estimated Number of Sub-Projects	Estimated Total Installed Capacity (MW)	Estimated Villages Supplied	Estimated Beneficiary Households
MMH	200	20	4.0	100	27,360[1]
SWM	20	100	2.0	100	7,080[2]
Total	**-**	**120**	**6.0**	**200**	**34,440**

[14] According to the NREPP study (2011), about 7-8 households can be supported by each kW of MMH capacity.

1 - based on the average number of households supplied per kW installed capacity by Sani Veri and Simrutu MMHs – 6.84 households/1 kW installed capacity.
2 – based on the average number of households supplied per kW installed capacity by Chisapani, Bhorleni and Kyangsingh SWMs – 3.54 households/1 kW installed capacity.

2.6 Sub-Project Development

Initiation, Screening and Selection

24. All sub-projects will be community-driven, initiated local communities who will submit their interest in the installation of an RE facility through their VDC, who will in turn formally apply to AEPC requesting development and financial support for the installation and operation of the sub-project. The development procedures for MMH and SM/SWM sub-projects are outlined in Appendix A and B respectively. VDC-proposed sub-projects will be screened by AEPC for conformity with sub-project selection criteria (Appendix C) to select those sub-projects that are feasible and will provide optimum benefit.

25. ADB's *Rapid Environmental Assessment* (REA) *Checklist* for hydropower projects, modified for MMHs, will be used to assign a category to these sub-projects (Appendix D). Sub-projects will be restricted to ADB categories B and C for environment, resettlement, and indigenous peoples. Potential sub-projects located in Protected Areas where multiple land uses are permitted under GoN law, including infrastructure development will be considered. RE installations in remote Protected Areas have the potential to reduce reliance on fuelwood (where it is partly used for lighting), kerosene and diesel use, and therefore provide a net environmental benefit whilst maintaining the environmental integrity of the area.

Feasibility Study

26. AEPC shall prepare a feasibility study for each selected sub-project, incorporating sub-project design and an environmental assessment. The level of detail contained in the environmental assessment will be commensurate with the significance of the potential impacts and risks of that activity[15]. For Category B sub-projects, an environmental assessment report, consistent with the outline and content of an Initial Environmental Examination (IEE) under ADB guidelines, will be prepared following AEPC's normal practice. MMHs located on streams are likely to be environmental Category B due to the diversion of flows (albeit over a short distance) and the potential effect of this change in river hydrology on the aquatic ecosystem and river users. The minimum level of detail required for such an MMH sub-project IEE is set out in Appendix E. SWMs and SMs are likely to be environmental Category C given that these are small-scale developments located on developed land. Sub-projects proposed within or adjacent to protected areas will require a sufficiently detailed IEE to formulate an effective environmental management plan.

Construction

27. Local communities are expected to contribute up to 10% of the total sub-project cost in the form of equity (which establishes the community as the owner). Each MMH sub-project will be implemented under an individual turnkey contract. The project development procedure will generally follow current AEPC practice and comply with ADB's Procurement Guidelines (2010, as amended from time to time). An imprest account will be established for payments to construction contractors and other service providers. This component will also include future participation of financial institutions via CREF, based on successful experience of the Micro Hydro Debt Fund.

[15] ADB, 2009. *Safeguard Policy Statement*. OM Section F1/OP, paragraph 7, page 2, 4 March 2010.

28. SWM plants face more challenges on the affordability of the tariff and sustainability of each sub-project when compared to MMH plants due to higher upfront capital cost per benefiting household. To reduce capital cost by utilizing economies of scale, bundled procurement based on turnkey contracts will be undertaken, considered feasible due to standardized major equipment such as the solar PV modules, wind turbines, and battery banks. Suppliers will be paid directly by ADB. Additional details on funds flow and other implementation arrangements will be incorporated into the project administration manual.

Operation

29. Sub-projects will be owned and operated by local communities. AEPC will provide technical support for operations and maintenance as well as advisory support for productive end-use of energy.

Review

30. After loan approval, AEPC will take the lead on sub-project environmental review and assessment, and ADB will monitor and review these assessments on a no-objection basis during the first year of project implementation. After Year 1, ADB will review sub-project assessments (i) on a spot basis for those sub-projects that are at least partly located within protected areas, and (ii) on a routine basis as part of project review missions and EA reporting requirements.

3. POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

3.1 Legal Framework

31. Mini-micro energy installations, including all proposed types of sub-project, are exempt from environmental assessment under GoN regulatory requirements, as set out in the *Environment Protection Act, 1997* and *Environment Protection Rules, 1997* [16] and subsequent amendments. Only hydropower installations of 5 megawatts (MW) or greater installed capacity are required to have an IEE or environmental impact assessment. MMH and SWM plants are not subject to Nepal regulatory requirements under the Act and Rules. Despite this, other GoN laws, regulations, policies and guidelines may be applicable to the Project based on the location, design and operation of sub-projects which are mostly yet to be determined, as summarized in Table 3.1.

Table 3.1: Environmental Regulatory Framework Relevant to the Project

Acts, Regulations, Policies and Guidelines	Content
Electricity Act, 1992	~ Governs the use of water for hydropower production. ~ Establishes a system of licensing. ~ Sets out the powers, functions and duties of a licence holder. ~ Provides certain financial incentives for licence holders. ~ Sets out the powers of the government. [1]
Electricity Regulation, 1993	~ Sets out the procedure for obtaining a license. ~ Deals with the acquisition of house and land and compensation. ~ Sets out the powers, functions and duties of licence holders.
Hydropower Development Policy, 2001	Hydropower development is emphasized with due consideration of environmental protection.
Water Resources Act, 1992	~ The umbrella Act governing water resource management. ~ Declares the order of priority of water use.

Acts, Regulations, Policies and Guidelines	Content
	~ Vests ownership of water in the State. ~ Provides for the formation of water user associations and establishes a system of licensing. ~ Prohibits water pollution.[1]
Local Self Governance Regulation, 2000	~ Sets out the powers, functions and duties of VDC, Municipality and DDC in relation to water and sanitation. ~ Establishes the procedure for the formulation of water-related planning and project implementation.[1]
National Parks and Wildlife Conservation Act, 1973	Specifies limitations on activities in parks and conservation areas, including construction and clearing of vegetation

1 – taken from WaterAid, 2005.

32. The *Electricity Act, 1992* (Section 3) requires any person or corporate body who wants to conduct survey, generation, transmission or distribution of electricity over 1,000 kW (1 MW) to obtain a license under the Act. Given that REREAP MMH plants will be no larger than 1,000 kW, applications for these sub-projects are not required, however when the project has a capacity of between 100-1,000 kW certain information must still be provided to the prescribed officer before generating, transmitting or distributing hydroelectricity. Under Section 3 of the *Electricity Regulation 1993* the following particulars must be provided: (i) detailed description of the project; (ii) map of the project (showing main structure/s); (iii) source of water and quantity of water to be utilized; (iv) area where electricity is to be distributed and estimated number of consumers to be benefited; (v) whether the water resource to be utilized has already been utilized by another or not, if so, particulars of the same; and (vi) other necessary particulars.

33. The *Water Resource Act, 1992* Clause 7 sets out the priority uses of water that shall generally apply. Hydropower takes priority over the use of water for cottage industries, industrial enterprises, mining, navigation and recreation, but is a lower priority than the use of water for drinking and domestic use, irrigation or agriculture. Clause 9 describes conditions for the use of water for hydroelectric purpose. Clauses 18 and 19 deal with water quality standards and water pollution, while Clause 20 stipulates that while utilizing water resources, it shall be done so in such a manner that "*no substantial adverse effect be made on environment by way of soil erosion, flood, landslide or similar other cause*".

34. Provisions of the *Hydropower Development Policy, 2001* that relate to REREAP MMH plants include (i) generating "*at low cost by utilizing the water resources available in the country*"; (ii) the extension of "*reliable and qualitative electric service throughout Nepal at a reasonable price*"; (iii) "*electrification of remote rural areas shall be encouraged by operating small and micro hydropower projects at the local level*"; and (iv) "*support for the development of rural economy by extending the rural electrification*". The Policy requires the mitigation of adverse environmental impacts likely to result from the operation of hydropower projects. This includes a key provision that requires the release of an environmental flow from each diversion weir, essentially to maintain the sustainability of aquatic ecosystems and other river uses, set out as:

> "*Provision shall be made to release such quantum of water which is higher of either at least ten per cent of the minimum monthly average discharge of the river/stream or the minimum required quantum as identified in the environmental impact assessment study report.*"

35. The *Local Self Governance Regulation, 2000* Clause 68 empowers VDCs to monitor and supervise development work implemented in the VDC. Clause 49 indicates that for infrastructure not approved by the Government of Nepal, an application for approval has to be lodged with the VDC, although given that the VDC is part of the process of initiating a sub-project it is unsure if this will apply.

36. The *National Parks and Wildlife Conservation Act, 1973* deals with the conservation and management of wildlife and habitat. The Act would apply to sub-projects proposed in national parks. The Act restricts entry into national parks without prior permission of the concerned authority. According to Article 5 of the Act, hunting of animals or birds, building or occupying houses, shelters or structures, occupying, clearing or planting or growing in any part, cutting, felling, removing or overshadowing any tree and removing any quarry or any other activities in national parks are banned. Under the *National Parks and Wildlife Conservation Regulation, 1974*, permission is required for entry into designated national parks. Section 22 of the Regulation deals with the permission required to prepare an inventory of plants and animals in national parks and wildlife conservation areas. Under Section 6 of the *Wildlife Reserve Regulation, 1977*, entry, construction of houses or sheds, clearance of forest and forest products, quarrying and overnight stay in a reserve area is prohibited unless authorized in writing by the relevant GoN authority. Section 11 of the Regulation restricts surveys and research works in these areas without prior written approval. All vehicles and persons passing through reserve areas are subject to security check. Under Article 7 of the *Buffer Zone Management Regulation, 1994*, clearance of forests and forest products, acquisition of land, use of quarry sites and hunting in buffer zones is restricted unless written approval of the relevant GoN authority is obtained.

3.2 International Environmental Agreements

37. Nepal is a party to the following international environmental conventions that may have some broad relevance to proposed Project activities:

(i) United Nations Framework Convention on Climate Change (UNFCCC) – for parties to take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. The related Kyoto Protocol includes the Clean Development Mechanism (CDM) which allows RE and other greenhouse gas reduction projects to earn and sell certified emissions reductions (CERs). Some sub-projects are expected to qualify for CDM registration, but CER revenue will not be mobilized as up-front cofinancing.

(ii) Convention on Biodiversity - the objectives of the Convention are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. The Project has the potential to affect biodiversity by disrupting the movement of significant fish species or by the removal of unique habitat or flora species. Article 14 of the Biodiversity Convention states that adequate attention should be given to minimize and/or avoid adverse impacts on protected species if a project area is the core habitat of such species. The GoN has included 17 plant species and 39 animal species in its protected list. Appropriate mitigation measures to minimize or avoid impacts on protected species from sub-project construction and operation are required.

(iii) Ramsar Convention on wetlands of international significance – Nepal has nine listed Ramsar sites that are all medium to large water bodies (each 90 ha or more in area). MMH plants have the theoretical potential to affect wetlands by impeding fish migration, but this is highly unlikely as they will be located in the upper catchments of small streams or on irrigation canals. Inflows into these wetlands will not be affected by MMHs as each sub-project will involve small scale run-of-river stream diversions over short stretches of streams (500-1,200 m in length).

(iv) Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal - the overarching objective of the Convention is to protect human health and the environment against the adverse effects of hazardous wastes, achieved through (i) a reduction of hazardous waste generation and promotion of environmentally sound management of hazardous wastes; (ii) restriction of transboundary movements of hazardous wastes; and (iii) a regulatory system applying to cases where transboundary movements are permissible. Nepal plans to install a battery management facility that will operate in accordance with the Convention's rules and guidelines. This plant will enable lead acid batteries, including batteries from the Project, to be recycled in Nepal rather than the current practice of recycling and/or disposal in India.

3.3 ADB Policy

38. In accordance with ADB's *Safeguard Policy Statement* (SPS, 2009) the Project requires an IEE. This report fulfils this environmental assessment requirement. In addition, each sub-project requires an environmental assessment, either in the form of an IEE or desktop assessment, based on whether the sub-project is classified as either an environmental category B or C, providing a level of detail commensurate with the likely impacts of that development. In-stream MMHs are likely to be classified as environment category B as they will alter stream hydrology along the dewatered stream section (albeit a short stretch of stream) that can affect aquatic ecology and river uses. An IEE will be prepared for each such sub-project.

39. Each SWM sub-project, as well an MMH sub-project located on an existing irrigation canal is likely to be categorized as environment category C as these sub-projects will primarily be installed on cleared agricultural land or in built-up village areas, and therefore they are likely to have minimal adverse environmental impacts. A review of the environmental implications of each of these sub-projects will be prepared using an environmental assessment checklist (Appendix F), primarily to identify if any significant impacts are likely. The one exception to this would be the development of project facilities, including transmission and distribution lines, in a protected area or through a significant area of vegetation/habitat, requiring the clearance of vegetation. In this instance the sub-project may be classified as environment category B if the vegetation to be removed cannot be avoided and is considered to have high conservation value. In the unlikely case that a SWM sub-project is a category B an IEE would be prepared.

40. The ADB principles for sensitive habitats will be applied at the sub-project screening stage and in the sub-project environmental assessment. Proposed sub-projects within 1 km of a sensitive habitat will be subject to prior review by ADB, and will be initially considered as environment Category B for purposes of assessment. Sub-projects located within sensitive habitats will be considered as the net benefits are expected to far outweigh any potential negative impacts. ADB principles for sensitive habitats are described in SPS Environmental Safeguards, Policy Principle number 8, as follows:

Critical Habitats

Do not implement project activities unless:

(i) There are no measurable adverse impacts on the critical habitat that could impair its ability to function

(ii) There is no reduction in the population of any recognized endangered or critically endangered species

(iii) Any lesser impacts are mitigated

Legally Protected Areas
Implement additional programs to promote and enhance the conservation aims of the protected area.

Natural Habitats

There must be no significant conversion or degradation, unless:

(i) Alternatives are not available

(ii) The overall benefits of the project substantially outweigh the environmental costs

(iii) Any conversion or degradation is appropriately mitigated

4. SUMMARY OF PROJECT IMPACTS AND BENEFITS

41. This section provides an overview of the Project's impacts and benefits, describing (i) the typical adverse impacts and benefits of each type of sub-project, and (ii) the total net adverse impacts and benefits of the overall Project. This description is based on the five case study sub-project assessments presented in sections 5-9 describing the typical types and significance of environmental and social impacts that are likely to occur.

4.1 ADB Environmental Categorization

42. Individual RE sub-projects will be classified as either ADB environment category B or C as they involve physical works but are generally expected to have limited, insignificant, and manageable direct and induced adverse environmental and social impacts. All SWM sub-projects are expected to be environmental category C given the small-scale of construction on open land, minor adverse construction impacts and the almost complete absence of adverse impacts during operation. MMH sub-projects are expected to be environmental category B or C depending on the type of water diversion. MMH sub-projects diverting water from an existing water supply/irrigation canal will generally be category C due to the small scale of these projects and the minimal impact on stream flows. MMH sub-projects with an in-stream diversion are likely to be category B as these plants will reduce downstream flows between the intake and tailrace outlet, potentially adversely affecting the aquatic ecosystem and any river uses along this stretch of the stream.

43. Overall, the Project is classified as ADB environment category B due to the potential impact of the most significant adverse impact: MMH diversion of stream flows and related potential impacts on river uses and aquatic ecology.

4.2 Typical Sub-Project Adverse Impacts

SWM Sub-Projects

44. SWM sub-projects, configured as either (i) solar, (ii) solar/wind hybrid or (iii) wind sub-project, will have limited adverse environmental and social impacts due to the small scale of the plant, location on cultivation land and in existing built-up areas (in yards, buildings, along tracks, etc), and limited activities during operation. A SWM hybrid plant has a small footprint of around 300 m^2 (0.03 ha), typically consisting of between 36-72 solar PV panels (1 m^2 each) mounted on 1 m high stands, two 14.5 m high wind turbines, a powerhouse housing an inverter and bank of batteries (commonly 220-300), and a low voltage 230/400 V distribution system servicing a single village. Each solar panel and wind turbine occupies 1 m^2, the powerhouse covers 40 m^2 and each distribution pole covers less than 1 m^2. Most panel and powerhouse sites will be on open flat or gently sloping land (either cultivation or grassland), while wind turbines will be located on the crest of ridges or rises wherever possible, generally set well back from forests. No forest will be cleared to install the panels, turbines and powerhouse, but individual trees may be removed near the panels and turbines, while sections of the 3.0 m wide distribution line right-of-way (RoW) may require clearing.

45. SWM facility construction will take 1-2 months and involve: minor site clearance; excavation of the panel stand footings and wind turbine foundations; transport of RE equipment to site; concreting footings and foundations; installation of the stands, panels, towers and turbines; and construction of the associated electricity mini-grid distribution system. Mini-grid distribution systems are expected to generally range between 1,200-1,800 m in total length, covering a single village including outlying clusters of houses. The transport of equipment to remote sites will usually be undertaken by porters (foot access) or mule from the nearest road. Construction camps will not be required due to the small scale of installations, short construction period and use of local labor. Operation phase activities will be limited to minor maintenance (e.g. cleaning solar panels, repairs to turbines, distribution line and electrical equipment) and the replacement of batteries every eight years or so.

46. Typical potential adverse impacts of SWM hybrid sub-projects, and the main management measures that will be implemented to avoid or mitigate these impacts, are:

47. **Land use change** – around 300 m^2 of land will be used for sub-project plant structures (excluding the mini-grid), commonly used for dryland cultivation but also likely to include bare ground and/or grassland. Land take will be kept to the minimum area required for the structures, and where alternative sites exist lower value land will be utilized in preference. Each SWM sub-project will generally service a single village that usually contains between 1-3 clusters of dwellings, therefore the average SWM distribution line length per sub-project is estimated to be 1,500 m, translating to a RoW area of 0.45 ha based on a 3.0 m wide RoW. The RoW will generally follow existing foot trails for ease of construction and maintenance, and to avoid features such as houses and trees.

48. **Habitat loss** – minor modified habitat loss may occur at some sites, but this will generally be restricted to the removal of individual trees near solar panels and/or wind turbines to improve their performance. Short sections of forest may be cleared to establish the 3.0 m

wide distribution line RoW for some sub-projects, but given that the plant will be located close to the village it is supplying then forest clearance is expected to be minimal in these circumstances (e.g. a 100 m section section of RoW through a forest requires clearance of 300 m^2).

49. **Noise** – noise from wind turbines is primarily emitted from the movement of the blades through air. Turbines are likely to produce noise levels that are generally lower than the World Bank guideline limits for residential areas, being daytime (55 dB(A)), night-time (45 dB(A)), but potentially exceeding the background noise level plus 3 dB(A)[17] guideline at 50-60 m downwind of a 5 kW wind turbine at wind speeds between 3-8 m/s. Background noise levels in isolated rural villages will generally be between 35-45 dB(A) across the day, while occasionally being higher when husking mills, saw mills or similar are operating. At 50-60 m downwind of an operating turbine the noise will be around 40-45 dB(A), equal to or less than the night-time guideline limit of 45 dB(A). At wind speeds over 8 m/s background noise from the wind passing through trees, over the ground, past buildings etc is likely to exceed the blade noise. Night-time wind turbine noise disturbance will be avoided by siting the turbines at least 50-60 m from the nearest dwelling.

50. **Waste** – minor volumes of waste will be generated from sub-project construction and maintenance. The main waste source will be the replacement of used lead acid batteries every eight years or so, requiring correct handling and disposal/recycling. Used batteries will be managed in accordance with Nepali policy and regulations covering re-manufacturing and/or recycling consistent with international best practice. Batteries will be managed in accordance with the ongoing NRREP programme has a special component to manage used lead acid batteries from rural electrification. In time this should involve the planned recycling of battery components in a proposed recycling facility in Nepal. The future replacement of lead acid batteries with lithium ion and/or other advanced technologies will be considered. AEPC will inform participating communities about required used battery management.

51. **Visual impact** - wind turbines will be a prominent feature in the landscape given (i) the preferred ridgetop location for these structures to optimize the wind speed, (ii) 14.5 m height and (iii) off-white colour, although the perception of the visual impact is subjective.

52. **Safety hazards** – solar panels and wind turbines produce electricity at 230 V which poses a risk of electrocution if contact is made with live lines. The bank of solar panels, each wind turbine and the powerhouse will be fenced to prevent public access. All electrical equipment, power lines and cables will be insulated in accordance with standard Nepal safety requirements. Lightning protection will be provided by earthing each turbine, the solar array and bank of batteries. Class 1B turbines will be installed, capable of withstanding gusts of up to 50 m/s (180 km/hr).

53. The adverse impacts of SWM solar-only or wind-only sub-projects are likely to be even less than those described above for SWM hybrid subprojects. No resettlement or building removal will be undertaken to install any SWM sub-projects.

MMH Sub-Projects

54. MMH sub-projects will generally have limited adverse environmental and social impacts due to the small scale of the plant, location on riverine features and currently utilized land (cultivation, and/or harvested forest), and limited activities during operation. The one exception

[17] World Bank Group, 2007. General EHS Guidelines: Environmental.

to this is the potential impact from the in-stream diversion of water around the section of stream between the diversion intake at the weir and the tailrace outlet.

55. MMH sub-projects will either utilize an in-stream diversion or divert water from an existing irrigation channel. These plants will mainly range in size from 100-1,000 kW, with irrigation diversion being smaller plants. Sub-projects will have a small footprint of around 0.8-1.2 ha (depending upon the installed capacity and site). Typical in-stream plants will consist of a diversion weir 1-2 m high, an intake canal and settling basin, a headrace canal (generally between 800-1,500 m in length), a forebay and penstock, powerhouse housing 2-3 turbines and an office, a switchyard in the powerhouse compound, a tailrace outlet, and a mini-grid system consisting of 11 kV transmission lines and 230/400 V distribution lines servicing a number of villages. Each mini-grid transmission/distribution system is expected to generally range from 8-20 km in total length, and may cover multiple villages.

56. In-stream plant facilities are primarily sited to enable water to be effectively diverted out of a stream and conveyed to the penstock, thereby creating sufficient head to economically generate power. Features such as villages, individual houses and religious shrines are avoided, particularly when aligning the headrace canal. Relatively flat land is sought for the powerhouse site, as well as the settling basin and forebay.

57. MMH construction will normally take 12-18 months and involve: up to 1.2 ha site clearance; excavation of structure foundations; transport of turbines, penstock pipe sections, other equipment and cement to site; local excavation of sand and rock for construction materials; construction of plant structures; and construction of the associated electricity mini-grid transmission/distribution system. The transport of equipment to remote sites will usually be undertaken by porters (foot access) or mule from the nearest road. The construction workforce will number around 17 supervisors and 115 labourers, depending upon the sub-project, with each worker receiving an average of around 206 days work. Construction camps will be avoided by the use of local labour. Activities during the operation phase will be limited to: power generation tasks and maintenance of structures, machinery and equipment (e.g. periodic sediment flushing from the settling basin and forebay; maintenance and repair of turbines; mini-grid line repair; stabilisation of eroding or landslip cuttings).

58. Typical potential adverse impacts of MMH stream diversion sub-projects, and the main mitigation measures that will be applied to manage these impacts, are:

59. **Land use change** – between 0.8-1.2 ha of land will be used for plant structures (excluding the mini-grid) for most MMH sub-projects, usually consisting of a range of land use/cover types such as riverine features, cultivation, bare ground, forest and grassland. Land take will be kept to the minimum area required for the plant structures, and where alternative sites exist lower value land will be utilized in preference. The transmission/distribution mini-grid line length for MMHs will vary substantially between sub-projects depending on installed capacity, annual generation, the local settlement pattern and population density. MMH mini-grid systems will generally have a total line length of between 8-20 km, with an estimated average length is 12 km. The 3.0 m wide RoW along a 12 km power line will occupy 3.6 ha. The majority of land uses in the RoW will continue, although tree/forest removal will be required where these features cannot be avoided. Cultivation will be permitted up to edge of all structures, including within the distribution line RoW.

60. **River diversion** - the main potential long-term impact of MMH sub-projects relates to the diversion of part of the natural stream flow through the turbines to generate power. Sub-

projects will have no effect on flows below the tailrace outlet, either daily or seasonally, due to run-of-river plant operation (without water detention/retention), but they will alter flows between the intake and the tailrace outlet by diverting water around this stretch of stream through the turbines during all periods when the stream flow exceeds 40% of a single turbine's capacity (the minimum flow required to operate a turbine) plus the minimum compensation release required by law. On some sub-projects diversion will occur 24 hours a day throughout the year, whereas on other streams the diversion will cease for some periods during the dry season due to inadequate stream flow. As most projects are sized based on a 60-85% dependable flow the change to flows in the dewatered stream section is greatest in the dry season and relatively minor during the four monsoon months (mid June to September/early October) when stream flows are high. Indicative monthly average stream flow changes created by MMH sub-projects will vary widely based on the dependable flow percentage that has been designed for, but broadly the dry season monthly average flow will be reduced to between 9-85% of the existing flow and the monsoon season monthly average flow will be reduced to between 65-98%.

61. A compensation (or environmental or riparian) release has to be made to provide water in the downstream dewatered section to maintain the downstream aquatic ecosystem and water uses. The flow has to be "*the higher of either at least ten per cent of the minimum monthly average discharge of the river/stream or the minimum required quantum as identified in the environmental impact assessment study report*" as per the *Hydropower Development Policy 2001* (MoWR, 2001). In practice the downstream flow from the weir will be greater at many times of the year as the weir will spill when stream flows exceed the generation capacity of the turbines plus the compensation flow volume. This diversion of water has the potential to affect (i) aquatic ecology and (ii) stream/water uses in the affected section between the intake and tailrace outlet (typically 800-1,500 m long), as described below.

62. Water quality will not be affected by generation diversion due to the short duration of the diversion (largely dependent upon the length of the headrace canal, but generally between 15-35 minutes) from the time the water enters the intake to the time it is released back into the river via the tailrace outlet (assuming an average velocity of 1 m/s plus detention time in the settling basin and forebay).

63. **Aquatic ecology** - the partial dewatering of a stream section has the potential to affect fish movement, breeding and population in the steam by:

(i) the diversion weir blocking fish migration (primarily upstream migration);
(ii) dewatering the stream section between the diversion weir and tailrace outlet, thereby
(iii) reducing the ability of fish to swim upstream and reducing the available aquatic habitat along the dewatered stretch; and
(iv) altering fish habitat in the weir pond area due to the accumulation of sediment.

64. Fish in hill streams/rivers in Nepal are classed as either long-distance, short-distance or resident species. Long-distance fish migration primarily occurs during the monsoon when migratory species move upstream to spawn during high river flows (mid-June to September) and migrate downstream to feed and grow in autumn (October-November) after river flows have decreased. Some of the main fish species are less likely to occur in the small upper catchments where the MMH plants will be sited as (i) these fish species require strong flowing water to swim upstream and hence favour larger rivers over small streams It should be noted that some of the main fish species require strong flowing water to swim upstream (i.e. *Tor* spp, *Bagarius yarellii*, *Pseudeutropius* spp., *Clupisoma* spp. and *Anguilla bengalensis*), therefore these species are

unlikely to use these watercourses; and (ii) the presence of these species is already compromised in some river basins because their distribution has been compromised by large downstream weirs or dams that do not allow these species to pass upstream (Appendix G).

65. The 1-2 m high concrete diversion weir step may affect the upstream migration of some short-distance migratory fish species, but downstream fish migration/movement is likely to remain largely unhindered. Some species will be unaffected by the weir as they are able to leap higher than 2 m, while others will be able to negotiate small weirs using sucker-like apparatus. Examples of such species are *Schizothorax plagiostomus* (Buchhe Asala), a short distance migratory fish that can jump up to 3 m in height, and *Glyptothorax* spp. and *Pseudecheneis sulcatus* that migrate upstream with the help of sucker-like apparatus. Where local species cannot pass over the weir upper catchment habitat will be lost, but this is considered to be a relatively minor impact due to the limited fish population in small streams, particularly at high elevations (i.e. above 2,000 m asl).

66. **River use** – multiple river uses are common along sub-project streams, including, for example, livestock watering, fishing (usually recreational on streams), sanitation, waste disposal, and water-powered mill operation. Adequate water has to be provided to maintain essential uses without an undue decline in water quality from these uses. The release of the minimum compensation flow should be adequate to maintain sufficient water for livestock watering and mill operation (mills typically require between 40-100 L/s (0.04-0.1 m^3/s) to operate[18]), even on small streams. Use of the river for sanitation purposes, waste disposal and other uses such (e.g. wool washing in some higher altitude areas) will reduce river water quality along the partially dewatered stream section due to reduced dilution, particularly during the dry season, but as this water is usually not used for human consumption the effect on existing water uses should be minimal.

67. **River morphology** - river morphology is expected to be marginally altered at each in-stream diversion weir site in the first 1-2 years following construction. The upstream weir pond (1-2 m deep) is expected to fill with coarse sediment in the first year of operation, creating a delta of sediment rising at a low grade upstream. Once the pond is full a new state of equilibrium will be reached and all river sediment and bed load material will flow over the weir and downstream at the existing natural rate.

68. Construction of weir wing walls at both ends of the weir structure will anchor it into the embankment, while floodwalls will be provided upstream and downstream to guide high flood discharges away from the river banks towards the main course of the river, therefore weir operation is not expected to induce river bank erosion. Weirs will have upstream and downstream aprons to protect the river floor from scouring and guide flows towards the desired path. Minor scouring is likely to occur downstream of the aprons but this will be filled with coarse sediment annually.

69. **Terrestrial habitat loss** – some terrestrial habitat will be removed during MMH plant and mini-grid construction, but the loss of better quality habitat such as forest and shrubland will usually be restricted to well less than 1.0 ha for plant structures, and to sections along the mini-grid RoW between some villages. Tree and shrub removal will be minimised by locating power line alignments to avoid standing vegetation wherever possible. Forests and shrublands that are

[18] Eagle, N., 2000. *Nepal Ghatta Project*. (Massachusetts Institute of Technology, School of Architecture and Planning) Retrieved September 11, 2012, from MIT Media Lab: http://web.media.mit.edu/~nathan/nepal/ghatta/

likely to be affected between villages are usually regularly harvested for fuelwood and other forest products, therefore these habitat types are rarely likely to be high value. Poaching of wildlife by outside construction workers during project construction is a risk, but this will be prohibited as a condition of employment.

70. **Construction material extraction** – in most instances sand and rock will be extracted from local sources (MMH plant sites, streams, rock outcrops and existing small quarries) close to plant sites to provide construction material for masonry works and powerhouse construction. The extraction of sand from a stream bed is unlikely to have an impact on river geomorphology as streams carry high volumes of coarse sediment during the annual monsoon, therefore the excavated volume is likely to be replaced in 1-2 years.

71. **Spoil disposal** – spoil will be generated from the excavation of weir foundations, settling basin, headrace canal, forebay, and tailrace outlet, with smaller volumes of material coming from the intake channel, penstock foundations, and powerhouse site. Spoil will mainly consist of subsoil, with a small volume of topsoil, rock and riverine deposits also generated. Some spoil, mainly sub-soil, will be utilized to form project structures such as fill embankments for the headrace canal and forebay, while any suitable rock will be utilized in masonry works. Excess spoil that cannot be utilised will generally be between 2,000-4,000 m^3 for a typical 200 kW MMH plant, but this is highly variable based on the plant design, topography and ground conditions.

72. Excess spoil will be disposed of near the plant sites where it is generated given that all works are likely to be undertaken by hand, therefore disposal at more distant sites is costly. Spoil disposal site selection will also be based on avoiding environmental and social impacts (short and long term). Lower value land will be used wherever possible, such as riverside deposits, degraded or barren areas, and grassland. The use of cultivation land for spoil disposal will be avoided. Where possible disposal will occur on construction sites, with a minimum setback of 20 m from watercourses. Disposal areas will be topsoiled and revegetated.

73. **Waste** - a small volume of waste will be generated during plant construction and operation. Wastes will include cleared vegetation, construction and maintenance materials (e.g. scrap metal, sections of conductor, used oil, grease and paint). As the construction and operation workforce will mainly consist of local residents, little additional waste will be generated by the workforce. Most unskilled construction workers will come from nearby villages and therefore will remain housed in their own dwellings, while the skilled workforce from outside the area will only number around 15-20 who will be accommodated in existing nearby hotels and houses, therefore no temporary workforce camps will be established.

74. Waste will be managed by collecting residual construction materials and waste for reuse, recycling or disposal, in accordance with standard and accepted practices. This may variously involve the removal of the waste to an off-site facility, or the burying or local reuse of materials.

75. **Temporary disruption to local services** – some existing facilities and services such as paths, water supply pipelines and irrigation canals are likely to be temporarily cut during MMH construction, particularly by the main linear structure, the headrace canal. These services will either be immediately reinstated or temporarily reconnected during construction to ensure that essential services such as water supply are maintained. Where a temporary connection is made the service will be permanently reinstated as soon as construction at that site has been completed. Reconnecting services will variously involve: reinstating foot trails by capping the headrace canal with concrete lids and installing permanent steps down cuttings and embankments; reconnecting water supply poly pipelines; and reconnecting irrigation channels.

76. **Historic and religious sites** - historic or religious sites have the potential to be affected by plant structures and project operation. Such sites include cremation ghats or small riverside shrines or temples along the dewatered stream section, or shrines/stupas located on potential plant sites. MMH site selection and design will consider these factors to avoid impacts.

77. **Safety hazards** - open water structures pose a drowning hazard to people and livestock. While most headrace canals will be small (generally less than 1 m wide by 1 m deep) with a flow velocity of 1.5 m/s, the deeper and broader gravel trap, settling basin and forebay will pose a hazard to young children and adults who cannot swim as these structures are usually between 2.5-3.5 m deep with vertical sides. Foot trails cut by the headrace canal will be reinstated by laying concrete lids over the canal at these points, while other sections of the canal will be capped adjacent to high pedestrian traffic areas (e.g. on the edge of a village). The gravel trap, settling basin and forebay will be fenced using barbed wire to prevent access to these structures. A trash rack will be fitted to the forebay in front of the penstock intake that will prevent people or animals being drawn into the penstock.

78. Electrocution can occur from contact with switchyard gear/transformers/live conductors, flashover from a conductor to a pole or vegetation, and conductor breakage. Electrical safety will be built into the project by: maintaining minimum vertical clearances between the conductors and the ground and structures; fitting lightning arrestors on the high voltage side of each transformer; grounding each high tension pole; and earthing all other necessary components. Lightning arrestors will be fitted on top of poles at intervals of approximately 300 m to protect electrical appliances from high current. Transmission and distribution lines will strictly adhere to electrical safety setbacks as set out in the Nepal Electricity Regulation[19]. For power lines from 230/400 V up to 11 kV the minimum distance from the line to a house or tree is 1.25 m, while minimum clearance between the ground and the line is 4.6 m. No houses or other buildings will be permitted within the RoW, with existing houses and other structures relocated outside the RoW. Awareness programs on safety will be conducted for project staff and local residents at key locations in the project area.

79. **Irrigation diversions** - the adverse impacts of MMH plants that divert water off existing irrigation canals will be less than the adverse impact of in-stream diversion plants as the stream diversion and, in effect, part of the headrace canal already exists, while these plants are likely to be smaller than the in-stream diversion plants.

4.3 Typical Sub-Project Benefits

80. SWM and MMH sub-projects will provide a greater and more reliable supply of power to isolated villages for household lighting and appliance use, community use, institutional use and business activities. Households will be better illuminated by multiple electric lights, replacing kerosene lamps, the light from fires, and a single electric bulb commonly powered by home solar systems. Households will also be able to run a variety of additional appliances, such as a refrigerator, television, radio, kitchen appliances, computer and mobile phone charger. Communities will be able to run additional facilities such as village street lights and to supply power/lights to shrines/stupas. Institutions such as schools and health posts will receive better illumination from electric lights and be able to run a range of appliances such as computers and refrigerators. Some existing businesses will be able to convert to electricity (e.g. husking mills, sawmills), while new businesses that use electricity may be established (e.g. furniture making).

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[19] Government of Nepal, 1993. Electricity Regulation 2050.

81. The amount of electricity produced by a 20 kWp SWM plant is highly dependant upon prevailing solar radiation and/or wind conditions, with around 28,000-35,000 kWh/yr produced by typical middle hill to high Himalaya projects. This volume of electricity is sufficient to supply around 60-80 households in a single village, and, for example, to convert a diesel husking mill to electricity and provide village street lighting.

82. A 200 kW MMH will generate around 1,150,000 kWh/a, sufficient to supply around 1,400 households (most likely in 3-6 villages), convert a number of existing diesel units to electric, provide street lighting and provide power for at least 1-2 new enterprises per village. The benefits of a typical 20 kWp SWM plant and a 200 kW MMH plant are indicated in Table 4.1.

Table 4.1: Indicative Power Supply Usage from Typical Sub-Projects

User Group	Uses	20 kWp SWM Sub-Project	200 kW MMH Sub-Project
Villages	Villages	1	5
Households	Households supplied	60-80	1,400
	Average household use - room lights - radio - direct to home receiver - TV/DVD - kitchen grinder/appliance - refrigerator - computer with LCD monitor - mobile charger - other (e.g. fan)	 5 1 1 1 1 1 1 1 1	 5 1 1 1 1 1 1 1 1
Community	- street lights - other uses	1 village 2	5 villages 5-10
Institutions	- school - health post	1 -	3-5 1-2
Businesses	- agro-processing/furniture manufacture - other uses	1 2	6-10 6-10

Note: SWM and MMH plants are designed to supply a similar amount of power to each connected household.

83. Plants will be sized to provide sufficient power for the operation of a broad range of appliances per household for the estimated population in 10 years time. SWM power supply reliability will be provided by having sufficient battery capacity to store project electricity output to meet 2-4 days of electricity demand. Additionally, by combining solar and wind in hybrid projects supply reliability is improved, while having multiple wind turbines (generally 2-3) also improves supply reliability in the event of a turbine not functioning. MMH power supply reliability will be provided with two turbines in the powerhouse, enabling the supply of power when one turbine is out of service and enabling generation off lower stream flows.

84. **Household energy cost** - the supply of power from the sub-projects is expected to reduce household energy costs by a small amount due to the replacement of existing power sources such as kerosene, diesel, small solar home systems and/or tukimara.

85. **Indoor air quality** – there is likely to be a slight improvement in household indoor air quality as kerosene lamps are replaced with electric lights in most households that will receive sub-project electricity supply. This benefit is expected to be minor as fuelwood will continue to burnt for cooking and heating in most dwellings, the main source of indoor smoke.

86. **Greenhouse Gas Savings** – the use of Project renewal energy in small communities will avoid the current emission of greenhouse gases (GHGs) by replacing kerosene, diesel and/or traditional biomass use to varying degrees in the supplied villages. Kerosene used for room lighting will be replaced by electric lights, while some diesel-powered machinery such as husking mills and sawmills is likely to be converted to electricity where sufficient power is supplied. The replacement of a small amount of fuelwood use will only occur where wood is burnt for room lighting, as cooking, the main use, will continue.

87. Whilst it is not possible to accurately estimate an average GHG saving per sub-project due to differences in the volume of use and number of users of fossil fuels in Project-supplied villages, several examples can be given to iullustrate the likely savings. The GHG emission saving from a 20 kW SWM (solar-wind hybrid) plant producing 29,000 kWh/a is estimated at 6.2 T/a CO_{2e} based on the replacement of 4 L/month kerosene use for lighting by 25% of connected households, plus 37 L/month of diesel use by three mills that will be converted to electricity, assuming that no fuelwood is burned for room lighting. The GHG saving from the supply of power from a 200 kW MMH plant producing 1,120,000 kWh/a is estimated at 21.8 T/a CO_{2e} based on the replacement of 3 L/month kerosene use for lighting by 17% of connected households.

88. The connection of Project-supplied villages to the electricity grid is not an economically feasible alternative due the cost of extending the grid and inherent poor supply reliability, therefore it is not appropriate to compare the emissions from grid-supplied electricity with project-supplied electricity to estimate the GHG emission savings.

89. **Reduced deforestation**: the Project is unlikely to reduce deforestation apart from replacing a small amount of fuelwood that is burnt to supply room lighting in some households. This benefit is relatively minor as the main use of fuelwood, cooking, will not be replaced by the Project supply of electricity.

90. **Employment** – construction of a typical 20 kWp SWM plant will require around 30-60 person-days of labour. Construction of a typical 200 kW MMH plant will require around 10 staff to supervise sub-project design and construction (totaling around 1,800 person-days), and a construction workforce of around 15 skilled and 110 unskilled staff (totaling around 23,500 man-days of labour). Project employment during operation will involve around 7-10 staff – a project manager, 1-2 technical support staff, 2-3 unskilled laborers (guard and staff to occasionally clean the canal, an accountant and two electricity meter readers.

4.4 Net Impact of REREAP

91. The overall environmental and social impacts and benefits of REREAP are estimated below, based on the assumption that 100 x 20 kWp SWM plants and 20 x 200 kW MMH plants will be installed (Table 2.1), and based on the typical impacts of the standard design of plants as described in Section 4.3.

4.4.1 Net Adverse REREAP Impacts

92. **Loss of productive land**: the land take for the entire Project for all plant structures (excluding mini-grid power line RoWs) is small, estimated to be around 23 ha. This estimate is based on an assumed average land take for each sub-project of: MMH = 10,000 m^2 (1 ha); and SWM = 300 m^2 (0.03 ha). Based on the example sub-projects, it is assumed that 55% of this

affected land will be cultivation (12.6 ha), 15% riverine features (3.5 ha), 15% shrubland (3.5 ha), 10% (2.3 ha) forest and and 5% grassland (1.1 ha).

93. The total land area likely to be used for mini-grid RoWs will be around 117 ha, consisting of 45 ha for SWM mini-grids (100 x 0.45 ha) and 72 ha for MMH mini-grids (20 x 3.6 ha). Based on the example projects, most of this land will remain under current use (i.e. cultivation, grassland, barren land, open areas within settlements, riverine areas), but an estimated 20% of the area (23.4 ha) will consist of forest and shrubland that will have to be cleared to establish mini-grid RoWs.

94. **Altered stream flows, and effects on aquatic ecology and river uses**: of the estimated 20 MMH sub-projects that will be installed it is assumed that 16 of these plants will be in-stream diversions and the remaining four will offtake water from existing irrigation canals. The 16 stream diversions will be located in upper catchments, with average annual flows likely to range between 2-20 m^3/s in most instances. Each stream diversion is expected to reduce flows along an average stream length of 1,200 m between the diversion weir and tailrace outlet, with upstream and downstream stream flows unchanged due to run-of-river generation only. Accordingly, the total affected stream length of the combined 16 MMH plants utilizing an in-stream diversion will be around 19.2 km.

95. **Reduced/disrupted fish migration/movement**: fish movement is expected to be modified along the 19.2 km of partly dewatered streams primarily in the dry season when flow reduction will be greatest. The upstream movement of fish past diversion weirs is also likely to result, but the total loss of aquatic habitat to affected fish species is extremely difficult to accurately estimate.

96. **Terrestrial habitat loss** – as described above, forest and shrubland removal on Project plant sites and within mini-grid RoWs is estimated to total 29.8 ha. Most of this area will consist of modified habitat given the high amount of forest harvesting that has typically occurred in settled areas over an extended period of time.

4.4.2 Net REREAP Benefits

97. Project environmental and socio-economic benefits are expected to far outweigh the Project’s adverse impacts given the number of households, community facilities, service institutions and businesses that will be powered, against the relatively minor construction and operation impacts of the proposed MMH and SWM plants. The primary benefit of the installation of the Project’s target 6.0 MW total installed capacity will be increased and more reliable energy supply to an estimated 34,440 households in 200 villages, thereby improving the quality of life of an estimated 189,400 people (based on an assumed average household size of 5.5 people).

98. An estimated 100 schools will be powered by the Project, based on the assumption that one school will be supplied in 50% of the connected villages. This translates to several thousands of students receiving better classroom illumination and educational facilities. It is also estimated that a health post will be electrified in 30 of the 200 villages that are likely to be supplied, providing better health care to an estimated 5,000 people or more. Around 100-200 new small enterprises are estimated to be established using Project power supply, while some local businesses will convert from fossil fuel use to electricity. In addition, the 200 supplied villages will be able to run street lights.

99. The supply of power from 6.0 MW of installed capacity to 200 villages will reduce the use of kerosene in households and diesel in businesses. As described earlier it is not possible to accurately estimate an average GHG saving per sub-project due to differences in the volume of use and number of users of fossil fuels in Project-supplied villages. But a broad indication of the magnitude of Project GHG emission reduction has been calculated using the the average estimated GHG savings of the MMH and SWM example plants (Sections 5-9) per installed kW (0.218 T/a and 0.069 t/a respectively) multiplied by the target project total installed capacity. This indicates that the total Project GHG emissions reduction will be in the order of 494 T/a.

C. Cumulative Impacts

The Project contribution to significant cumulative biophysical and socioeconomic impacts that are occurring from the range of activities and developments in a defined geographic area/district/region/catchment will be insignificant due to the small scale and dispersed location of REREAP sub-projects.

5. SANI VERI HYDROPOWER SUB-PROJECT

100. This assessment of the likely environmental and social impacts of the proposed Sani Veri HEP is based on: (i) *Feasibility Study of Sani Veri Mini Hydro Project*[20]; (ii) an inspection of the proposed project sites; (iii) a social survey of some local households that will benefit from project power supply; and (iv) the ADB REREAP Technical Report.

5.1 Project Description

101. The 300 kW Sani Veri HEP is a small run-of-river type hydropower project located on the Sani Veri Khola in Taksera VDC, Rukum District, western Nepal. It is designed to provide power to 6 villages (Table 5.1) in three VDCs (Taksera, Kol and Rangshi), servicing an estimated 2,034 households. The project will generate around 1,839,600 kWh energy each year.

Table 5.1: Villages to be Supplied by the Project

VDC	Villages
Taksera	Taka Gaun, Bachhi Gaun, Upallo Sera, Tallo Sera
Kol	Kol Gaun, Birgum
Rangshi	Nahaka Pani, Golkhada, Chammari

Source: ADB REREAP, 2012.

102. The project was initiated by the residents of Taka Gaun, Upallo Sera and Tallo Sera villages, who made representation to AEPC via Taksera VDC. These residents subsequently formed the Sani Veri Uttar Ganga Hydro Power Users Committee to develop the project.

103. The main project structures are a 2 m high diversion weir, settling basin, 765 m long headrace canal, forebay, penstock, powerhouse and tailrace outlet channel, with 42.4 m net head. Power will be transmitted to households via a single circuit 11 kV overhead transmission line (estimated at 17 km) that will connect the powerhouse step up substation switchyard to

[20] Devkota, K. (2010). *Fesibility Study of Sani Veri Mini Hydro Project*. Kathmandu: AEPC.

various distribution substations. The distribution substations will connect to consumers' premises through 230/400V overhead lines and 400V overhead lines.

5.2 Description of the Environment

5.2.1 Physiographic Region, Topography and Drainage

104. The proposed Sani Veri HEP site is located at Taksera in the Middle Hills physiographic region at an elevation of 2,100 m asl, in Rukum District, Mid-Western Development Region. Topography in the project area consists of deep river valleys that generally drain to the south, commonly rising in elevation from the valley floor to the adjoining ridges by 800-1,300 m (up to 3,200 m asl). Hill side slopes are steep, generally between 15-35^{o}.

105. The project has a 350 km^2 catchment. The Sani Veri Khola drains to the northwest into the Thuli Bheri River approximately 69 km below the project tailrace outlet site. The Thuli Bheri River flows into the Bheri River which then discharges into the Karnali River.

5.2.2 Climate

106. Taksera has a cool temperate climate, primarily due to its high elevation at 2,100-2,160 m asl. The area experiences strong seasonal climatic variations, with the monsoon from June to September and dry weather from October to May. Snowfalls occur down to around 2,500 m asl in most years[21].

107. The project area has a mean maximum temperature of 21.4°C in June and mean minimum temperature of -2.2°C in January (DHM, 2012)[22]. Rainfall data obtained from Department of Hydrology and Meteorology (DHM) for rainfall stations at Rukumkot (located 19 km to the west at 1,560 m asl) for 1987-2011 and Sheragaun (located 700 m to the south at 2,150 m asl) for 1987-2000 indicate average monthly rainfall varying from 16.1 mm in December to 465.4 mm in July, with 86% falling from May to September (Table 5.2).

Table 5.2: Average Monthly Rainfall - Rukumkot (1986-2011) and Shera Gaun (1986-2000)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rukumkot (mm)	29.1	43.4	38.9	69.5	134.2	298.6	529.0	473.3	182.9	35.2	13.3	14.7
Shera Gaun (mm)	31.8	42.6	51.5	50.7	95.5	209.5	356.3	384.8	167.8	40.8	16.7	19.0

Source: DHM, Kathmandu, Nepal.

5.2.3 River Hydrology

108. The Sani Veri Khola drains westwards through a steep sided valley, flowing into the larger Thuli Veri River approximately 69 km downstream of the project tailrace site (Note: the Sani Veri Khola is named the Uttar Ganga Nadi above the Pelma Khola confluence on topographic maps, and known by both names locally). The river bed is steep at around 3.1^{o}

[21] WWF. (2009). *Inventory of Three High Altitude Wetlands:Sundaha in Dhorpatan Hunting Reserve, Panch Pokhari in Makalu Barun National Park and Dudh Kunda in Langtang National Park.* Kathmandu: WWF Nepal and DNPWC.

[22] DHM. (2012). Meteorological Data. Department of Hydrology and Meteorology, Government of Nepal, Babarhmahal, Kathmandu, Nepal.

slope. The project catchment forms part of the upper reaches of the Thuli Veri basin. Two local streams flow into the Sani Veri in the Project area. A small stream, Kharimban Khola, enters the river approximately 340 m downstream of the diversion weir intake site on the left bank, on the outskirts of Tallo Sera village. The other stream enters approximately 130 m upstream of the powerhouse site on the right bank.

109. The estimated average monthly flow rate of the Sani Veri is 16.3 m^3/s, with average monthly flow rates ranging from a low of 2.3 m^3/s in April during the dry season, up to a peak of 56.6 m^3/s in August during the monsoon (Table 5.3). 85% of river flows by volume occur in the monsoon season from June to September when there is the potential for flash flooding and riverbed scouring. Flooding during the monsoon is common, but floods have not broken over the main river banks in living memory. River banks have been planted with trees by local people to reduce bank erosion.

Table 5.3: Estimated Mean Monthly Sani Veri Khola Flow Rate

Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow (m^3/s)	5.43	4.08	2.94	2.26	5.89	13.58	32.83	56.60	37.36	18.11	9.28	7.02

1 – based on the Medium Irrigation Project (MIP) method of flow estimation, used in the absence of stream gauging apart from a single reading.
Source: *Feasibility Study of Sani Veri Mini Hydropower Project* (2010) and Universal Consultancy Services P. Ltd. & Energy Development Services P. Ltd. JV, AEPC/ESAP.

5.2.4 Geology, Site Stability and Soils

110. Site geology consists of Lesser Himalayan Metasediments. The river flows along the East West Fault line that forms the boundary between the Nawakot Group north of the river and the Kuncha Group south of the river. The Nawakot Group consists of Precambrian to Lower Paleozoic, mainly shallow marine sediments with the lower part dominantly clastic (phyllites, sandstones, quartzites and calcareous sandstones). Stromatolitic limestones and black slates occur in the upper part. Basic sills and dykes are present. While the Kuncha Group consists of Precambrian, mainly of flyschoid sequence (bedded schists, phyllites and metasandstones), locally shallow water quartzite beds and basic sills and dykes. The ridges on the northern river bank consist of Tertiary and Mesozoic Series, while the ridges south of the river bank consist of Bhimphedi Group and Phulchauko Group of Lesser Himalayan Crystallines. Furthermore, the Mahabharat Thrust exists south of the river.

111. The main soil types found at the site are Dystrochrepts, Haplumbrepts, Haplustalfs, Rhodustalfs, Cryumbrepts and Haplustalfs-calcarious materials.

5.2.5 Land Use

112. The main land use types in the project area are grazing on grasslands and in forest areas, dryland cultivation on small areas of flatter riverside land and on terraced hillslopes, and forest harvesting for timber, fuelwood and non-timber forest products (Figures 5.1 and 5.2).

Figure 5.1: Sani Veri Headrace Canal (initial section) and Settling Basin

Figure 5.2: Sani Veri Headrace Canal (final section), Forebay and Powerhouse

113. Livestock grazing is the main livelihood source in area. The main livestock are sheep, with goats and cattle also raised. The main local crops are maize grown in summer, and wheat, millet and barley grown in winter, together with potatoes, grown as a single crop on non-irrigated fields. Most dwellings are clustered in settlements (Figure 5.3) where household gardens are cultivated for vegetables such as pumpkin, potatoes, beans and tomatoes.

Figure 5.3: Tallo Sera and Upallo Sera Settlements (looking upstream)

114. Steeper slopes in the project area are mostly public land under forest, shrubland and grassland, and are mainly used for livestock grazing and harvesting forest products (fuelwood harvesting and the collection of medicinal herbs). National forest land lies about 80 m from the local settlements next to project sites, while large grassland areas border cultivated land along the right bank of the Sani Veri Khola. A few patches of shrubland with pole-sized salix saplings growing below the settlement of Tallo Sera will be crossed by a 120 m long section of the headrace canal approximately 200 m downstream of the intake.

115. Two registered community forests are located in the project area: Sajaba Community Forest of Bachhigaun - 68 ha supporting 108 households; and Madhuse Community Forest of Tallo Sera - 38 ha supporting 106 households. These forests are located in Wards 8 and 9, Taksera VDC, approximately 1 km away from settlements. Both forests have around 70% canopy cover, with the main species being *Pinus wallichiana* (Salla), *Cedrus deodara* (Deodar/Devdaru), *Taxus buccata* (Loath Salla), *Quercus lanata* (Banjh), *Juglans regia* (Okhar), *Quercus semecarpifolia* (Khasru) and apple trees. A plantation consisting of Japanese Salla, Lekali Salla and Deodar was established on 2 ha in Sajaba Community Forest over the past eight years. Furthermore, GTZ initiated the planting of Walnut (*Juglans regia*) in Sajaba Community Forest. These forests are rich in non-timber forest products that include *Dactylorhiza hatagirea (D. Don) Soo*, *Berberis aristata*, *Asparagus sp*, *Picrorhiza scrophulariiflora* etc that are harvested by local people.

5.2.6 River Use

116. The 950 m stretch of the Sani Veri that will be partly dewatered by the project is used by two local riverside villages, Tallo Sera and Taka Gaun. Uses along this river section include livestock water, fishing, sanitation, waste disposal, washing sheep wool for carpet production,

and powering water mills. A water mill used for grinding grain is located 390 m upstream of the powerhouse site (560 m downstream of the weir), run across the year using water diverted from the river. Sheep wool is washed in the river throughout the year, as required for weaving. The river is also used to transport fuelwood, while driftwood is occasionally gathered from the river as another source of fuelwood, as witnessed near the proposed diversion weir site and at Upallo Sera and Dhamchan.

5.2.7 Terrestrial Ecology

117. The proposed project site is located on the left bank of Sani Veri River valley in between steep mountains slopes at an altitude of 2,100 m. Settlements and cultivated land are close to the river, with forests and grassland on steep hill and mountain slopes. Forest cover consists of Deodar (*Cedrus deodara*), Juniper (*Juniperus sps.)*, Birch, *Rhododendron sps*., Walnut (*Juglans regia)* and Oak (*Quercus sps)* with around 70% canopy cover. Major animal species found in these forests include Barking Deer, Musk Deer, Bharal, Himalayan Thar, Himalayan Ghoral, Snow Leopard, Hare and Himalayan Black Bear.

118. The site is located on the boundary of the Northern Mountain Landscape, as designated by WWF Nepal (1996). This landscape was delineated for the conservation of Sheyphoksundo National Park (located approximately 43 km north of the project site) and adjoining areas.

119. **Protected Areas:** the Dhorpatan Hunting Reserve lies to the north of the diversion weir and intake site, with the boundary being the Kharimban Khola next to Taka Gaun (as indicated on the Department of Survey 1:50,000 scale topographic sheet No. 2882 08) (Figure 5.4). All project component sites are outside the Reserve, as are the load centres that will be serviced by the project. The Reserve rises from an elevation of 2,000 m asl up to 7,246 m asl. It is divided into seven blocks, with the Falgune and Surtibhang blocks bordering the project site. Local people have cultural and religious ties to these areas, and utilize them to support their livelihoods. Villages to the east of Upallo Sera village lie within the Reserve. There are reports of conflict relating to the location of the reserve boundary in Rukum District.

Figure 5.4: Location of Sani Veri Powerhouse and Load Centres

Green line – boundary of Dhorpatan Hunting Reserve.
Red lines – straight line distance to load centres (villages).
Note: no load centres or power lines will be located within the Reserve.

120. The Reserve is classified as IUCN management category VIII and has been preserved as the only hunting reserve in Nepal, allowing multi-use management. It contains 30 species of importance[23] (Appendix H), including Red Panda (*Ailurus fulgens*), Musk Deer (*Mochus chrysogaster*), Snow Leopard (*Uncia uncia*), Blue Sheep (*Pseudois nayaur*) and Cheer Pheasant (*Catreus wallichi*). Red Panda is generally found at 3,000-3,200 m asl[24] while Musk Deer is known to occur at 2,600-4,000 m asl[25], therefore neither species is in the immediate project area. Cheer Pheasant, protected under the *National Park and Wildlife Conservation Act 1973* and categorized as Vulnerable under the IUCN Red List and CITES Appendix I, is found at greatest density in the Dhorpatan valley, in the Surtibhang and Phagune blocks[26] that adjoin the project site. Cheer Pheasant habitat range is recorded as being between 1,800-3,005 m altitude[27].

121. Discussions in Taksera VDC indicated that most women travel up to three hours each day in February and March to harvest fuelwood from forests. Fuelwood collection is important to local likelihoods, reportedly occurring along the Reserve boundary at higher altitudes. Fuelwood is then stored for use from May-November. It is unclear if harvesting is occurring in the Reserve, but the Department of National Parks and Wildlife Conservation (DNPWC) has concerns about community use of the Reserve in relation to: degradation of high altitude areas; overgrazing of pastures and competition with wild ungulates; conflicts between local communities livelihood practices and management of protected areas; poaching and illegal trade of wild and endangered protected species; and the potential risk of disease transfer between livestock and wild undulates.

122. A buffer zone is currently being planned around the Reserve that incorporates the entire Taksera VDC area. DNPWC is in the process of preparing a management plan for this area. The nearest wetlands to the project site are at Sun Daha, Kamal Daha, Shyapru Daha and Ramajima Tal, at least five hours walk from the site and not affected by Sani Veri River flows.

5.2.8 Aquatic Ecology

123. No surveys of the Sani Veri River aquatic ecosystem near the project site are known, but the Sani Veri was surveyed further downstream at 915 m asl (approximately 50 km downstream of the site) where *Schizothorax plagiostomus* (Buchhe Asala) was found[28], classified as a Vulnerable species under the Nepal Biodiversity Resource Book[29], but yet to be assessed for the IUCN Red List (January 2013). This short distance migratory species has a reported range

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[23] Bhushal, A., 2005. *Dhorpatan Shikar Arakchak Ek Chinari.* Baglung: Manoj Printing House.
[24] Kandel, R., 2000. Distribution and Conservation Status of Red Panda in Dhorpatan Hunting Reserve, Nepal. *MS Thesis Submitted to Department of Zoology, TU.* Kathmandu: Department of Zoology, T.U.
[25] Karki, M. B., 2008. Distribution and Population of Himalayan Musk Deer in Dhorpatan Hunting Reserve, Nepal. *MS Thesis Submitted to Central Department of Zoology, T.U.* Kathmandu: Central Department of Zoology, T.U.
[26] Singh, P. B., Subedi, P., Garson, P. J., and Poudyal, L., 2011. Status, habitat use and threats of cheer pheasant Catreus wallichii in and around Dhorpatan Hunting Reserve, Nepal. *International Journal of Galliformes Conservation*, 22-30.
[27] Baral, H. S., and Inskipp, C., 2004. *The State of Nepal's Birds 2004*. Kathmandu: Bird Conservation Nepal, DNPWC, IUCN-Nepal.
[28] Shrestha, J., 1995. *Enumeration of Fishes of Nepal.* The Netherlands: HMGN, Euroconsult Arnhem.

[29] ICIMOD, 2007. *Nepal Biodiversity Resource Book*. International Centre for Integrated Mountain Development (ICIMOD), Ministry of Environment, Science and Technology (MOEST), Government of Nepal (GoN). Kathmandu, Nepal.

of 345-3,323 m asl[30] and appears to occur in the Sani Veri River at the project site as local people reported the presence of Asala (*Schizothorax*).

5.2.9 VDC and Project Area Profile

124. The three VDCs that will receive electricity from the project have a total population of 8,923 (Table 5.4) (Population Census, 2011), with an average household size of 4.5. All households in these VDCs are targeted to benefit from the project.

Table 5.4: VDC Population

VDC	Population				Total Households	Household Size
	Male	Female	Total	Sex Ratio		
Taksera	1,670	2,028	**3,698**	80%	**902**	4.1
Kol	1,399	1,728	**3,127**	81%	**707**	4.4
Rangshi	992	1,106	**2,098**	90%	**425**	4.9
Total	**4,061**	**4,862**	**8,923**	**-**	**2,034**	**4.5**

Source: Population Census, 2011, CBS.

125. The dominant ethnic group in the three project VDCs are Magars, comprising 67% of the total VDC population. Other major groups are Chhetri (21%) and Dalit (7%) (Table 5.5).

Table 5.5: Ethnic Composition by VDC

VDC	Population						
	Magar (Janajati)	Chhetri	Dalit	Gurung (Janjati)	Thakuri	Sanyasi	Others
Taksera	3,572	735	0	0	0	0	31
Kol	1,858	344	708	187	37	24	123
Ranshi	1,142	980	10	0	25	0	36
Total	**6,572**	**2,059**	**718**	**187**	**62**	**24**	**190**

Source: Population Census, 2001.

126. Relative to other communities in Nepal, local women have greater power in family decision making, particularly given that most males of working age go abroad for work or education. Most water collection, fuelwood and fodder gathering activities are undertaken by women, with men undertaking most of the ploughing.

5.2.10 Livelihoods

127. Subsistence agriculture, consisting of livestock raising and rainfed cultivation, is the main livelihood earning activity in the project area. However, some households depend upon multiple occupations such as wage labour, service provision and petty businesses to earn their livelihood.

128. Agricultural land and livestock holdings of households in Taksera VDC are summarised in table 5.6. Ownership of agricultural land is common, with 98% of households reporting ownership. Livestock are also owned by most households, used for subsistence and income generation.

[30] Shrestha, J., 1995. *Enumeration of Fishes of Nepal.* The Netherlands: HMGN, Euroconsult Arnhem.

Table 5.6: Ownership of Agricultural Land and Livestock in Project Area VDCs

VDC	Households Owning (%)				Total Households
	Agricultural Land Only	Land and Livestock	Land, Livestock and Poultry	Other	
Taksera	136	134	566	16	852
Kol	28	32	551	13	624
Rangshi	6	81	295	15	397

Source: Population Census, 2001.

129. The main source of income of many households is the remittances provided by male household members working elsewhere in Nepal or in foreign jobs. Some INGOs (e.g. CARE Nepal) and NGOs (e.g. WASH) support womens' groups to establish enterprises such as pig rearing, while plantation and community forest management are also supported.

5.2.11 Energy Supply and Use

130. The main sources of energy in the project VDCs were reported to be: fuelwood for cooking and heating (99.1% of households); home solar power for lighting (66.1%); fuelwood for lighting (26.4%); kerosene for lighting (6.2%); LPG (gas) for cooking (0.9%); and battery light (Tukimara) (1.3%)[31]. Discussions with local users indicate that fuelwood costs NRS 4/kg (with around 350 kg used per month per household[32]), household kerosene use costs around NRS 330/month (3 L by NRS 110/L), household solar power system costs around NPR 167/month (NRS 2,000/year), and a tukimara LED light costs around NRS 333-417/month (NPR 4,000-5,000/year).

131. A number of micro hydropower projects have been proposed in the project area but none are operational, as summarized in Table 5.7.

Table 5.7: Proposed Hydropower Projects in the Sani Veri Area

Project Name / River	VDC	Capacity (kW)	Status
Kuchai Khola	Taksera	30	In disrepair – never commissioned
Domai Khola	Rangshi	10-15	Not approved by TRC
Dhausbur Khola	Rangshi	10-15	Not approved by TRC
Okma Khola	Koal	63	Proposed
Tila Khola	Koal	10-12	Proposed

TRC = Technical Review Committee.
Source: AEPC District Staff and community users (pers. comm.)

132. Construction of the Kuchai Khola HEP commenced in 2004 (according to information provided by members of the Users Committee), but this project was never completed because the generator was damaged during transport. The penstock, powerhouse building and electricity distribution lines have been abandoned (Figure 5.5). The Pelton turbine and other components

[31] REREAP social survey data, 2012
[32] UNDP, 2012. *Energy to Move Rural Nepal Out of Poverty: The Rural Energy Development Programme Model in Nepal*. UNDP, Alternative Energy Promotion Center. Kathmandu: UNDP, Alternative Energy and Promotion Center.

were found rusting in the roofless powerhouse building, while local people reported that some of the wooden electricity distribution poles had been stolen. Members of the Uttar Ganga Sani Veri Hydro Power Users Committee plan to construct a 100 kW HEP using private funding if the Sani Veri HEP is not installed.

Figure 5.5: Kuchai Khola HEP – disused penstock and powerhouse

5.2.12 Water Supply

133. The main water supply for Upallo Sera and Tallo Sera villages comes from a local hillside spring. Water is reticulated from the spring by a system of polyethylene and steel distribution pipelines to community taps in the villages. Water quality from these taps is good, but the quality of river and stream water for drinking is poor due to high levels of E. coli being common due to livestock in the catchment and the use of watercourses for village sanitation purposes.

5.2.13 Transport and Local Services

134. Access to the site is gained via a fair-weather (earth) road (part of the Mid Hill Highway) from Musikot, the headquarters of Rukum District, for the initial 35 km of the 60 km journey. This road is currently under construction and aims to connect Musikot to Burtibang in Baglung District. It is scheduled to be completed up to the project site by early 2013. Access from the road head to the project site is currently via foot access along a 25 km long trail, with goods transported to the project area by porter and mule.

135. There are four Government schools (in Ward 4, 7, 8 and 9) and three private boarding schools in Taksera VDC. A Health Post exists in Mahat VDC, while there are Sub-Health Posts in Taksera, Kol and Rangshi VDCs. Communication services in the project area consist of GSM and CDMA mobile telephony, while a solar-powered Very Small Aperture Terminal (VSAT) - based phone is located in Upallo Sera village. Each type of phone service is subject to regular

outages. The VSAT phone was reported to have temporary technical problems due to insufficient charge (pers. comm. - telephone owner).

5.3 Impacts and Mitigation Measures

5.3.1 Biophysical Impacts

Hydrology

136. The project will have no effect on Sani Veri Khola flows below the tailrace, either daily or seasonally, due to the run-of-river project operation (without water detention), but it will alter flows between the intake and the tailrace outlet by diverting water around this 950 m long stretch of the river throughout the year.

137. The existing average monthly flow rate in the Sani Veri Khola at the intake site is estimated to range between 13.6-56.6 m^3/s in the wet season (June to October) and 2.3-9.3 m^3/s in the dry season (November to May) (Table 5.8). These natural flows will be reduced by the diversion of 0.87 m^3/s (incorporating an allowance for losses through infiltration etc) through the powerhouse throughout the year (24 hours per day), reducing the average monthly river flow along the Sani Veri between the weir and tailrace outlet to between 62-98% of the natural flow rate.

Table 5.8: Average Monthly Sani Vera Khola Flow Rate – Existing and Project Operation

Month	Existing River Flow[1] (m^3/s)	Project Operation			
		Generation Diversion (m^3/s)	Environ. Release (m^3/s)	Dewatered Section Flow	
				(m^3/s)	% Existing Flow
Jan	5.43	0.87	0.23	**4.56**	**84**
Feb	4.08	0.87	0.23	**3.21**	**79**
Mar	2.94	0.87	0.23	**2.07**	**70**
Apr	2.26	0.87	0.23	**1.39**	**62**
May	5.89	0.87	0.23	**5.02**	**85**
Jun	13.58	0.87	0.23	**12.71**	**94**
Jul	32.83	0.87	0.23	**31.96**	**97**
Aug	56.60	0.87	0.23	**55.73**	**98**
Sept	37.36	0.87	0.23	**36.49**	**98**
Oct	18.11	0.87	0.23	**17.24**	**95**
Nov	9.28	0.87	0.23	**8.41**	**91**
Dec	7.02	0.87	0.23	**6.15**	**87**

1 – based on the Medium Irrigation Project (MIP) method of flow estimation, used in the absence of stream gauging apart from a single reading.
Source: *Feasibility Study of Sani Veri Mini Hydropower Project* (2010).

138. A compensation (or environmental or riparian) release of 0.23 m^3/s has been designed (10% of the average flow in the direst month - April) as the minimum flow to be released from the diversion weir to maintain the downstream aquatic ecosystem and water uses along the 950 m dewatered river section. In practice this flow will be much larger, consisting of the compensation release plus spill flows over the weir throughout the year. The minimum average monthly flow will be 1.39 m^3/s, occurring in April, the lowest flow month. This flow is equal to 62% of the average natural flow rate during this month.

139. Water quality will not be affected by generation diversion due to the short duration of the diversion, estimated at 20-30 minutes from the time the water enters the intake to the time it is released back into the river via the tailrace outlet (assuming an average velocity of 1 m/s plus detention time in the settling basin and forebay).

River Morphology

140. River morphology is expected to be marginally altered at the diversion weir site in the first 1-2 years following construction. The upstream pond created by the weir (up to 2 m deep) is expected to fill with coarse sediment in the first year of operation, creating a delta of sediment rising at a low grade upstream. Once the pond is full a new state of equilibrium will be reached and all river sediment and bed load material will flow over the weir and downstream at the natural rate.

141. Construction of the weir wing walls at both ends of the structure will anchor it into the embankment, while floodwalls will be provided upstream and downstream to guide high flood discharge away from the river banks towards the main course of the river, therefore weir operation is not expected to induce river bank erosion. The weir will have upstream and downstream aprons to protect the river floor from scouring and guide flows towards the desired path. Minor scouring will occur downstream of the apron but this will be filled with coarse sediment annually.

River Use

142. The diversion of 0.87 m^3/s of water for power generation around a 950 m stretch of the Sani Veri River (between the weir intake and tailrace outlet) has the potential to effect river uses along this river section in the driest month of the year when the average monthly flow will drop to 1.39 m^3/s in April, equivalent to 62% of the natural average flow rate during this month. For all other months of the year the average minimum monthly flow will be 2.07 m^3/s or greater, sufficient to supply the various river uses. Given that multiple river uses occur in this stretch (livestock water, fishing, sanitation, waste disposal, wool washing and water-powered mill operation), adequate water has to be provided to maintain essential uses without an undue decline in water quality.

143. The minimum flow of 1.39 m^3/s will be adequate to maintain sufficient water for livestock watering and mill operation as such mills typically require between 40-100 L/s (0.04-0.1 m^3/s) to operate[33]. Use of the river for sanitation purposes, waste disposal and wool washing will marginally reduce river water quality along this section of the river due to reduced dilution, but as this water is not used for human consumption the effect on existing water uses should be minimal.

Aquatic Ecology

144. The dewatering of 950 m of the Sani Veri River has the potential to affect fish movement, breeding and population in the river by:

[33] Eagle, N., 2000. *Nepal Ghatta Project*. (Massachusetts Institute of Technology, School of Architecture and Planning) Retrieved September 11, 2012, from MIT Media Lab: http://web.media.mit.edu/~nathan/nepal/ghatta/

(v) blocking fish migration (primarily upstream) by creating a barrier from the diversion weir;
(vi) dewatering a section of river between the diversion weir and tailrace outlet; and
(vii) altering fish habitat by creating a weir pond where sediment build-up will occur.

145. Long-distance fish migration primarily occurs during the monsoon when migratory species move upstream to spawn during high river flows in the monsoon season (mid-June to September) and migrate downstream to feed and grow in autumn (October-November) after river flows have decreased. Long-distance migratory species are unlikely to occur in this section of the river as their distribution has been compromised by the Girijapur Barrage located downstream on the Karnali River, 20 km inside India. In addition, long range migratory species are attracted upstream by strong river flows and are likely to favour other larger rivers than the Sani Veri.

146. The 2 m high concrete weir step may affect the upstream migration of some fish species, but downstream fish migration/movement is likely to remain largely unhindered. The only species that has been positively identified as occurring in the Sani Veri Khola, *Schizothorax plagiostomus* (Buchhe Asala), a short distance migratory fish. This species is known to jump up to 3 m in height, therefore it will be able to pass upstream over the weir. If the 350 km^2 catchment above the weir is inaccessible to some species that cannot pass upstream over the weir the loss of this habitat is considered to be a relatively minor impact due to the limited population of fish at these high elevations.

Land Use

147. Sub-project plant (excluding the mini-grid) is estimated to cover a total of 0.9 ha, based on the following assumed footprint dimensions (Table 5.9). This footprint consists of 0.73 ha of dryland cultivation, 0.14 ha of shrubland and 0.04 ha of riverine features (Table 5.10). In addition, the proposed 17.05 km long 11 kV overhead transmission line right-of-way (RoW) is estimated to cover 5.1 ha based on an assumed RoW width of 3.0 m.

Table 5.9: Project Land Area

Structure	Structure Dimensions	Assumed Footprint Dimensions[1]	Main Land Type	Land Area (ha)
Diversion weir, gravel trap	23 m long 2 m wide x 7 m long	30 m long x 10 m wide 5 m wide x 15 m long	Riverine deposits	0.04
Settling basin, sediment flushing channel	3 m wide x 25 m long 1 m wide x 15 m long	6 m wide x 25 m long 4 m wide x 15 m long	Cultivation	0.02
Headrace canal	10 m wide x 765 m long	10 m wide x 765 m long	Cultivation 83% Shrubland 17%	0.77
Forebay, overflow spillway	4 m wide x 17 m long	12 m wide x 27 m long	Cultivation	0.03
Penstock	1 m wide x 81 m long	3 m wide x 81 m long	Cultivation 64% Shrubland 36%	0.02
Powerhouse compound, tailrace outlet	10 m x 17 m 1 m wide x 17 m long	17 m x 10 m 5 m wide x 17 m long	Cultivation	0.03
Total				**0.91**

1 – assumed footprint dimensions include cut slopes and fill embankments.

Table 5.10: Land Use on Proposed Sani Veri HEP Sites

Land Use	Affected Area (ha)	Percentage of Total Area (%)
Dryland cultivation	0.73	80.2
Shrubland	0.14	15.4
Riverine features	0.04	4.4
Total	**0.91**	**100**

148. The 11 kV transmission line RoW (5.1 ha) and distribution line RoWs have not been included in this table as final alignments are yet to be selected. The land cover/use within the line RoWs that will be affected by line construction and operation is likely to include short sections of forest and shrubland where these features cannot be avoided, requiring clearing to establish safe electrical clearances between the line and standing vegetation.

149. Transmission and distribution line routes are yet to be finalized, but during detailed design they will: (i) follow trails wherever possible for ease of construction and maintenance; (ii) cross open and stable land where possible; (iii) avoid forest areas and large trees wherever possible; and (iv) avoid the Hunting Reserve. Any disused power lines that are serviceable and in the right location will be utilized. Forest and trees within the RoWs will be permanently removed.

150. The impact of the line on cultivated land will be minimal as pole sites will be located on the edge of fields wherever possible. Poles that have to be located within fields will create a minor obstruction, but given that cultivation will be permitted up to the base of the pole and all local cultivation is non-mechanical, this obstacle will have minimal impact on cultivation. Cultivation will be permitted within the RoW, but land use restrictions within the RoW will prohibit the construction of houses and other buildings in this easement, and restrict the height of trees.

151. Land for project facilities is proposed to be acquired from private landowners. In the event of project failure land ownership will be returned to the previous owner. In addition, the powerhouse site landowners will be given a project operation job to compensate for the loss of land.

Mitigation Measures

- Minimal land area will be utilized for permanent project structures, including power line RoWs and the establishment of stable cut batters and fill embankments.
- Transmission/distribution line routes will follow trails and avoid forest and shrubland wherever possible.
- Poles will be located on land with low economic value wherever possible and on the edge agricultural fields to avoid creating obstacles in plots.
- Temporary construction sites will be located on low value land where possible, and no temporary sites will be located on forested land.
- Cut batters and fill embankments will be established at stable grades, taking into account the soil type.
- Cut batters, fill embankments and all other disturbed areas will be revegetated to stabilize this land, including rehabilitating temporary sites to original condition.
- Care will be taken to avoid the disturbance of crops and other vegetation outside the land area required for permanent project sites.

Residual Impact
152. The total conversion of agricultural land will be limited to 0.73 ha of dryland cultivation, replaced by hydropower generation, a high value land use.

Terrestrial Ecology
153. **Flora:** project construction (excluding transmission and distribution lines) will involve the clearance of an estimated 0.14 ha of shrubland and planted willow saplings, primarily along a 120 m long section of the headrace canal. This small area of vegetation clearance is expected to be offset by forest regeneration that is predicted to indirectly result from the reduced harvesting of fuelwood in the area due to electricity supply partly replacing fuelwood use.

Forest and shrubland clearance is likely to be required to establish the transmission and distribution line RoWs, but this area of clearance cannot be estimated until alignments have been planned. Given that the alignments will follow trails and avoid vegetation where possible, the extent of clearance will be minimised.

Mitigation Measure
- Power line alignments will follow trails and avoid standing vegetation wherever possible.

154. **Fauna:** the direct project impact on terrestrial fauna will be minimal as the majority of the project sites (excluding transmission and distribution lines) are located in cultivation fields, with only 0.14 ha of shrubland clearance required. The headrace canal and other structures with open water will create a safety hazard for fauna. Canal sections close to houses will either be fenced with barbed wire and capped with concrete slabs to allow people and animals to cross. Poaching of wildlife by outside construction workers during project construction is a risk, but this will be prohibited as a condition of employment.

Mitigation Measures
- Construction workers from outside the area will be prohibited from hunting wildlife.

155. **Protected Area:** the supply of power to local villages is likely to indirectly reduce forest harvesting in the project area, including in nearby forests within Dhorpatan Hunting Reserve, as the 28% of households that currently use fuelwood for lighting are likely to replace this with electric lighting.

Materials Extraction and Spoil Disposal
156. Sand will be extracted from the Sani Veri River while rock will be quarried from rock outcrops (preferably existing local quarries) close to construction sites and a small volume excavated during project construction, used for construction material. The extraction of sand from the river will not have a noticeable impact due to the high volumes of coarse sediment that it transports annually.

157. The river bed and banks and hillslopes will be excavated to construct project facilities. The main sources of spoil will be the weir foundations, headrace canal, settling basin, forebay, and tailrace outlet, with smaller volumes of material coming from the intake channel, penstock foundations, powerhouse area and tailrace outlet. Spoil will mainly consist of subsoil, with a small volume of topsoil, rock and riverine deposits also generated.

158. Some of this material, mainly sub-soil, will be utilized to form project structures such as fill embankments for the headrace canal and forebay, while rock will be utilized if suitable for masonry works. An estimated 5,037 m^3 of excess spoil will remain after the construction of

project structures (Table 5.11) that will be disposed of near the sites where it is generated given that all works will be undertaken by hand and disposal at further sites is costly.

Table 5.11: Excess Spoil Volumes

Site	Excess Spoil Volume (m^3)
Intake weir, head works, gravel trap, spillway, canal	3,936
Settling basin	445
Forebay	411
Penstock	28
Powerhouse	109
Tailrace	108
Total	**5,037**

Source: Devkota (2010), revised by REREAP (2012).

159. Spoil disposal site selection will be based on avoiding environmental and social impacts (short and long term). Lower value land will be used wherever possible, such as riverside deposits, degraded or barren areas, and grassland. The use of cultivation land for spoil disposal will be avoided.

Mitigation Measures

- Construction material extraction will avoid river and slope destabilization.

160. Spoil disposal site planning will be finalized during the project pre-construction phase when disposal sites are identified with the community and landowners. Disposal sites will be selected based on:

- use of lower value land (avoidance of cultivation and other higher value sites);
- a minimum setback from watercourses; and
- preference for lower slope land.

161. Spoil management measures to be implemented will include:

- topsoil stripping and stockpiling separately from subsoil; and
- topsoil spreading and site revegetation of the final landform.

Waste Management

162. A small volume of waste will be generated during project construction and operation. Wastes will include cleared vegetation, construction and maintenance materials (e.g. scrap metal, sections of conductor, used oil, grease and paint), and domestic waste from the non-local construction and operation workforce (e.g. kitchen waste). Only small volumes of waste will be produced but they have to be managed and disposed of properly to ensure that they do not pollute soil and water resources or create health and safety hazards.

163. The proper disposal, reuse and recycling of wastes will prevent land degradation and health and safety hazards at project sites. As the construction and operation workforce will mainly consist of people residing locally, little additional waste will be generated by the workforce. Unskilled construction workers will come from nearby villages and therefore will remain housed in their own dwellings, while up to 17 skilled workers sourced from outside the

local area will stay in existing nearby hotels and houses, therefore no temporary workforce camps will be established.

Mitigation Measures

- Residual construction materials and waste will be collected, reused, recycled or disposed of safely, in accordance with standard and accepted practices.
- Biodegradable and non-hazardous domestic wastes generated by the outside workforce will be properly disposed of by burying in pits away from water sources and settlements.

Greenhouse Gas Savings

164. It is estimated that the annual generation of 1,839,600 kWh of electricity by the project will avoid the emission of 12.6 T/a CO_{2e} per annum from the burning of kerosene. This estimate is based on 73.31 kg of CO_2 emitted per MMBtu of energy consumed from the use of kerosene as an energy source[34].

5.3.2 Socio-Economic Impacts

Disruption to Local Services

165. The project will not permanently cut or disrupt any existing local services. No irrigation canals will be crossed by the headrace canal or other project structures. The water-driven mills along the dewatered section of the Sani Veri Khola will continue to be operable throughout the year despite reduced river flows, as described in Section 4.2.1. The new fair weather road under construction that runs approximately 80 m above the proposed powerhouse site will be unaffected by the project.

166. A number of local foot trails will be cut by headrace canal construction but most of these will be reinstated by capping the canal with concrete lids and installing permanent steps down cuttings and embankments. Other sections of the canal as well as the settling basin and forebay will be fenced with barbed wire.

Historic and Religious Sites

167. No historic or religious sites will be affected by project structures or project operation. There are no cremation ghats along the section of river to be dewatered.

Employment

168. An estimated 13 people will be employed to supervise project design and construction for an estimated total of 1,755 person-days. The construction workforce is likely to consist of 17 skilled and 114 unskilled staff, with an estimated 23,500 man-days of labour required. Project employment during operation will involve a project manager, 1-2 technical support staff, 2-3 unskilled laborers (guard and staff to occasionally clean the canal, an accountant and two electricity meter readers.

Project Revenue

169. The project will be community owned and operated, with electricity sold to end users through a metered system[35]. Revenue generated will be used to operate and maintain the system, including the employment of a full-time engineer to supervise these activities, and staff to assist with these activities and read electricity meters.

Electricity Provision and Use

[34] http://www.eia.gov/oiaf/1605/excel/Fuel%20Emission%20Factors.xls

[35] AEPC – pers. comm.

170. An estimated 6,375 people residing in 1,500 households in two VDCs will receive electricity supply from the project. The main benefits of an improved power supply will be:

(i) improved house illumination;
(ii) the option to run a range of household appliances such as a refrigerator, television and radio;
(iii) operation of community facilities such as street lighting; and
(iv) greater business opportunities, such as a sawmill and electric sewing.

171. Local institutions that will be connected to project electricity supply will include four schools in Taksera VDC and a health post. Local businesses likely to utilize project electricity include a saw mill (currently diesel-powered), furniture shop and hotel in Kol VDC. It is anticipated that several additional furniture making enterprises will establish once power is available given the local demand for furniture, but this will be up to local initiatives.

Reduced Energy Cost
172. 20% of the project installation cost will be provided by the community, most likely in the form of labour, with the remaining cost met by the Government. Households will also pay for the connection of electricity from the distribution line their dwelling. A one-off equity capital contribution of NPR 10,000/household will be charged to households connecting to the project that will be used to establish the project maintenance fund. On-going project running costs will primarily be met by user households and businesses, with support sought from charities to reduce these costs.

173. The total monthly household energy cost spent on fuelwood, kerosene, home solar systems and tukimara is predicted to decrease once households commence using project electricity. The monthly hydropower project running cost (operation and maintenance cost) that will be charged to each household is estimated to be less that NPR 300/household[36]. It is assumed that the following household energy uses will be replaced by project electricity: solar home systems in 66.1% of households (around NRS 167/month), fuelwood for lighting in 26.4% of households (at around NRS 1,400/month[37]), kerosene in 6.2% of households (at around NRS 330/month) and tukimara in 1.3% of households (around NRS 135/month/). Based on this there is likely to be a cost saving per household, with the amount saved based on the current uses that will be replaced.

Safety
174. **Drowning:** open water structures pose a hazard to people and livestock. The headrace canal, with a width and depth of 1 m x 1 m and a flow velocity of 1.5 m/s, will pose a safety hazard to very young children. The deeper and broader gravel trap, settling basin and forebay will pose a hazard to children and adults who cannot swim as each of these structures is between 2.5-3.5 m deep with vertical sides.

Mitigation Measures

- Foot paths/trails cut by the headrace canal will be reinstated by laying concrete lids over the canal, while the canal will also be capped in other areas of high pedestrian traffic (e.g. near a village).

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[36] REREAP Economist – pers. comm.

[37] UNDP, 2012. *Energy to Move Rural Nepal Out of Poverty: The Rural Energy Development Programme Model in Nepal*. UNDP, Alternative Energy Promotion Center. Kathmandu: UNDP, Alternative Energy and Promotion Center.

- The gravel trap, settling basin and forebay will be fenced to prevent access to these structures.
- A trash rack will be fitted to the forebay in front of the penstock intake that will prevent people or animals being drawn into the penstock.

175. **Electrocution:** electrocution can occur from contact with switchyard gear/transformers/live conductors, flashover from a conductor to a pole or vegetation, and conductor breakage. Electrical safety will be built into the project by:

- maintaining minimum vertical clearances between the conductors and the ground and structures;
- fitting lightning arrestors on the high voltage side of each transformer
- grounding each high tension pole; and
- earthing all other necessary components.

176. Lightning arrestors will be fitted on poles at intervals of approximately 300 m to protect electrical appliances from high current. The arrestors consist of 45 cm tubes earthed to the ground via a wire.

Mitigation Measures

- Transmission and distribution lines will strictly adhere to electrical safety setbacks as set out in the Nepal Electricity Regulation (1993). For power lines from 230/400 V up to 11 kV the minimum distance from the line to a house or tree is 1.25 m, while minimum clearance between the ground and the line is 4.6 m.
- No houses or other buildings will be permitted within the RoW, with existing houses and other structures relocated outside the RoW.
- Awareness programs on safety will be conducted for project staff and local residents at key locations in the project area.

6. SIMRUTU HYDROPOWER SUB-PROJECT

177. This assessment of the likely environmental and social impacts of the proposed Simrutu MMH is based on: (i) *Feasibility Study of Simritu Mini Hydro Project*[38]; (ii) an inspection of the proposed project sites; (iii) a social survey of some local households that will benefit from project power supply; and (iv) the ADB REREAP Technical Report.

6.1 Project Description

178. The 200 kW Simrutu MMH is a small run-of-river type hydropower project located on the Simruth Khola in Rugha and Balackhi VDC, Rukum District, western Nepal. It is designed to provide power to 89 villages/household cluster/settlements (Table 6.1) in four VDCs (Rugha, Khara, Muru and Balackchi), servicing an estimated 1,386 households. The project is designed to will generate around 1,122,000 kWh energy per annum.

[38] AEPC, 2010. *Simrutu Mini Hydropower Project Rukum,* Nepal. Kathmandu: AEPC.

Table 6.1: Villages to be Supplied by the Project

VDC	Villages
Rugha-1	Kalleri, Bhedakharka, Pipalbot, Pahalpun, Top Bdr, Damai Tole, Sindbang, Sanchaur, Mavi School, Kamitole.
Rugha-2	Simrutu, Gosaidanda, Barkhetakura, Danda, Jumlepokheri.
Rugha-3	Chendanda, Puntole, Hemanta, Jokh, Kamitole
Rugha-4	Khaltakura, Gharighar, Paiyubot, Jethabajya, Khalekhani, Bedkhola, Sanekhark, Bichgaun, Badaure.
Rugha-5	Chinchare, Unchaur, Areledanda, Berbot Panigaira, Subegaira tole, Pundera, Chortole, Gaireneta, Jorpokhari, Badarpani, Lasune, Okharidanda, Budathokitole.
Rugha-6	Dahsbage, Chera, Phulika, Pakha, Pakha, Lagra,lek, Gothchaune
Rugha-7	Karagaun, Bahuntole, Tersabat, Gharigaun
Rugha-8	Pakha,Risamja,Kimugaira,Boksithala,Jepale,Mukhyatat,Kaphalgaira,Ghartidera, Khatridera
Rugha-9	Ballejura,Gamthalicaur,Kamare, Thulekhor, Dholendanda, Ijra, Boheredera, Balushshi,Jukepani, Bherikhola
Bhalakchi-7	Khanikholagaun, Gothbang,Ghorneti,Jaharya
Bhalakchi-8	Siari,Chotdanda, Lamidanda, Khanikhola
Khara-1	Mali Bachhi, Kulsiban,KunbariB
Khara-7	Jiban
Muru-4	Dopka, Rthen, Murukurl

Source: AEPC, 2010.

179. The project was initiated by the residents of Rugha VDC who made representation to AEPC. These residents subsequently formed the Simrutu Khola Small Hydro Power Users Committee to develop the project.

180. The main project structures are a 2 m high diversion weir, settling basin, 1,134 m long headrace canal, forebay, penstock, powerhouse and tailrace outlet channel, with 50.4 m net head. Power will be transmitted to villages via a single circuit 11 kV overhead transmission line (7 km) that will connect the powerhouse step-up substation switchyard to various distribution substations. The distribution substations will connect to consumers' premises via 230/400 V and 400 V overhead lines totaling 7 km in length.

6.2 Description of the Environment

6.2.1 Physiographic Region, Topography and Drainage

181. The proposed Simrutu MMH site is located at Rugha VDC in the Middle Hills physiographic region at an elevation of 1,100 m asl, in Rukum District, Mid-Western Development Region. Topography in the project area consists of deep river valleys that generally drain to the south, (however this river and its tributaries flow to the north to meet Thuli Veri River approximately 9.3 km downstream), rising in elevation from the valley floor to the adjoining ridges by 1,600 (up to 2,700 m asl). Side slopes are steep, generally between 15-35o.

182. The project has a 45 km^2 catchment. The Simrutu Khola and its tributaries drain to the north into the Thuli Bheri River approximately 9 km downstream of the tailrace outlet site. The Thuli Bheri River flows into the Bheri River which then discharges into the Karnali River.

6.2.2 Climate

183. Simrutu Bazaar has a warm temperate climate, primarily due to its elevation at 1,100 m asl. The area experiences strong seasonal climatic variations, with the monsoon from June to September and dry weather from October to May.

184. The project area has a mean maximum temperature of 28.8°C in June and mean minimum temperature of -2.2°C in January (DHM, 2012)[39]. Rainfall data obtained from Department of Hydrology and Meteorology (DHM) for rainfall stations at Rukumkot (located 17.8 km to the east at 1,560 m asl) for 1987-2011 and Sheragaun (located 38 km to the east at 2,150 m asl) for 1987-2000 indicate average monthly rainfall varying from 16.1 mm in December to 465.4 mm in July, with 86% falling from May to September (Table 6.2).

Table 6.2: Average Monthly Rainfall - Rukumkot (1986-2011) and Shera Gaun (1986-2000)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rukumkot (mm)	29.1	43.4	38.9	69.5	134.2	298.6	529.0	473.3	182.9	35.2	13.3	14.7
Shera Gaun (mm)	31.8	42.6	51.5	50.7	95.5	209.5	356.3	384.8	167.8	40.8	16.7	19.0

Source: DHM, Kathmandu, Nepal.

6.2.3 River Hydrology

185. The Rugha and Khara Khola of Simrutu drains northwards through a steep sided valley, flowing into the larger Thuli Veri River approximately 9 km downstream of the project tailrace site . The river bed is steep at around 3.1^{o} slope. The project catchment forms part of the upper reaches of the Thuli Veri basin. One local stream flows into the Simrutu in the Project area. A small stream, Muru Khola, enters the river approximately 100 m downstream of the diversion weir site on the left bank, on the outskirts of Simruth bazaar. .

186. The estimated average monthly flow rate of the Simruth (Rugha and Khara Khola) ranges from a low of 0.36 m^3/s in March during the dry season, up to a peak of 6.18 m^3/s in August during the monsoon (Table 6.3). 85% of river flows by volume occur in the monsoon season from June to September when there is the potential for flash flooding and riverbed scouring. Flooding during the monsoon is common, and locals informed of a flood that cause loss of property and life a few years back.

Table 6.3: Estimated Mean Monthly Simrutu Khola Flow Rate

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flow (m^3/s)	0.56	0.45	0.36	0.32	0.55	1.57	4.43	6.18	4.45	2.05	0.94	0.66

1 – based on the Medium Irrigation Project (MIP) method of flow estimation, used in the absence of stream gauging apart from a single reading.
Source: *Feasibility Study of Simruth Mini Hydropower Project* (2010) and Sitara Consult Pvt Ltd. and Engineering and Educational Services P. Ltd. & Energy Development Services P. Ltd. JV, AEPC/ESAP.

[39] DHM, 2012. Meteorological Electronic Data. Department of Hydrology and Metrology, Nepal, Kathmandu,.

6.2.4 Geology, Site Stability and Soils

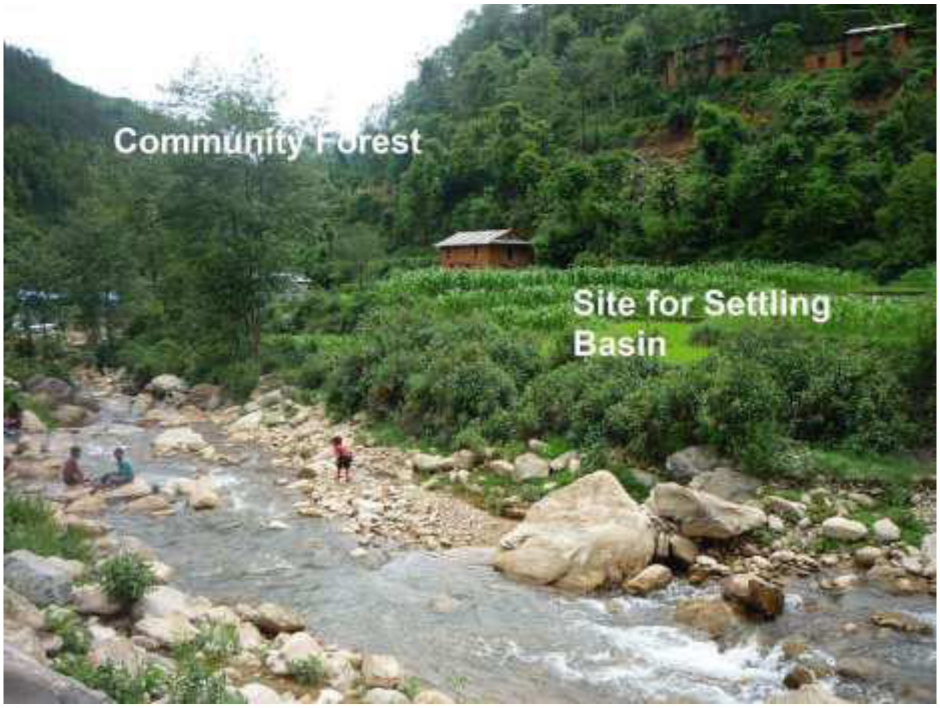
187. Site geology consists of Lesser Himalayan Metasediments. The river flows along the Kuncha Group. This Group consists of Precambrian. Mainly of flyschoid sequence (bedded schists, phyllites and metasandstones), locally shallow water quartzite beds and basic sills and dykes. The ridges on the south the river bank consist of Tertiary of Tansen Group. The main soil types found at the site are Dystrochrepts, Haplumbrepts, and Rhodustalfs.

6.2.5 Land Use

188. The main land use types in the project area are grazing on grasslands and in forest areas, wetland cultivation on areas close to the rivers, dryland cultivation on small areas of flatter riverside land and on terraced hillslopes, and forest harvesting for timber, fuelwood and non-timber forest products (Figures 6.1 and 6.2).

Figure 6.1: Simrutu Project Layout

Figure 6.2: Simrutu Settling Basin Site and Adjacent Community Forest



189. Agriculture and livestock rearing are the main livelihood sources in area. The main local crops are paddy, maize grown in summer, and wheat, millet and barley grown in winter, together with potatoes, grown as a single crop on non-irrigated fields. Most dwellings are in scattered settlements (Figure 6.3) where household gardens are cultivated for vegetables such as pumpkin, potatoes, beans and tomatoes. The main livestock are goats, while cattle are also raised.

Figure 6.3: Settlements at Simrutu Bazaar

190. Shiru Danda Community Forest lies adjoining local settlements next to project sites, while large cultivated land border along the right bank of the Simrutu Khola. A large section of this Lower Temperate Oak forest will be crossed by a 585 m long section of the headrace canal approximately 100 m downstream of the intake.

191. One registered community forest is located in the project area: Shiru Danda Community Forest in Ward 2, Rugha VDC – 50.78 ha supporting 61 households. This forest lies immediately next to the settlement. The forest has around 50% canopy cover, with the main species being *Quercus lanata* (Banjh), *Quercus leucotrichophoral* (Banjh), *Quercus glauca* (Phalat), *Pinus roxburghii* (Khote Salla), *Alnus nepalensis* (Uttis) and *Engelhardia spicata* (Mauwa). This forest is rich in non-timber forest products that include Amriso, Cardamom (Alinchi), *Zanthoxylum armatum* (Timur), *Eulaliopsis binata* (Babiyo), *Viburnum mullaha* (Mahelo), *Berberis chitria* (Chutro), *Rubus ellepticus* (Aainselu) and *Pyracantha crenulata* (Ghangaru) that are harvested by local people.

6.2.6 River Use

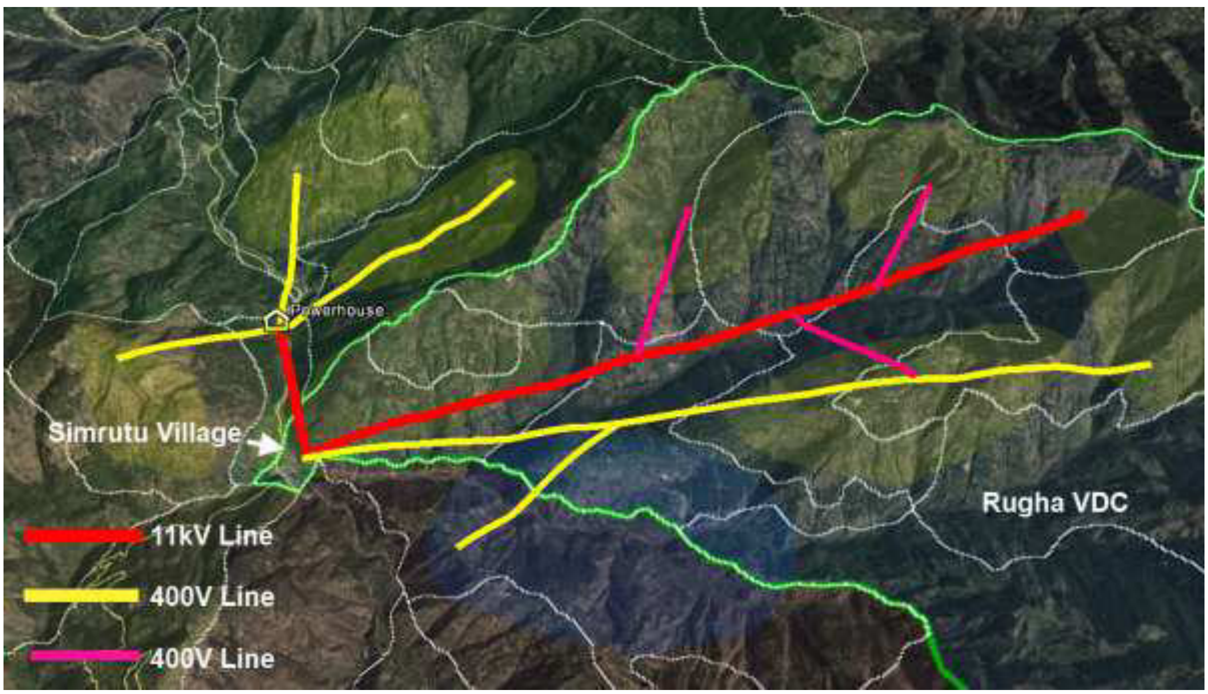
192. The 1.2 km stretch of the Simrutu Khola that will be partly dewatered by the project is used by a local riverside village, Simrutu Bazaar. Uses along this river section include livestock water, fishing, sanitation, waste disposal, festival bathing at the confluence and powering two water mills. The mills are used for grind grain and are located approximately 30 m from the desander basin and 70 m upstream of the powerhouse site. The river is also used for Simrutu Bazaar's waste disposal, at the Muru Khola confluence.

6.2.7 Terrestrial Ecology

193. The proposed project site situated on the right bank of Simrutu River valley in between steep mountains slopes at an altitude of 1,100 m. Settlements and cultivated land are close to the river, with forests and grassland on steep hill and mountain slopes. Forest cover consists of Nepalease Alder (*Alnus nepalensis*), Pine (*Pinus roxburghii*), Hill Sal (*Shorea robusta*) and Oak (*Quercus* sps) with 50% of canopy cover. Major animal species found in the forest include *Martef Flabigula* (Malsapro), Dhukur, Kalij, Titri, Kalikalchu, Hare, *Canis aureus* (Syaal) and snakes.

194. The nearest protected area from the site is Dhorpatan Hunting Reserve. Its western boundary is at an aerial distance of 31 km north east of the project site.

Figure 6.4: Location of Simrutu Mini-Grid



6.2.8 Aquatic Ecology

195. Local people reported the presence of the fish species Asala (*Schizothorax*), Karenge (*Puntius chilinoides*), Jhoja and Gadela (*Nemasheilus* spp.), as well as Genda (a small frog) and crabs. No surveys of the Rugha and Khara River aquatic ecosystem near the project site are known to have been done in the past, but the Sani Veri downstream of this project site was surveyed at 915 m asl (around 10.7 km downstream of the site). The only species identified in that survey was *Schizothorax plagiostomus* (Buchhe Asala)[40], classified as a Vulnerable

[40] Shrestha, J., 1995. *Enumeration of Fishes of Nepal.* The Netherlands: HMGN, Euroconsult Arnhem.

species under the Nepal Biodiversity Resource Book[41]. This short distance migratory species has a reported range of 345-3,323 m asl[42].

6.2.9 VDC and Project Area Profile

196. The four VDCs that will receive electricity from the project have a total population of 18,063 (Table 6.4)[43], with an average household size of 5.2. Of these, an estimated 1,386 households will benefit from the project out of the total 3,454 total households in these four VDCs.

Table 6.4: VDC Population

VDC	Population				Total Households	Household Size
	Male	Female	Total	Sex Ratio		
Rugha	1,924	2,309	**4,233**	83%	**805**	5.3
Khara	2,763	3,423	**6,186**	81%	**1,113**	5.6
Muru	1,805	2,126	**3,931**	85%	**788**	5.0
Balakchi	1,683	2,030	**3,713**	83%	**748**	5.0
Total	**8,175**	**9,888**	**18,063**	**-**	**3,454**	**5.2**

Source: Population Census, 2011, CBS.

197. The dominant ethnic group in the four project VDCs are Chettris, comprising 80% of the total VDC population. Other major groups are Magar (22%) and Dalit (8%) (Table 6.5).

Table 6.5: Ethnic Composition by VDC

VDC	Population							
	Chhetri	Brahmin (Hill)	Dalit	Gurung (Janjati)	Thakuri	Sanyasi	Magar (Janajati)	Others
Rugha	2,411	199	352	384	29	0	723	43
Khara	4,451	0	597	0	0	0	253	125
Muru	2,498	0	22	0	0	0	1,035	13
Balakchi	2,394	28	159	10	0	0	1,196	620
Total	**11,754**	**227**	**1,130**	**394**	**29**	**0**	**3,207**	**801**

Source: Population Census, 2001.

198. Relative to other communities in Nepal, local women have greater power in family decision making, particularly given that most males of working age go abroad for work or education. Most water collection, fuelwood and fodder gathering activities are undertaken by women, with men undertaking most of the ploughing.

6.2.10 Livelihoods

199. Subsistence agriculture, consisting of livestock raising and rainfed cultivation, is the main livelihood earning activity in the project area. However, some households depend upon multiple

[41] ICIMOD, 2007. *Nepal Biodiversity Resource Book.* International Centre for Integrated Mountain Development (ICIMOD), Ministry of Environment, Science and Technology (MOEST), Government of Nepal (GoN). Kathmandu, Nepal..

[42] Shrestha, J., 1995. *Enumeration of Fishes of Nepal.* The Netherlands: HMGN, Euroconsult Arnhem.

[43] Population Census, 2011

occupations such as wage labour, service provision and petty businesses to earn their livelihood.

200. Agricultural land and livestock holdings of households in Rugha VDC are summarised in Table 6.6. Ownership of agricultural land is common, with 98% of households reporting ownership. Livestock are also owned by most households, used for subsistence and income generation.

Table 6.6: Ownership of Agricultural Land and Livestock in Project Area VDCs

VDC	Households Owning (%)				Total Households
	Agricultural Land Only	Land and Livestock	Land, Livestock and Poultry	Other	
Rugha	11	56	605	31	703
Khara	10	49	810	23	892
Muru	15	22	555	13	605
Balakchi	29	24	589	11	653

Source: Population Census, 2001.

201. The main source of income of many households is the remittances provided by male household members working elsewhere in Nepal or in foreign jobs.

6.2.11 Energy Supply and Use

202. The main sources of energy in the project VDCs were reported to be: fuelwood for cooking and heating (100% of households); home solar power for lighting (57%); kerosene for lighting (17%); and battery light (Tukimara) (26%) (REREAP social survey data, 2012). Discussions with local users indicate that fuelwood costs NRS 4/kg, household kerosene use costs around NRS 330/month (3 L by NRS 110/L), household solar power system costs around NPR 167/month (NRS 2,000/year), and a tukimara LED light costs around NRS 333-417/month (NPR 4,000-5,000/year).

203. There is already a distribution line at Simrutu Bazaar from a nonoperational micro hydro power plant (Photo). This power plant ceased to operate as the forebay was destroyed while constructing an Earthen Road to Simrutu. Currently the power house site (close to the proposed headrace canal alignment) is being used as a church. Even though the locals are using solar at their home they have bigger demands for electricity use and are eager to have the system installed. According to 2001 census data Rukum is among the eight least developed districts[44].

6.2.12 Water Supply

204. The main water supply for Simrutu Bazaar comes from a local hillside spring. Water is reticulated from the spring by a system of polyethylene and steel distribution pipelines to community taps in the villages. Water quality from these taps is good, but the quality of river and stream water for drinking is poor due to high levels of *E. coli* being common due to livestock in the catchment and the use of watercourses for village sanitation purposes.

[44] ICIMOD, 2003. *Districts of Nepal, Indicators of Development Update*. Kathmandu, Nepal: ICIMOD and CBS.

6.2.13 Transport and Local Services

205. Access to the site is gained via a fair-weather (earth) road from Musikot, the headquarters of Rukum District, for the 13 km journey. Access from the road head to the project site is currently via foot access along a 200 m trail, with goods transported to the project area by porter and mule.

206. There are eight Government schools in Rugha VDC. A Health Post exists in Rugha VDC, while there are Sub-Health Posts in Muru, Khara and Balakchi VDCs. Communication services in the project area consist of GSM and CDMA mobile telephony, Each type of phone service is subject to regular outages.

6.3 Impacts and Mitigation Measures

6.3.1 Biophysical Impacts

Hydrology

207. The project will have no effect on Simrutu (Rugha and Khara) Khola flows below the tailrace outlet, either daily or seasonally, due to the run-of-river project operation (without water detention), but it will alter flows between the two intakes and the tailrace outlet by diverting water around a 1,200 m long stretch of the river throughout the year.

208. The existing average monthly flow rate in the Simrutu (Rugha and Khara) Khola at the intake site is estimated to range between 1.27-5.3 m^3/s in the wet season (June to October) and 0.21-0.86 m^3/s in the dry season (November to May) (Table 6.7). These natural flows will be altered by the diversion of up to 0.5 m^3/s (incorporating an allowance for losses through infiltration etc) through the powerhouse when sufficient natural flow is available, reducing the average monthly river flow along the Simrutu between the weir and tailrace outlet. From May to December the diversion is likely to be 0.5 m^3/s. From January to April the average monthly river discharge rate is less than the plant design discharge rate, therefore turbines will be run at less than the design discharge, down to the minimum operating discharge of 0.1 m^3/s for a single turbine. Below this rate no generation will occur, with the entire river flow released over the weir.

Table 6.7: Average Monthly Sani Vera Khola Flow Rate – Existing and Project Operation

Month	Existing River Flow[1] (m^3/s)	Project Operation			
		Generation Diversion[2] (m^3/s)	Environ. Release (m^3/s)	Dewatered Section Flow	
				(m^3/s)	% Existing Flow
Jan	0.56	0.50	0.05	0.06	**11**
Feb	0.45	0.40	0.05	0.05	**11**
Mar	0.36	0.31	0.05	0.05	**14**
Apr	0.32	0.27	0.05	0.05	**16**
May	0.55	0.50	0.05	0.05	**9**
Jun	1.57	0.50	0.05	1.07	**68**
Jul	4.43	0.50	0.05	3.93	**89**
Aug	6.18	0.50	0.05	5.68	**92**
Sept	4.45	0.50	0.05	3.95	**89**

Oct	2.05	0.50	0.05	1.55	**76**
Nov	0.94	0.50	0.05	0.44	**47**
Dec	0.66	0.50	0.05	0.16	**24**

1 – based on the Medium Irrigation Project (MIP) method of flow estimation, used in the absence of stream gauging apart from a single reading.
2 – it is assumed that the generation flow in the direst months (January-April) will be the natural flow minus the environmental release.
Source: *Feasibility Study of Simrutu Mini Hydropower Project* (2010).

209. A compensation (or environmental or riparian) release of 0.05 m^3/s has been designed (equivalent to 16% of the average flow of the direst month - April) as the minimum flow to be released from the diversion weir to maintain the downstream aquatic ecosystem and water uses along the 1,200 m dewatered river section down to the tailrace outlet. However, approximately 100 m downstream from the intake site the Muru Khola tributary flows into the dewatered stream section, a stream of similar size to each of the diverted streams, thus increasing the stream flow along most of the dewatered reach.

210. Water quality will not be affected by generation diversion due to the short duration of the diversion, estimated at 20-30 minutes from the time the water enters the intake to the time it is released back into the river via the tailrace outlet (assuming an average velocity of 1 m/s plus detention time in the settling basin and forebay).

River Morphology

211. River morphology is expected to be marginally altered at the diversion weir site in the first 1-2 years following construction. The upstream pond created by the weir (up to 2 m deep) is expected to fill with coarse sediment in the first year of operation, creating a delta of sediment rising at a low grade upstream. Once the pond is full a new state of equilibrium will be reached and all river sediment and bed load material will flow over the weir and downstream at the natural rate.

212. Construction of the weir wing walls at both ends of the structure will anchor it into the embankment, while floodwalls will be provided upstream and downstream to guide high flood discharge away from the river banks towards the main course of the river, therefore weir operation is not expected to induce river bank erosion. The weir will have upstream and downstream aprons to protect the river floor from scouring and guide flows towards the desired path. Minor scouring will occur downstream of the apron but this will be filled with coarse sediment annually.

River Use

213. The diversion of around 0.27-0.50 m^3/s of water for power generation around a 1,200 m stretch of the Simrutu River (between the weir intake and tailrace outlet) has the potential to affect stream uses along this section in the driest months of the year when the average monthly flow will drop to between 0.05-0.16 m^3/s in from December-May, equivalent to 9-24% natural average monthly flow rate. For all other months of the year the average monthly flow rate will be 0.44 m^3/s (47% of the natural flow rate in November) or greater, sufficient to supply the various river uses. Given that multiple river uses occur in this stretch (livestock water, fishing, sanitation, waste disposal and water-powered mill operation), adequate water has to be provided to maintain essential uses without an undue decline in water quality.

214. The minimum flow of 0.15 m^3/s will be adequate to maintain sufficient water for livestock watering and mill operation as such mills typically require between 40-100 L/s (0.04-0.1 m^3/s) to operate[45]. Use of the river for sanitation purposes, waste disposal and washing will marginally reduce river water quality along this section of the river due to reduced dilution, but as this water is not used for human consumption the effect on existing water uses should be minimal. However, the stretch of 100 m between the intake site and confluence of Muru Khola will be affected for five months (January to May).

Aquatic Ecology

215. The dewatering of 1,200 m of the Simrutu Khola has the potential to affect fish movement, breeding and population in the river by:

(i) blocking fish migration (primarily upstream) by creating a barrier from the diversion weir;
(ii) dewatering a section of river between the diversion weir and tailrace outlet; and
(iii) altering fish habitat by creating a weir pond where sediment build-up will occur.

216. Long-distance fish migration primarily occurs during the monsoon when migratory species move upstream to spawn during high river flows in the monsoon season (mid-June to September) and migrate downstream to feed and grow in autumn (October-November) after river flows have decreased. Long-distance migratory species are unlikely to occur in this section of the river as their distribution has been compromised by the Girijapur Barrage located downstream on the Karnali River, 20 km inside India. In addition, long range migratory species are attracted upstream by strong river flows and are likely to favour much larger rivers than the Simrutu Khola.

217. The 2 m high concrete weir step may affect the upstream migration of some fish species, but downstream fish migration/movement is likely to remain largely unhindered. The only species that has been positively identified as occurring in the local river system is *Schizothorax plagiostomus* (Buchhe Asala), a short distance migratory fish identified in the Sani Veri Khola at 915 m asl. This species is known to jump up to 3 m in height, therefore it will be able to pass upstream over the weirs if it moves along the Simrutu Khola. If the 45 km^2 catchment above the weirs is inaccessible to some species that cannot pass upstream over the weir the loss of this habitat is considered to be a relatively minor impact due to the small size of the streams and hence limited population of fish.

Land Use

218. The project is estimated to cover a total of 0.78 ha, based on the following assumed footprint dimensions (Table 6.8). In addition, the proposed 14 km long overhead distribution line (230/400 and 11 kV) right-of-ways (RoW) are estimated to cover 4.2 ha based on a RoW width of 3.0 m.

Table 6.8: Project Land Area

Structure	Structure Dimensions	Assumed Footprint Dimensions[1]	Main Land Type	Land Area (ha)
Diversion weir, gravel trap	10 m long 1 m wide x 2.5 m long	138 m long x 29 m wide 3 m wide x 39 m long	Riverine deposits	0.41
Approach canal	1 m wide x 47 m long	1 m wide x 47 m long	Cultivation	0.02

[45] Eagle, N., 2000. *Nepal Ghatta Project*. (Massachusetts Institute of Technology, School of Architecture and Planning) Retrieved September 11, 2012, from MIT Media Lab: http://web.media.mit.edu/~nathan/nepal/ghatta/

Settling basin, sediment flushing channel	3 m wide x 20 m long 1 m wide x 15 m long	7 m wide x 20 m long 4 m wide x 15 m long		
Headrace canal	0.9 m wide x 1,134 m long	2.5 m wide x 1,136 m long	Forest 77% Shrubland 23%	0.28
Forebay, overflow spillway	2.5 m wide x 6 m long	5 m wide x 6 m long	Forest	0.02
Penstock	0.5 m wide x 132 m long	3.1 m wide x 112 m long	Forest	0.03
Powerhouse compound,	8 m x 12.8 m 0.9 m wide x 28 m long	8 m x 12.8 m 3 m wide x 35 m long	Cultivation	0.02
Total				**0.78**

1 – assumed footprint dimensions include cut slopes and fill embankments.

219. The project footprint consists of 0.04 ha of dryland cultivation, 0.06 ha of shrubland, 0.27 ha of forest and 0.41 ha of riverine features (Table 6.9).

Table 6.9: Land Use on Proposed Simrutu MMH Sites

Land Use	Affected Area (ha)	Percentage of Total Area (%)
Cultivation	0.04	5.1
Forest	0.27	34.6
Shrub land with scattered trees	0.06	7.7
Riverine features	0.41	52.6
Total	**0.78**	**100**

220. The 11 kV transmission line RoW (3.0 m wide by (i) 7 km 11 kV and (ii) 7 km 230/400V = 4.2 ha) and distribution line RoWs have not been included in this table. The land cover/use within the line RoWs that will be affected by line construction and operation is likely to include short sections of forest and shrubland where these features cannot be avoided, requiring clearing to establish safe electrical clearances between the line and standing vegetation.

221. Transmission and distribution line routes are yet to be finalized, but during detailed design they will: (i) follow trails wherever possible for ease of construction and maintenance; (ii) cross open and stable land where possible; (iii) avoid forest areas and large trees wherever possible; and (iv) avoid the Hunting Reserve. Any disused power lines that are serviceable and in the right location will be utilized. Forest and trees within the RoWs will be permanently removed, while branches on nearby trees will be lopped to provide the required setback.

222. The impact of the line on cultivated land will be minimal as pole sites will be located on the edge of fields wherever possible. Poles that have to be located within fields will create a minor obstruction, but given that cultivation will be permitted up to the base of the pole and all local cultivation is non-mechanical, this obstacle will have minimal impact on cultivation. Cultivation will be permitted within the RoW, but land use restrictions within the RoW will prohibit the construction of houses and other buildings in this easement, and restrict the height of trees.

223. Private land required for project facilities is proposed to be acquired from landowners. In addition, the powerhouse site landowners will be given a project operation job to compensate for the loss of land. In the event of project failure land ownership will revert to the previous owner.

Mitigation Measures

- Minimal land area will be utilized for permanent project structures, including power line RoWs and the establishment of stable cut batters and fill embankments.
- Transmission/distribution line routes will follow trails and avoid forest and shrubland wherever possible.
- Poles will be located on land with low economic value wherever possible and on the edge agricultural fields to avoid creating obstacles in plots.
- Temporary construction sites will be located on low value land where possible, and no temporary sites will be located on forested land.
- Cut batters and fill embankments will be established at stable grades, taking into account the soil type.
- Cut batters, fill embankments and all other disturbed areas will be revegetated to stabilize this land, including rehabilitating temporary sites to original condition.
- Care will be taken to avoid the disturbance of crops and other vegetation outside the land area required for permanent project sites.

Residual Impact

224. The total conversion of agricultural land will be limited to 0.04 ha of dryland cultivation, replaced by hydropower generation, a high value land use.

Terrestrial Ecology

225. **Flora:** project construction (excluding transmission and distribution lines) will involve the clearance of an estimated 0.27 ha of forest and 0.06 ha of shrubland, primarily along a 585 m long section of the headrace canal, forebay and penstock.

226. Forest and shrubland clearance is likely to be required to establish the transmission and distribution line RoWs, but this area of clearance cannot be estimated until alignments have been planned. Given that the alignments will follow trails and avoid trees and shrubs where possible, the extent of clearance will be minimised.

Mitigation Measure

- Power line alignments will follow trails and avoid standing vegetation wherever possible.

227. **Fauna:** the direct project impact on terrestrial fauna will be minimal as the majority of the project sites (excluding transmission and distribution lines) are located in lower boundary of community forest, with only 0.27 ha of forest clearance required. The headrace canal and other structures with open water will create a safety hazard for fauna. Canal sections close to houses will be fenced The canal section close to household will be fenced through barbed wire and capped with concrete slabs to cattle to cross over. Poaching of wildlife by outside construction workers during project construction is a risk, but this will be prohibited as a condition of employment.

Mitigation Measures

- Outside construction workers will be prohibited from hunting wildlife.

Materials Extraction and Spoil Disposal

228. Sand will be extracted from the Simrutu Khola for project construction purposes, while rock will be quarried from rock outcrops (preferably existing quarries) close to construction sites and a small volume excavated during project construction, used for construction material. The

extraction of sand from the river will not have a noticeable impact due to the high volumes of coarse sediment that it transports annually.

229. The river bed and banks and hillslopes will be excavated to construct project facilities. The main sources of spoil will be the weir foundations, headrace canal, settling basin, forebay, and tailrace outlet, with smaller volumes of material coming from the intake channel, penstock foundations, powerhouse area and tailrace outlet. Spoil will mainly consist of subsoil, with a small volume of topsoil, rock and riverine deposits also generated.

230. Some of this material, mainly sub-soil, will be utilized to form project structures such as fill embankments for the headrace canal and forebay, while rock will be utilized if suitable for masonry works. An estimated 2,448 m^3 of excess spoil will remain after the construction of project structures (Table 6.10) that will be disposed of near the sites where it is generated given that all works will be undertaken by hand and disposal at further sites is costly.

Table 6.10: Excess Spoil Volumes

Site	Excess Spoil Volume (m^3)
Intake weir, head works, gravel trap, spillway, canal	1,776
Settling basin	242
Forebay	47
Penstock	46
Powerhouse and Tailrace	337
Total	**2,448**

Source: AEPC (2010) estimate - revised by REREAP (2012).

231. Spoil disposal site selection will be based on avoiding environmental and social impacts (short and long term). Lower value land will be used wherever possible, such as riverside deposits, degraded or barren areas, and grassland. The use of cultivation land for spoil disposal will be avoided.

Mitigation Measures

232. Spoil disposal site planning will be finalized during the project pre-construction phase when disposal sites are identified with the community and landowners. Disposal sites will be selected based on:

- use of lower value land (avoidance of cultivation and other higher value sites);
- a minimum setback from watercourses; and
- preference for lower slope land.

233. Spoil management measures to be implemented will include:

- topsoil stripping and stockpiling separately from subsoil; and
- topsoil spreading and site revegetation of the final landform.

Waste Management

234. A small volume of waste will be generated during project construction and operation. Wastes will include cleared vegetation, construction and maintenance materials (e.g. scrap metal, sections of conductor, used oil, grease and paint), and domestic waste from the non-local construction and operation workforce (e.g. kitchen waste). Only small volumes of waste will be

produced but they have to be managed and disposed of properly to ensure that they do not pollute soil and water resources or create health and safety hazards.

235. The proper disposal, reuse and recycling of wastes will prevent land degradation and health and safety hazards at project sites. As the construction and operation workforce will mainly consist of people residing locally, little additional waste will be generated by the workforce. Unskilled construction workers will come from nearby villages and therefore will remain housed in their own dwellings, while up to 17 skilled workers sourced from outside the local area will stay in existing nearby hotels and houses, therefore no temporary workforce camps will be established.

Mitigation Measures

- Residual construction materials and waste will be collected, reused, recycled or disposed of safely, in accordance with standard and accepted practices.
- Biodegradable and non-hazardous domestic wastes generated by the outside workforce will be properly disposed of by burying in pits away from water sources and settlements.

Greenhouse Gas Savings

236. It is estimated that the annual generation 1,122,000 kWh of electricity by the project will avoid the emission of 21.8 T/a CO_{2e} per annum from the burning of kerosene oil. This estimate is based on 73.31 kg of CO_2 emitted per MMBtu of energy consumed from the use of kerosene oil as an energy source[46].

6.3.2 Socio-Economic Impacts

Disruption to Local Services

237. The project will not permanently cut or disrupt any existing local services. No irrigation canals will be crossed by the headrace canal or other project structures. The water-driven mills along the dewatered section of Simrutu Khola will continue to be operable throughout the year despite reduced river flows, as described in Section 4.2.1.

238. A number of local foot trails will be cut by headrace canal construction but most of these will be reinstated by capping the canal with concrete lids and installing steps down cuttings and embankments. Other sections of the settling basin and forebay will be fenced withsection close to any households will be fenced by barbed wire.

239. One newly constructed 22ft wide fair weather road leading Rugha villages will also be crossed by headrace canal approximately 240 m downstream from the intake site. Furthermore, this same site is a zone of an old landslide (triggered by 1995 earthquake) which can cause some slope stability problems.

Employment

240. An estimated 13 people will be employed to supervise project design and construction for an estimated total of 1,755 person-days. The construction workforce is likely to consist of 17 skilled and 114 unskilled staff, with an estimated 23,500 man-days of labour required. Operation staff will consist of a project manager, 1-2 technical support staff, 2-3 unskilled laborers (guard and staff to occasionally clean the canal, an accountant and two electricity 2 meter readers.

[46] http://www.eia.gov/oiaf/1605/excel/Fuel%20Emission%20Factors.xls

Project Revenue

241. The project will be community owned and operated, with electricity sold to end users through a metered system[47]. Revenue generated will be used to operate and maintain the system, including the employment of a full-time engineer to supervise these activities, and staff to assist with these activities and read electricity meters.

Electricity Provision and Use

242. An estimated 8,239 people residing in 1,386 households in four VDCs will receive electricity supply from the project. The main benefits of an improved power supply will be:

(i) improved house illumination;
(ii) the option to run a range of household appliances such as a refrigerator, television and radio;
(iii) operation of community facilities such as street lighting; and
(iv) greater business opportunities, such as a sawmill and electric sewing.

243. Local institutions that will be connected to project electricity supply will include eight schools and one health post at Rugha and three sub health posts in other VDCs. Local businesses likely to utilize project electricity include a hotel, furniture shop and dairy. It is anticipated that several additional furniture making enterprises will establish once power is available given the local demand for furniture, but this will be dependent upon local initiatives.

Reduced Energy Cost

244. 20% of the project installation cost will be provided by the community, most likely in the form of labour, with the remaining cost met by the Government. Households will also pay for the connection of electricity from the distribution line their dwelling. A one-off equity capital contribution of NPR 10,000/household will be charged to households connecting to the project that will be used to establish the project maintenance fund. On-going project running costs will primarily be met by user households and businesses, with support sought from charities to reduce these costs.

245. The total monthly household energy cost spent on fuelwood, kerosene, home solar systems and tukimara are predicted to decrease once households commence using project electricity. The monthly hydropower project running cost (operation and maintenance cost) that will be charged to each household is estimated to be less that NPR 300/household[48]. It is assumed that the following household energy uses will be replaced by project electricity: solar home systems in 57% of households (around NRS 167/month), kerosene in 17% of households (at around NRS 330/month) and tukimara in 26% of households (around NRS 135/month). Based on this there is likely to be a cost saving per household, with the amount saved based on the current uses that will be replaced.

Safety

246. **Drowning:** open water structures pose a hazard to people and livestock. The headrace canal, with a width and depth of 1 m x 1 m and a flow velocity of 1.5 m/s, will pose a safety hazard to very young children. The deeper and broader gravel trap, settling basin and forebay will pose a hazard to children and adults who cannot swim as each of these structures is between 2.5-3.5 m deep with vertical sides.

[47] AEPC – pers. comm.
[48] REREAP Economist – pers. comm.

Mitigation Measures

- Foot trails cut by the headrace canal will be reinstated by laying concrete lids over the canal, while the canal will also be capped in other areas of close to high pedestrian traffic (e.g. near a village).
- The gravel trap, settling basin and forebay will be fenced using barbed wire to prevent access to these structures.
- A trash rack will be fitted to the forebay in front of the penstock intake that will prevent people or animals being drawn into the penstock.

247. **Electrocution:** electrocution can occur from contact with switchyard gear/transformers/live conductors, flashover from a conductor to a pole or vegetation, and conductor breakage. Electrical safety will be built into the project by:

- maintaining minimum vertical clearances between the conductors and the ground and structures;
- fitting lightning arrestors on the high voltage side of each transformer;
- grounding each high tension pole; and
- earthing all other necessary components.

248. Lightning arrestors will be fitted on top of some poles at intervals of approximately 300 m to protect electrical appliances from high current. The arrestors consist of 45 cm tubes earthed to the ground via a wire.

Mitigation Measures

- Transmission and distribution lines will strictly adhere to electrical safety setbacks as set out in the Nepal Electricity Regulation[49]. For power lines from 230/400 V up to 11 kV the minimum distance from the line to a house or tree is 1.25 m, while minimum clearance between the ground and the line is 4.6 m.
- No houses or other buildings will be permitted within the RoW, with existing houses and other structures relocated outside the RoW.
- Awareness programs on safety will be conducted for project staff and local residents at key locations in the project area.

7. BHORLENI SOLAR-WIND POWER SUB-PROJECT

7.1 Project Description

249. The 35 kW Bhorleni Solar-Wind Power (SWP) Project is proposed to provide power to Bhorleni village, Ward 8 of Phaparbari VDC, Makwanpur District, in the Central Development Region of Nepal. The project will supply an estimated 120 households and two rice mills. Each household is anticipated to use five CFL bulbs (7-15 W) and run a radio, TV/DVD, direct-to-home receiver, kitchen appliance/grinder, refrigerator, computer with LCD monitor, mobile phone charger and one other item (e.g. a fan) with power from the project. In addition, sufficient power is available to electrify the school and run eight 20 W street lights that will be installed by project, while some local people have shown interest in operating a sawmill, a furniture manufacturing enterprise and water pumps for irrigation using the remaining available power from the project.

[49] Government of Nepal, 1993. Electricity Regulation 2050.

250. Bhorleni village consists of 120 houses in a linear settlement (distributed among 20 clusters of between 2-9 houses each separated between 30-140 m) located along the bank in the Bagmati River at the eastern end of Makwanpur District. The area is on the boarders Kavrepalanchok District whose population access Bhorleni village for basic requirements and trade rather than district headquarters. The site is located 830 m north-east of the proposed SREP Chisapani Solar-Wind Power Project site and has a similar wind resource. The project is designed to generate 63,328 kWh energy each year.

251. The project was initiated by Mr. Bal Krishna KC, a temporary resident of Bhorleni village, who identified that the local wind resource may be adequate to generate wind power. He approached a number of local residents and businessmen who in turn approached the Alternative Energy Promotion Centre (AEPC). A User Committee is yet to be formed for the project.

252. The solar-wind hybrid project will consist of three 5 kW wind turbines and 72 photovoltaic solar panels each with 280 Wp capacity, providing 35 kW total system capacity. The turbines, solar panels and powerhouse will be located on open cultivation land adjacent to one another at a single site. The turbines will be located north of the panels and each component will be fenced.

253. Each wind turbine is likely to have three 2.5 m long blades mounted on a 12 m high steel tower. The turbine rotates 360^{o} to face into the wind. The towers and blades will be white or off-white. Three 5 kW wind turbines have been selected instead of a single 15 kW turbine to provide better system reliability and ease of maintenance, while all turbine components capable of being carried into the site by men (maximum weight of 250 kg) and installed without the use of a crane. Each tower is likely to be mounted on a 1 x 1 x 1 m concrete foundation. The minimum wind speed (velocity) at which the wind turbines start to generate (cut-in wind speed) is 3 m/s, with the maximum generating wind speed being 25 m/s. Power will be generated at 230 V and converted to DC to charge the batteries by an adaptor.

254. The solar panels will be mounted on inclined stands around 1 m in height, connected to a bank of batteries to be housed in a nearby powerhouse via a 150 m long power line strung from poles. Direct current (DC) electricity from the solar panels will be used to charge a bank of 300 VRLA Gel 2 V/1000 Ah sealed lead acid batteries. The batteries will have sufficient capacity to store two days of project electricity output that will meet around four days of electricity demand. DC drawn from the batteries will be converted to alternating current (AC) using an inverter then fed directly into the distribution line. All project components will be fenced.

Table 7.1: Main Project Components

Component	Quantity	Unit	Total
Wind Turbine	3	5 kW	15 kW
Solar PV	72	280 Wp	20 kWp
Battery Bank	330	2 V/1,000 Ah	220V/3,000 Ah
DC/AC Inverter	2	60 kVA	120 kVA
Distribution System	**3 Phase**	**1 Phase**	1,293 m
	700 m	593 m	

255. Power will be distributed to households and other users in the village (Figure 7.1) via three phase 400 V and single phase 230 V overhead transmission and distribution lines (1.29 km total length) that will run from the powerhouse to premises. The lines will be capable of being connected into the Nepal electricity grid at a later date if required.

Figure 7.1: Location of Bhorleni Mini-grid

256. The local wind and solar resources are complementary in the hybrid system as stronger winds appear to occur at night while solar radiation is limited to daytime. In addition, the wind resource pattern appears to coincide well with the demand pattern that peaks in the morning and evening. While there is no recorded data on local wind speeds, based on villager reports wind power generation is expected to occur for part of most days of the year when speeds exceed 3 m/s (minimum speed at which the turbines generate power), complementing daytime solar power conversion. A known period of limited to no wind occurs when it rains during part of the monsoon season, in June and July.

257. Solar power conversion will peak during the dry season months of April and May when the average hours of sunshine peak at 8.5-9 hours/day, while minimum generation at less than 40% of the peak rate will occur in the monsoon month of July when the average is just 4.5-5 hours per day[50].

258. Village daily demand for electricity has been estimated at 76 kWh in 2013 based on 120 households and ancillary uses, rising to 93 kWh in 2023 based on 144 households (Table 7.2). Average estimated demand per household is based on the use of a large range of appliances, but it is recognised that this is likely to be an overestimate at least in the early years as most

[50] Bajracharya, B. T., 1996. *Climatic and Hydrological Atlas of Nepal.* Kathmandu: ICIMOD.

households do not own the range of appliances that have been included in the demand forecast. This increasing demand over the next decade will be covered by the average daily electricity generation of the project (Table 7.3).

Table 7.2: Demand Forecast

User	Daily Electricity Consumption (kWh)		
	2013	**2018**	**2023**
Households	76	84	93
Businesses	36	42	48
School	3	3.4	3.7
Community	0.9	1	1.1
Project powerhouse	2.7	3	3.3
Total	**119**	**133**	**150**

Table 7.3: Estimated Average Daily Electricity Generation

Equipment	Rated	Quantity	Total	Capacity Factor	Daily Energy (kWh)
Wind turbine	5 kW	3	15.0 kW	16.0%	57.6
PV panels	280 kWp	72	20.16 kWp	5.75%	115.9
Average daily energy production					**173.5**

7.2 Description of the Environment

7.2.1 Physiographic Region, Topography and Drainage

259. The proposed project site is located in the Siwalik Hills physiographic region at an elevation of 265 m asl on a riverside area in the Bagmati valley (Figure 7.2). Topography in the project area consists of a north-south oriented valley between two hills that rise as high as 912 m asl. The project site lies on gently sloping alluvial deposits that fall to the south at grades of 1-4%. The turbine sites are on the northern side of the site, while the solar panel site lies on slightly lower land to the south. The Bagmati River valley drains to the southwest across the Nepal-India border into the Koshi River in Bihar state.

Figure 7.2: Bhorleni Powerhouse Site

260. The proposed turbine sites have good exposure to wind to the north and west, however to the east a section of ridgeline up to 912 m asl reduces exposure to the wind. The closest household is set back approximately 20 m from the nearest project site, a wind turbine location.

7.2.2 Climate

261. Bhorleni has a warm subtropical climate, primarily due to its low elevation at 247-265 m. The area experiences strong seasonal climatic variations, with wet monsoons from June to September and dry weather from October to May. The project area has a mean maximum temperature of 30.3°C in June and mean minimum temperature of 16.6°C in January[51]. Rainfall data for a station in Hariharpur Gadhi valley, 3 km east of Bhorleni village at 250 m asl, indicates that average monthly rainfall varies from 12.1 mm in December to 703.5 mm in July (Table 7.4), with 95% falling from May to October[52].

Table 7.4: Average Monthly Rainfall - Hariharpur Gadhi Valley (1991-2011)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hariharpur Gadhi valley (mm)	15.8	13.5	16.1	53.4	179.0	385.6	703.5	586.3	363.4	88.8	9.1	12.1

Source: DHM, Kathmandu, Nepal.

[51] MoFSc, 2005. *District-Wise Watershed Information Book.* Kathmandu: His Majesty's Government, Department of Soil Conservation and Watershed Management.
[52] Department of Hydrology and Meteorology

262. The sun shines on around 300 days a year. The mean daily hours of sunshine at the site vary from a minimum of 4.5-5 hours in July to 8.5-9 hours in November (Table 7.5), compared with the national average sunshine hours of 6.8 per day. Average daily solar radiation varies between 3.6–6.2 kWh/m^2/day, with a yearly average of around 4.7 kWh/m^2/day.

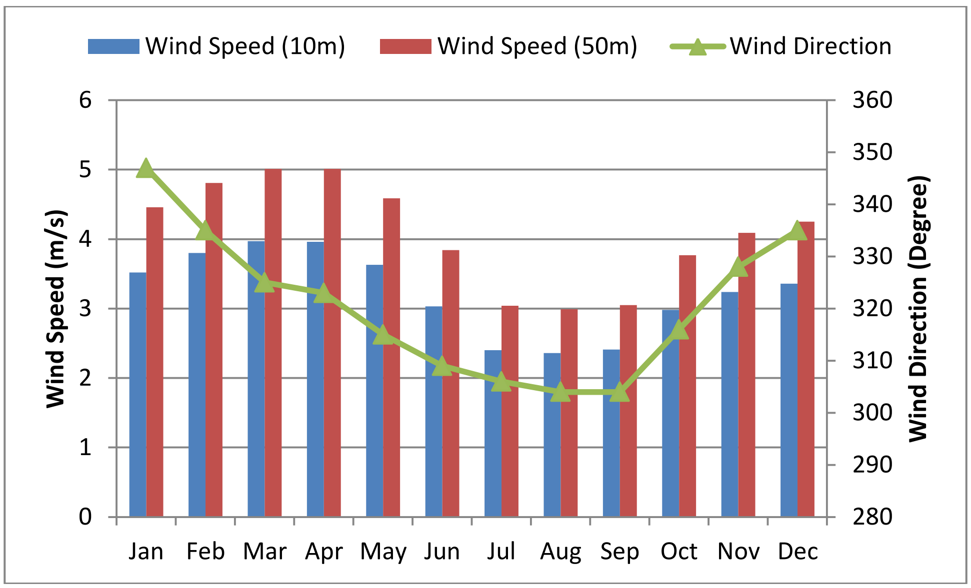
Table 7.5: Average Daily Hours of Sunshine

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
6.5-7	7.5-8	8-8.5	8-8.5	8-8.5	5.5-6	4.5-5	6-6.5	5.5-6	8-8.5	8.5-9	7.5-8

Source: (ICIMOD, 1996).

263. The local wind resource is affected by topography at the site, but in the absence of measured wind speeds in the local area general data from NASA has been used as an approximate indication of the likely wind speeds at the site (Table 7.6).

Table 7.6: Average Monthly Wind Speed



Source: NASA, 2012 (http://eosweb.larc.nasa.gov/)

7.2.3 River Hydrology

264. The Bagmati River drains southwards through a valley, flowing across the Indian boarder approximately 89 km downstream of the project site. The river bed is steep at around 1.1° slope. 85% of river flows by volume occur in the monsoon season from June to September when there is the potential for flash flooding and riverbed scouring. Flooding during the monsoon is common, and floods broke over the main river banks in 2002.

7.2.4 Geology

265. Site geology is made up of the Siwalik Group, lying close to the boundary with the Sub Himalaya. The Main Boundary Thrust runs approximately 2 km from the site along the Bagmati

River. The Siwalik Group consists of Middle-Miocene to Plio-Pleistocene molassic fluvial deposits, conglomerates, sandstone and shale with vertebrate fossils. The Sub Himalaya consists of Quartenary Alluvial deposits of Dun Basins.

7.2.5 Land Use

266. The main land use types in the project area are: irrigated cultivation (khet) on small areas of flatter riverside land; dryland cultivation (bari) on terraced hillslopes; forests on steeper slopes; and grasslands in forest clearings and on marginal land. Most Bhorleni households own khet land close to the river that provides the main source of household food and income due to high crop yields on this irrigated land. Forests are harvested for timber, fuelwood and non-timber forest products. Grazing occurs on grasslands.

267. The main local crops are paddy grown in summer, and mustard, maize, radish and soybean grown in winter, with potatoes grown as a single crop on non-irrigated fields. The main livestock are goats, cattle and poultry. Most dwellings have house gardens where a range of vegetables and herbs are grown, including pumpkin, green leafy vegetables, tomatoes and chillis. and tomatoes. Two local cooperatives, Jadibutti and Janaekta, have financed cash cropping, primarily asparagus growing, and have both been profitable over the past few years. Makwanpur District contributes around 40% of the total national asparagus crop[53].

268. Forests are located on public land and are mainly used for livestock grazing and harvesting forest products (fuelwood and medicinal herb collection). National forest land lies adjacent to the settlement clusters, mainly on the steeper ridgeline slopes. A registered community forest exists in the area: Tanke Bhorleni Community Forest – 197.7 ha supporting 89 households. The boundary of the community forest lies to the north of the village (Figure 7.2). Local forests have around 50% canopy cover, with the main species being *Shorea robusta* (Sal), *Terminalia alata* (Saj), *Schima wallichii* (Chilaune), *Desmodium oojeinense* (Sandan), *Phylanthus emblica* (Amala) and *Semecarpus anacardium* (Bhalayo).

7.2.6 River Use

269. The stretch of the Bagmati River close to Bhorleni village is used by Bhorleni, Chisapani, Sikre Dobhan, Kokati and Goth Danda villages. Uses along this river section include irrigation, fishing, waste disposal, and running water mills. Pollution loads in this river are high as this river drains the Kathmandu valley. A water mill used for grinding grain and electricity generation (2-2.5 kW) that supplies 40 households is located 630 m downstream of the powerhouse site (at the time of field visit it was not operating). Two additional mills used to grind grain are located 400 m downstream from the proposed powerhouse site.

7.2.7 Terrestrial Ecology

270. The proposed project site is located 30 m from the right bank of the Bagmati River in irrigated cultivation. The nearest forest boarders the northern settlement cluster, situated on the foot of the ridge. The forest consists of Sal (*Shorea robusta*), Indian Laurel (*Ficus nitida*), Needlewood schima (*Schima wallichii*), Sandan (*Desmodium oojeinense*), Indian gooseberry (*Phylanthus emblica*) and Marking nut (*Semecarpus anacardium*). The forest has 50% canopy

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[53] Yadav, B. K., 2008. Cultivation and Marketing of Asparagus (Asparagus racemosus) in Sarlahi District. *Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Forestry*, 12. Pokhara: Tribhuvan University, Institute of Forestry.

cover and is regularly harvested. The main wildlife species in the area are Red Fox (*Vulpes vulpes*), Indian Porcupine (*Hystrix indica*), Rhesus monkey (*Macaca mullata*) and Common Langur (*Presbytis entellus*) (Tanke Bhorleni Community Forest User Group members - pers. comm.), typical species found on hill farming land in the lower Siwaliks.

271. The closest protected area to the site is Chitwan National Park, located approximately 50 km west. The site is located on the eastern boundary of the Terai Arc Landscape (TAL), a conservation initiative of the Department of National Parks and Wildlife Conservation and WWF Nepal. This broad area encompasses 11 protected areas in Nepal and trans-boarder protected areas in India, and was established to protect this Himalayan landscape (86 species of mammals, 550 species of birds, 47 species of herpato fauna, 126 species of fish and over 2,100 species of flowering plants[54]).

7.3 District, VDC and Project Area Socioeconomic Profile

272. Makwanpur is among the most developed Districts in Nepal, with a Socioeconomic and Infrastructural Development Index rank of 16 out of 75 districts[55]. According to the 2001 census, 29.0% of farm households are classed as Marginal in the district (farm size <0.5 ha), road density is 13.44/100 km^2 (rank 34), health institution density is 1.46 (rank 70) and per capita development budget expenditure is NPR 745 (rank 42).

273. Phaparbari VDC has a total population of 16,776 (Table 7.7)[56], with an average household size of 5.2. The 120 households in Bhorleni village have a population of 530 (average 4.42/household), located in twenty clusters of 2-9 households from north to south along a 830 m section of the valley. The village population consists of 46% male and 54% female.

Table 7.7: VDC Population

VDC	Population				Total Households	Household Size
	Male	Female	Total	Sex Ratio		
Phaparbari	7,991	18,785	**16,776**	91%	708	6.7

Source: Population Census, 2011, CBS.

274. The strongly dominant ethnic group in Phaparbari VDC is Tamang, comprising 63% of the total population. Other groups present are Magar (14%), Rai (5%) and Dalit (5%) (Table 7.8).

Table 7.8: Ethnic Composition by VDC

VDC	Population				
	Tamang (Janajati)	Magar (Janjati)	Rai (Janjati)	Dalit	Others
Hariharpur Gadhi	10,493	2,282	798	807	2,287

Source: Population Census, 2001.

54 Flemming st al., 1975; Maskey, 1992; Shah, 1995; Gurung, C. P., 2005. Terai Arc Landscape. In U. R. Sharma, and P. B. Yonzon, *People and Protected Areas in South Asia* (pp. 134-137). Kathmandu: IUCN World Commission on Protected Areas, South Asia and Resources Himalaya Foundation

55 ICIMOD, 2003. *Districts of Nepal, Indicators of Development Update.* Kathmandu, Nepal: ICIMOD and CBS.

56 Population Census, 2011

275. Household decisions are primarily made by the male head of the house, with women having less power in family decision making. Most water collection and fuelwood and fodder gathering is done by women, with men undertaking most of the field ploughing.

7.4 Livelihoods

276. Subsistence agriculture, consisting of irrigated and rainfed cultivation and livestock raising, is the main livelihood earning activity in the project area. In addition, many households rely on remittances provided by male household members working elsewhere in Nepal or internationally.

277. Agricultural land and livestock holdings of households in Phaparbari VDC are summarised in Table 7.9. Ownership of agricultural land is common, with 95% of households reporting ownership. Livestock are also owned by most households, used for subsistence and income generation. Fishing provides a source of food and livelihood for some residents of Bhorleni, however following construction of the Bagmati dam 38 km downstream fish numbers have declined and the fish catch has reduced as a result of this[57].

Table 7.9: Ownership of Agricultural Land and Livestock in Project VDC

VDC	Households Owning				Total Households
	Agricultural Land Only	Land and Livestock	Land, Livestock and Poultry	Other	
Phaparbari	71	211	2,252	122	2,656

Source: Population Census, 2001.

278. Two cooperatives, Jadibuti Cooperative and Jana Utthan Cooperative, support local investment in cash crop cultivation, particularly Asparagus.

7.5 Energy Supply and Use

279. The main sources of energy in the project VDC were reported to be: fuelwood for cooking and heating (89% of households at an estimated average rate of 3.8 Bhari per household (133 kg) per household per month[58]); biogas (from cow dung and toilets, with an average unit size of 4 m^3) for cooking (13% of households); solar power for lighting (48% of households), with peak output per system between 10-30 Wp; LPG for cooking (approximately 32% of the households); and kerosene for lighting (58% of households)[59]. Households using LPG for cooking also use fuelwood for cooking, but consume only 19% of the fuelwood volume of non-LPG households.

280. The SREP household survey of 19 sampled households indicated that the average monthly household expenditure on cooking and lighting is NPR 851 (cooking NRS 476, lighting NPR 375). Household kerosene use for lighting averages 2 L/month. The average monthly expenditure on solar home systems per household is NPR 267.

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[57] Chisapani villagers – pers. comm.

[58] ADB, 2012. *PPTA Technical Report - TA-8081 NEP: Scaling Up Renewable Energy Proje*ct - Minigrid (Solar and Wind) – SWM02/SREP/2013 Bhorleni, Faparbadi – 2, Makwanpur, N*epal*.

[59] SREP social survey data, 2012

281. Two diesel-powered rice mills used for husking are operated in Bhorleni village. The mills each consume 30-60 L of diesel per month, except during the Diwali and Dashain festivals (one month) when diesel consumption rises to 100 L/month. The monthly cost of diesel per mill was reported to be NPR 4,950 (based on NPR 110 per litre).

7.6 Water Supply

282. The main supply of domestic water in Bhorleni village comes from a local hillside spring in Betini. Water is reticulated by gravity from the spring by a system of polyethylene and steel distribution pipes to community taps in Bhorleni. Water quality from these taps is good, but the quality of local river water for drinking is poor due to high levels of *E. coli* from livestock in the catchment and the use of watercourses for village sanitation purposes.

7.7 Transport and Local Services

283. Access to the site is primarily gained from Hetaunda Municipality (approximately 65 km west of the village) via a fair-weather (earth) road, along which regular bus services run. A section of this road is currently under construction and aims to connect Chatara of Sunsari District. Several sections of this road cross braided river channels due to a lack of bridges. Public buses connect Bhorleni to the following VDCs: Hariharpurgadi and Mahindrejhyadi in Sindhuli District; Betini in Makwanpur District; and Milche, Dandagaun, Phalametar, Ghartichapp, Saldhara, Salme, Gokule and Banakhu in Kavrepalanchok District. Accordingly, Bhorleni village serves as the gateway for 40,511 people[60] in the project area and neighbouring VDCs.

284. The Government school in Bhorleni provides classes up to 12th grade. The village does not have a Health Post, but a nearby market has chemist shops and a dispensary. Communication services in the project area consist of CDMA mobile telephony and a CDMA booth in the village. Most adult residents of Bhorleni own a mobile phone.

7.8 Impacts and Mitigation Measures

7.8.1 Biophysical Impacts

285. The 35 kW solar-wind power project will provide a net environmental and social benefit, while creating minor adverse impacts.

286. **Land use change:** the total land area required for project installation is estimated to be 300 m^2 (0.03 ha). Each wind turbine will be mounted on 12 m high steel towers on cultivation land, occupying a base pad area of 1 x 1 m^2. Three immature trees on the eastern side of the site are likely to be removed as they partly impede solar radiation. Around 150 m of power line will connect the panels to the powerhouse, mounted on 4 m high poles that will each occupy less than 1 m^2/pole.

287. The land area required for solar panel installation is estimated to be 72 m^2 (1 m^2 per photovoltaic panel), roughly equivalent to the footprint of two local houses. A 20 m long power line will connect the turbines to the powerhouse, strung on 4 m high poles. The solar panels will be mounted on stands on open cultivation land, while the poles will also be in located on cleared land, therefore no forest land will be converted and no existing structures will be removed. The

[60] Population Census 2011.

powerhouse housing the bank of batteries will occupy around 40 m^2 (5.5 x 7.3 m), while distribution line poles will each cover less than 1 m^2 per pole.

288. The area that will be occupied by the wind turbines, solar panels and powerhouse, totaling an estimated 550 m^2 of rainfed cultivation land, will reduce crop production by the equivalent of 127 kg of rice per annum (based on an average yield of 2.3 T/ha[61]). It is proposed that this privately-owned land owned by two landowners will be donated to the User Committee in return for a long-term project job.

Mitigation Measures

- Minimal land area will be utilized for project structures, including power line RoWs.
- Care will be taken to avoid the disturbance of crops and other vegetation outside the land area required for permanent project sites.
- Temporarily disturbed land will be rehabilitated after use by removing excavated spoil and waste, and revegetating.
- Poles will be located on land with low economic value wherever possible and on the edge agricultural fields to avoid creating obstacles in plots.
- Temporary construction sites will be located on low value land where possible, and no temporary sites will be located on forested land.
- Disturbed areas will be revegetated.

289. **Spoil disposal:** small volumes of spoil will be generated from the excavation of each wind turbine foundation, limited to around 1.6-2 m^3 of spoil per foundation (allowing for bulking from the excavation of 1 m^3). Around 10-30% of this material will be topsoil and the rest will be subsoil and/or rock.

Mitigation Measures

- The site landowner will be asked if he/she wishes to use the excess spoil, and if so it will be made available free of charge.
- Only topsoil will be disposed of on cultivation land, with the permission of the landowner.
- Disposed spoil will be revegetated where possible.

290. **Habitat loss:** all project components will be constructed on cleared cultivation land

Mitigation Measures

- Vegetation clearance will be kept to the minimum required to install the project, including restricting the power line RoW to the required width (1.25 m between the line and a house or tree as per the Electricity Regulation[62] plus an assumed 0.5 m to allow for line swing).
- Individual trees to be removed will be clearly marked prior to clearance and permission will be obtained from the landowner or community to remove this vegetation.
- Tree clearance will be restricted to cutting down trees to ground level, with the retention of tree stumps and roots.

291. **Noise:** the main sources of noise from wind turbines are from blade movement through the air and turbine mechanical noise. The nearest house to a proposed turbine site is located 20 m to the west. Noise from turbines primarily propagates downwind, therefore downwind sites

[61] MoAD, 2010. *Statistical Information on Nepalese Agriculture 2010/11*. Singhadurbar, Kathmandu, Bagmati, Nepal.
[62] Government of Nepal, 1993. *Electricity Regulation 2050*.

receive the greatest noise impact. The nearest house will be in the downwind area for some of the time that the turbines are generating. Noise levels at this dwelling are estimated to be over 45 dB(A) when wind speeds are between 3 m /s (start up) and 8 m/s based on the Evance 9000R 5 kW turbine as an example[63], exceeding the World Bank night-time guideline limit for residential areas of 45 dB(A). If wind turbines are sited with a minimum setback of around 50-60 m then noise levels are likely to be around 40-45 dB(A), thereby meeting World bank guidelines. At wind speeds above 8 m/s the background noise of wind moving through trees, etc usually exceeds the noise produced by the wind turbines.

Mitigation Measures

- Construction activities will be restricted to daylight hours to minimize disturbance, and local communities will be informed of the construction schedule.
- Site turbines with a minimum setback of 50-60 m from the nearest dwelling.
- GoN health and safety regulations will be adhered to.
- Construction workers and operation staff will be provided with personal protective equipment as required.

292. **Bird mortality:** moving wind turbine blades can cause bird and bat death and injury, although this hazard is difficult to quantify. Waterbirds are thought to be at greater danger from moving blades due to their generally slower flight. The nearest waterbody to the Bagmati River, lying along the southern side of the village. Bird life on the river is sparse, mainly consisting of Indian Pond Heron (*Ardeola grayii*) and Cattle Egret (*Bubulcus ibis*). Overall the hazard to bird life from moving blades is estimated to be low, largely due to the relatively low height of the blades (maximum height 12.5 m off the ground), small swept area of the blades (5 m diameter) and the lack of birdlife.

293. **Aviation hazard:** the wind turbines (14.5 m high to blade tip) will not create an aviation hazard as the site is located in the base of a large valley. The white or off-white blades and towers will be highly visible at most times.

294. **Interference with telecommunication and television signals:** mobile phone signals are transmitted and received via a telecommunications tower located approximately 10 km to the east, in Ward 2, Hariharpurgadi VDC. Some of the village clusters are located to the west of the turbines, therefore phone reception at dwellings will be monitored to identify if any loss of reception occurs. Given that several mobile companies propose to construct new towers close to the village there is unlikely to be an impact. Television signals in the village are received by satellite dishes mounted on dwellings. The proposed wind turbine sites are set back 20 m from the nearest residence. If this distance is increased to 50-60 m interference with TV signals should not occur.

295. **Waste management:** the main waste that will be produced by the project is used lead acid batteries (ULAB) that require replacing every eight years or so. Solar panels have a guaranteed life of 25 years therefore they will not produce waste for a considerable period of time unless they are physically damaged. The wind turbines do not produce waste apart from any parts that require replacement from time to time.

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[63] http://www.evancewind.com/images/uploads/products/Evance_R9000.pdf

damaged. The wind turbines do not produce waste apart from any parts that require replacement from time to time.

297. Lead acid batteries need to be recycled to avoid pollution from the lead plates and the sulphuric acid that the plates sit in. Recycling involves the recovery of lead to produce new batteries. Local scrap dealers collect lead for (i) crushing then transportation to India for processing, or (ii) local recycling in small quantities by a battery company, however, neither method is environmentally safe[64]. Informal battery recycling involves breaking open the battery case by hand and melting down the lead plates on small fires or stoves to recover it. This process poses a health hazard from: (i) inhaling lead toxins during the melting process; (ii) contact with lead particulates in battery acid; (iii) contact with or inhaling lead dust generated from dry soil contaminated with lead particulates; and (iv) ingesting contaminated water. Lead scraps left in the open also pose a health hazard from direct contact. Accordingly, disposal has to be in accordance with sound procedures to avoid human health issues and soil and water contamination.

298. Villagers in Bhorleni reported that spent lead acid batteries are usually disposed of locally rather than being collected for reuse as occurs at other sites. Some surveyed households have retained used batteries inside their houses, but it is assumed that many spent batteries have been disposed of in informal landfills on the banks of Bagmati River.

299. Nepal, as a party to the Basel Convention on transboundary movements of hazardous waste and their disposal, plans to install a lead recycling plant that will operate in accordance with the Convention's rules and guidelines. AEPC is in the process of selecting a site for the plant, with sites under consideration at Biratnagar and Hetaunda. AEPC will facilitate the recycling of all SREP sub-project ULABs in this facility. This may involve a public-private partnership where ULABs are purchased at 13 District collection centres and then transported to the recycling facility. The Government is currently preparing a lead acid battery management regulation.

300. AEPC will provide an information pamphlet to the project User Committee detailing the required ULAB disposal procedure. Each battery will be labeled with a contact phone number to obtain current advice on how to safely dispose of batteries given that the first set will operate for around eight years. AEPC will also mail out any new information on safe battery disposal to the school (such as new Government regulations and recycling facilities), while it is also considering a maintenance contract with private companies using a battery voucher program to promote the central collection and recycling/reuse/disposal of battery components either through scrap dealers or solar power companies.

301. In addition, used energy efficient (CFL and LED) bulbs pose a toxic hazard risk. These bulbs contain excessive levels of leachable lead and high levels of copper and zinc[65]. Total metal content is around 10 times higher in CFL bulbs and around 150 times higher in LED bulbs compared to incandescent bulbs, therefore it is important that they are disposed of properly.

Mitigation Measures

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[64] Wald, A., & Lemor, R., 2009. *Report on Lead Acid SHS Battery Recovery System in Nepal.* Kathmandi: German Financial Cooperation in Nepal.

[65] Lim, S.-R., Kang, D., Oladele, A. O., & Julie, M. S., 2012. Potential Environmental Impacts from the Metals in Incandescent, Compact Fluorescent Lamp (CFL), and Light-Emitting Diode (LED) Bulbs. *Environmental Science & Technology*.

- Residual construction materials and waste will be collected, reused, recycled or disposed of safely, in accordance with standard and accepted safe practices.
- Non-hazardous wastes such as packaging (e.g. wooden framing around electrical components) will reused wherever possible for other purposes or disposed of by burying in a pit away from water sources and settlements.
- Pamphlets will be provided to households outlining the safe handling and disposal of used ULABs and CFL/LED lamps to prevent a risk to human health and the environment. This will include cleaning up broken bulbs by:
    - proper ventilation of rooms prior to cleaning;
    - avoid using brooms to clean up powder to avoid spreading the particles; and
    - wash hands after cleaning.

302. **Reduction in indoor and outdoor air pollution:** the replacement of kerosene lamps with solar-wind powered CFLs for household lighting will eliminate this source of indoor air pollution, while the conversion of diesel-powered rice mills to electricity will improve air quality at these facilities. A secondary source of house lighting comes from the burning of fuelwood in cooking stoves, for cooking year-round and heating in winter. Fuelwood use is likely to continue at a similar rate as these primary uses will continue.

303. **Greenhouse gas emissions reduction:** the volumes of carbon emissions (CO_2) that are likely to be avoided by project power replacing (i) kerosene lighting and (ii) diesel use in the rice mills are estimated to total 4.3 T/a and 2.8 T/a respectively (Table 7.10).

Table 7.10: Estimated Annual CO_2 Emissions Avoided by Replacement of Kerosene and Diesel

Category	Value
Number of HHs using kerosene[1]	70
Average kerosene consumption/HH/month[1]	2 L
Total yearly kerosene consumption	1,680 L
Kerosene energy content per L[2]	37.0 MJ
Total energy from kerosene[3]	58.9 MMBtu
Total annual CO_2 emissions from kerosene	**4.3 T**
Yearly consumption of diesel by rice mills (2)	1,080 L
Diesel energy content per L[4]	37.3 MJ
Total energy from diesel[3]	38.15 MMBtu
Total annual CO_2 emissions from diesel	**2.8 T**

Sources:
1 - SREP Social Survey, 2012.
2 – RETRUD-03 Conference Paper, CES, TU Pg. 273.
3 – http://www.unitjuggler.com/convert-energy-from-kJ-to-MMBtu.html
4 - http://en.wikipedia.org/wiki/Energy_density

7.9 Socio-Economic Impacts

304. The socio-economic impacts that will occur from project construction and operation, providing a greater and more reliable power supply, will primarily be beneficial.

305. **Greater power supply and improved supply reliability:** the main benefits of an improved power supply will be:

(v) improved house illumination;
(vi) the option to run a range of household appliances such as a refrigerator, television and radio;
(vii) operation of community facilities, including a school and street lighting; and
(viii) greater business opportunities, such as a sawmill and electric sewing.

306. Solar-wind power will enable the operation of a range of equipment by an estimated 120 households (530 people) that is not operated in the village due to a lack of electricity, or will be replaced by the provision of electricity. Foremost among the additional facilities are room lights, televisions, computers and refrigerators, the Lower Secondary School and possibly a sawmill, furniture manufacturing enterprise and irrigation pumps. Eight streetlights will be powered in the village. In addition, a rice husking mill will be run on electricity, replacing the diesel-powered units. These new and replaced facilities will result in improved living conditions and increased economic activity in the village.

307. Irrigation from the Bagmati River using electric pumps powered by the project may be possible, although irrigation feasibility will have to be assessed due to a high pollutant load in river that may cause adverse health effects. Local people indicated that sludge in irrigation water sourced from the Bagmati River, containing manure, is highly productive and greatly increases crop yields.

308. **Conversion of the mills:** the two diesel-powered mills can be converted to electricity with the addition of a 10 Hp electric motor at each mill at an approximate cost of NRS 21,000-35,000/motor.

309. **Visual impact:** the visual impact of three wind turbines and 74 solar panels is considered to be low given the location in the valley at a relatively low elevation and the size of these structures.

310. **Safety hazards:** solar panels and wind turbines produce electricity at 230 V which poses a risk of electrocution if contact is made with live lines, therefore safety protection is required. Each wind turbine, the bank of solar panels and the powerhouse will each be fenced to prevent public access. All electrical equipment, power lines and cables will be insulated in accordance with standard Nepal safety requirements. This includes installation and handling safety measures such as keeping children away from the components and not wearing metallic objects/jewelry while handling equipment. Lightning protection will be provided by earthing each turbine, the solar array and bank of batteries using a copper earth rod, with soil conductivity improved with the incorporation of coal and salt in the soil[66]. Lighting protection on the wind turbines will be provided by a conductor on top of each tower, earthed to the ground via the tower.

311. As there is no wind data available for the site, Class 1B turbines will be installed, capable of withstanding gusts of up to 50 m/s (180 km/hr). The probability of a turbine catching fire or a blade flying off a turbine is very low, but given that the turbines are located 60 m away from the nearest dwelling the hazard to human life is considered negligible.

[66] SREP, 2012 – pers. comm.

Mitigation Measures

- The wind turbines, solar panels and powerhouse will be fenced to prevent access, with signs fitted to warn people not to enter due to the electrocution hazard.
- A general awareness program on safety will be conducted for local residents, including the issuing of a safety pamphlet to villagers specifying hazards and prohibited activities (Appendix I).

312. **Improved respiratory health:** the removal of kerosene lamps will improve air quality (reducing particulate matter and carbon monoxide levels) inside homes. As most households will continue to use wood stoves for cooking, the improvement in the overall respiratory health (i.e. reduction in respiratory irritation and possible reduction in respiratory infections) is expected to be limited as the long term effects of poor indoor air quality from wood burning at home will greatly outweigh the short-term improvement in air quality provided by the clean energy lighting. The replacement of diesel-powered mills will improve outdoor air quality near these facilities.

313. However, mercury led CFL bulbs can pose hazard when broken or not handled properly. This threat will be higher especially in ill ventilated houses as 424 times more volume of air is required to dilute the quantity of mercury released these bulbs compared to incandescent bulbs[67].

314. **Reduced energy cost:** 20% of the project installation cost will be provided by the community, most likely in the form of labour, with the remaining cost met by the Government. A one-off subscription cost of NPR 7,000/household will be charged to households connecting to the project that will be used to establish the project maintenance fund. On-going project running costs will primarily be met by user households and businesses, with support sought from charities to reduce these costs.

315. The monthly household cost of lighting, cooking and other energy uses currently provided by fuelwood, biogas, LPG, kerosene and diesel, micro hydro and dry cell batteries is predicted to decrease once households commence using project electricity. The estimated monthly solar-wind project running cost (operation and maintenance cost) is NPR 320/household. Assuming that kerosene use and solar home systems will be replaced by project power, while LPG and firewood will continue at the current rate, the monthly cost of energy per household is expected to decrease slightly from a total of NRS 807 at present to NPR 751, a decrease of NPR 56.

316. It is estimated that the two diesel mills consume a total of around NPR 118,800 (NPR 59,400/mill) of diesel per year, compared with the estimated cost of project electricity to run a single mill of NPR 57,600 per year (based on total usage of 8 kWh/day charged at NPR 20/kWh (the rate charged by a solar-wind project in Nawalparasi District). It is estimated that a single electric mill will be able to replace the two diesel-powered mills, therefore the net saving on fuel will be around NPR 61,200/annum.

317. **Employment:** project installation will take an estimated 30 person-days, requiring skilled and unskilled labour. Project employment during operation will consist of a full-time technician and two part-time staff to read electricity meters and undertake routine inspections of the

[67] Lim, S.-R., Kang, D., Oladele, A. O., & Julie, M. S., 2012. Potential Environmental Impacts from the Metals in Incandescent, Compact Fluorescent Lamp (CFL), and Light-Emitting Diode (LED) Bulbs. *Environmental Science & Technology*

turbines, solar panels and batteries. The two part-time staff will be sourced from Bhorleni village and trained as a component of the project.

8. CHISAPANI SOLAR-WIND POWER SUB-PROJECT

8.1 Project Description

318. The 20 kW Chisapani Solar-Wind Power (SWM) Project is proposed to provide power to Chisapani village, Ward 8 of Hariharpur Gadhi VDC, Sindhuli District, in the Eastern Development Region of Nepal. The project will supply an estimated 66 households and a rice mill. Each household is anticipated to use six CFL bulbs (7-15 W) and run a radio, TV/DVD, direct-to-home receiver, kitchen appliance/grinder, refrigerator, computer with LCD monitor, mobile phone charger and one other item (e.g. a fan) with power from the project. In addition, sufficient power is available to run seven 20 W street lights that will be installed by project, while some local people have shown interest in operating a sawmill, a furniture manufacturing enterprise and water pumps for irrigation using the remaining available power from the project.

319. Chisapani village consists of 66 houses in three clusters located along a ridge in the Bagmati River valley, at the western end of Sindhuli District. The area is on the boarder of Makwanpur and Kavrepalanchok Districts, whose population access Bhorleni village for basic requirements and trade rather than district headquarters. The site is located 830 m south-west of the proposed SREP Bhorleni Solar-Wind Power Project site and has a similar wind resource. The project is designed to generate 28,032 kWh energy per annum.

320. A solar-wind project was initiated in nearby Bhorleni village by Mr. Bal Krishna KC, a temporary resident. This information was shared with Chisapani villagers, including Mr. Chamar Ghalan whose land was identified as potentially suitable for a solar-wind installation. A number of local residents and businessmen proposed the project to the Alternative Energy Promotion Centre (AEPC). A User Committee is yet to be formed for the project.

321. The solar-wind hybrid project will consist of two 5 kW wind turbines and 36 photovoltaic solar panels each with 280 Wp capacity, providing 20 kW total system capacity. The turbines, solar panels and powerhouse will be located on open cultivation land adjacent to one another at a single site. The turbines will be located north of the panels and each component will be fenced.

322. Each wind turbine is likely to have three 2.5 m long blades mounted on a 12 m high steel tower. The turbine rotates 360^{o} to face into the wind. The towers and blades will be white or off-white. Two 5 kW wind turbines have been selected instead of a single 10 kW turbine to provide better system reliability and ease of maintenance, while all turbine components capable of being carried into the site by men (maximum weight of 250 kg) and installed without the use of a crane. Each tower is likely to be mounted on a 1 x 1 x 1 m concrete foundation. The minimum wind speed (velocity) at which the wind turbines start to generate (cut-in wind speed) is 3 m/s, with the maximum generating wind speed being 25 m/s. Power will be generated at 230 V and converted to DC to charge the batteries by an adaptor.

323. The solar panels will be mounted on inclined stands around 1 m in height, connected to a bank of batteries to be housed in a nearby powerhouse via a 150 m long power line strung from poles. Direct current (DC) electricity from the solar panels will be used to charge a bank of 220 VRLA Gel 2 V/500 Ah sealed lead acid batteries. The batteries will have sufficient capacity

to store 1.5 days of project electricity output that will meet around four days of electricity demand. DC drawn from the batteries will be converted to alternating current (AC) using an inverter then fed directly into the distribution line. All project components will be fenced.

Table 8.1: Main Project Components

Component	Quantity	Unit	Total
Wind Turbine	2	5 kW	10 kW
Solar PV	36	280 Wp	10 kWp
Battery Bank	220	2V/500 Ah	220V/1,000 Ah
DC/AC Inverter	2	30 kVA	60 KVA
Distribution System	**3 Phase**	**1 Phase**	1,600 m
	940 m	660 m	

324. Power will be distributed to households and other users in the three clusters (Figure 8.1) via three phase 400 V and single phase 230 V overhead transmission and distribution lines (1.5 km total length) that will run from the powerhouse to premises. The lines will be capable of being connected into the Nepal electricity grid at a later date if required.

Figure 8.1: Location of Chisapani Powerhouse and Benefiting Households

325. The local wind and solar resources are complementary in the hybrid system as stronger winds appear to occur at night while solar radiation is limited to daytime. In addition, the wind resource pattern appears to coincide well with the demand pattern that peaks in the morning and evening. While there is no recorded data on local wind speeds, based on villager reports

wind power generation is expected to occur for part of most days of the year when speeds exceed 3 m/s (minimum speed at which the turbines generate power), complementing daytime solar power conversion. A known period of limited to no wind occurs when it rains during part of the monsoon season, in June and July.

326. Solar power conversion will peak during the dry season months of April and May when the average hours of sunshine peak at 8.5-9 hours/day, while minimum generation at less than 40% of the peak rate will occur in the monsoon month of July when the average is just 4.5-5 hours per day[68].

327. Village daily demand for electricity has been estimated at 46 kWh in 2013 based on 66 households and ancillary uses, rising to 67 kWh in 2023 based on 80 households (Table 8.2). Average estimated demand per household is based on the use of a large range of appliances, but it is recognised that this is likely to be an overestimate at least in the early years as most households do not own the range of appliances that have been included in the demand forecast. This increasing demand over the next decade will be covered by the average daily electricity generation of the project (Table 8.3).

Table 8.2: Demand Forecast

User	Daily Electricity Consumption (kWh)		
	2013	2018	2023
Households	23	27	31
Businesses	18	23	29
Community	2	2	3
Project powerhouse	3	3	4
Total	**46**	**55**	**67**

Table 8.3: Estimated Average Daily Electricity Generation

Equipment	Rated	Quantity	Total	Capacity Factor	Daily Energy (kWh)
Wind turbine	5 kW	2	10 kW	15.0%	36.0
PV panels	280 kWp	36	10 kWp	17.0%	40.8
Average daily energy production					**76.8**

8.2 Description of the Environment

8.2.1 Physiographic Region, Topography and Drainage

328. The proposed project site is located in the Siwalik Hills physiographic region at an elevation of 366 m asl, on a 100 m high ridge above the Bagmati River. Topography in the project area consists of a ridge rising from the Bagmati River valley floor at around 265 m asl up to as high as 912 m asl on nearby hills. The project site lies on ridgetop land that slopes to the south at a grade of 2-8%. The turbine sites are on the crest of the ridge while the solar panel site lies on a dryland cultivated slope that is partly terraced (Figure 8.2). Side slopes off this east-west running ridge are steep, generally between 17-44^{o}. The Bagmati River valley drains to the southwest across the Nepal-India border into the Koshi River in Bihar state.

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[68] Bajracharya, B. T., 1996. *Climatic and Hydrological Atlas of Nepal.* Kathmandu: ICIMOD.

Figure 8.2: Chisapani Solar Panel Site – foreground and mid-ground

329. The proposed turbine sites have good exposure to wind to the north, east and west as this section of the ridge juts out to the north. The closest household is set back approximately 60 m from the nearest project site, a wind turbine location.

8.2.2 Climate

330. Chisapani has a warm subtropical climate, primarily due to its low elevation at 330-380 m. The area experiences strong seasonal climatic variations, with wet monsoons from June to September and dry weather from October to May. The project area has a mean maximum temperature of 30.3°C in June and mean minimum temperature of 16.6°C in January[69]. Rainfall data for a station in Hariharpur Gadhi valley, 4 km east of Chisapani village at 250 m asl, indicates that average monthly rainfall varies from 12.1 mm in December to 703.5 mm in July (Table 8.4), with 95% falling from May to October[70].

Table 8.4: Average Monthly Rainfall - Hariharpur Gadhi Valley (1991-2011)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hariharpur Gadhi Valley (mm)	15.8	13.5	16.1	53.4	179.0	385.6	703.5	586.3	363.4	88.8	9.1	12.1

Source: DHM, Kathmandu, Nepal.

331. The sun shines on around 300 days a year. The mean daily hours of sunshine at the site vary from a minimum of 4.5-5 hours in July to 8.5-9 hours in November (Table 8.5), compared with the national average sunshine hours of 6.8 per day. Average daily solar radiation varies between 3.6–6.2 kWh/m^2/day, with a yearly average of around 4.7 kWh/m^2/day.

Table 8.5: Average Daily Hours of Sunshine

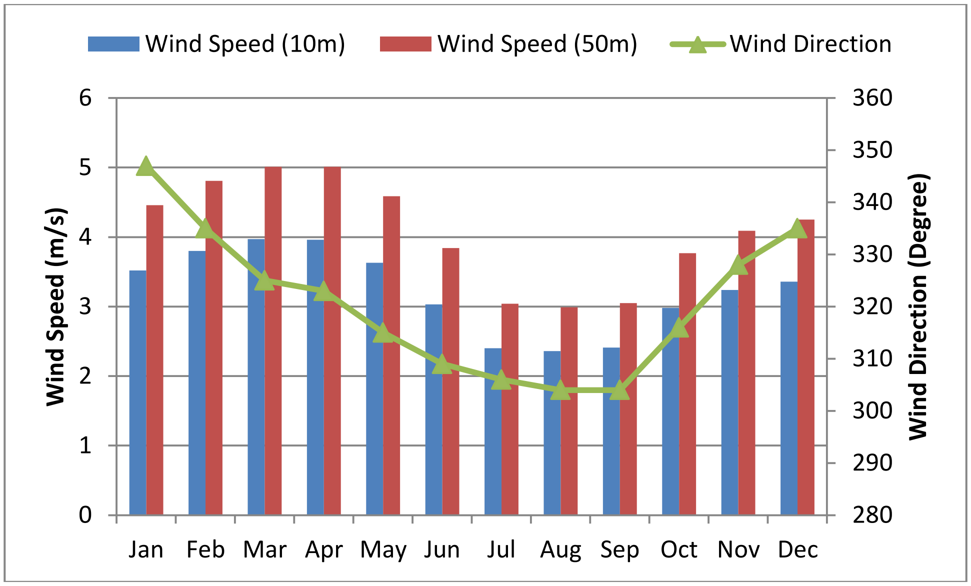
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
6.5-7	7.5-8	8-8.5	8-8.5	8-8.5	5.5-6	4.5-5	6-6.5	5.5-6	8-8.5	8.5-9	7.5-8

Source: (ICIMOD, 1996).

[69] MoFSc, 2005. *District-Wise Watershed Information Book.* Kathmandu: His Majesty's Government, Department of Soil Conservation and Watershed Management.
[70] DHM 2012, Department of Hydrology and Meteorology, Government of Nepal, Babarmahal, Kathmandu, Nepal.

332. The local wind resource is affected by topography at the site, but in the absence of measured wind speeds in the local area general data from NASA has been used as an approximate indication of the likely wind speeds at the site (Table 8.6).

Table 8.6: Average Monthly Wind Speed



Source: NASA, 2012 (http://eosweb.larc.nasa.gov/)

8.2.3 River Hydrology

333. The Bagmati River drains southwards through a valley, flowing across the Indian boarder approximately 89 km downstream of the project site. The river bed is steep at around 1.1° slope. 85% of river flows by volume occur in the monsoon season from June to September when there is the potential for flash flooding and riverbed scouring. Flooding during the monsoon is common, and floods broke over the main river banks in 2002.

8.2.4 Geology and Soils

334. Site geology is made up of the Siwalik Group, lying close to the boundary with the Sub Himalaya. The Main Boundary Thrust runs approximately 2 km from the site along the Bagmati River. The Siwalik Group consists of Middle-Miocene to Plio-Pleistocene molassic fluvial deposits, conglomerates, sandstone and shale with vertebrate fossils. The Sub Himalaya consists of Quartenary Alluvial deposits of Dun Basins. The main soil types found at the site are Udipsamments, Dystrochrepts and Rhodustalfs.

8.2.5 Land Use

335. The main land use types in the project area are: irrigated cultivation (khet) on small areas of flatter riverside land; dryland cultivation (bari) on terraced hillslopes; forests on steeper slopes; and grasslands in forest clearings and on marginal land. Most Chisapani households own khet land close to the river that provides the main source of household food and income due to high crop yields on this irrigated land. Forests are harvested for timber, fuelwood and non-timber forest products. Grazing occurs on grasslands.

336. The main local crops are paddy grown in summer, and mustard, maize, radish and soybean grown in winter, with potatoes grown as a single crop on non-irrigated fields. The main livestock are goats, cattle and poultry. Most dwellings have house gardens where a range of vegetables and herbs are grown, including pumpkin, green leafy vegetables, tomatoes and chillis.

337. Forests are located on public land (Figure 8.3) and are mainly used for livestock grazing and harvesting forest products (fuelwood and medicinal herb collection). National forest land lies adjacent to the three settlement clusters, mainly on the steeper ridgeline slopes. A registered community forest exists in the area: Dung Dunge Community Forest – 198 ha supporting 140 households. The boundary of the community forest lies to the north of the eastern cluster of 26 households. A private forest is located between the eastern and central clusters of houses (Figure 8.3). Local forests have around 50% canopy cover, with the main species being *Shorea robusta* (Sal), *Terminalia alata* (Saj), *Schima wallichii* (Chilaune), *Desmodium oojeinense* (Sandan), *Phylanthus emblica* (Amala) and *Semecarpus anacardium* (Bhalayo).

Figure 8.3: Chisapani Forest Areas and Distribution Line Forest Crossing

8.2.6 River Use

338. The stretch of the Bagmati River close to Chisapani village is used by Chisapani, Bhorleni, Sikre Dobhan, Kokati and Goth Danda villages. Uses along this river section include irrigation, fishing, waste disposal, and powering water mills. Pollution loads in this river are high as this river drains the Kathmandu valley.

8.2.7 Terrestrial Ecology

339. The proposed project site is located 240-300 m from the left bank of Bagmati River on dryland cultivation. The nearest forest boarders the eastern settlement cluster, situated on the ridge sideslopes. The forest consists of Sal (*Shorea robusta*), Indian Laurel (*Ficus nitida*), Needlewood schima (*Schima wallichii*), Sandan (*Desmodium oojeinense*), Indian gooseberry (*Phylanthus emblica*) and Marking nut (*Semecarpus anacardium*). The forest has 50% canopy cover and is regularly harvested. The main wildlife species in the area are Red Fox (*Vulpes vulpes*), Indian Porcupine (*Hystrix indica*), Rhesus monkey (*Macaca mullata*) and Common Langur (*Presbytis entellus*) (Dung Dunge Community Forest User Group members - pers. comm.), typical species found on hill farming land in the lower Siwaliks.

340. The closest protected area to the site is Chitwan National Park, located approximately 50 km west. The site is located on the eastern boundary of the Terai Arc Landscape (TAL), a conservation initiative of the Department of National Parks and Wildlife Conservation and WWF Nepal. This broad area encompasses 11 protected areas in Nepal and trans-boarder protected areas in India, and was established to protect this Himalayan landscape (86 species of mammals, 550 species of birds, 47 species of herpato fauna, 126 species of fish and over 2100 species of flowering plants[71]).

8.3 District, VDC and Project Area Socioeconomic Profile

341. Sindhuli is among the least developed Districts in Nepal, with a Socioeconomic and Infrastructural Development Index rank of 58 out of 75 districts[72]. According to the 2001 census, 59.1% of farm households are classed as Marginal in the district (farm size <0.5 ha), road density is 3.77/100 km^2 (rank 52), health institution density is 2.08 (rank 51) and per capita development budget expenditure is NPR 473 (rank 69).

342. Hariharpur Gari VDC has a total population of 4,744 (Table 8.7) (Population Census, 2011), with an average household size of 6.7. The 66 households that comprise Chisapani village have a population of 464 (average 7.03/household), located in three clusters of 26, 21 and 19 households from east to west along a 700 m section of the ridge. The village population consists of 47% male and 53% female.

Table 8.7: VDC Population

VDC	Population				Total Households	Household Size
	Male	Female	Total	Sex Ratio		
Hariharpur Gadhi	2,253	2,491	**4,744**	90%	708	6.7

Source: Population Census, 2011, CBS.

343. The strongly dominant ethnic group in Hariharpur Gadhi VDC is Tamang, comprising 95% of the total population. Other groups present are Dalit (2%) and Magar (1%) (Table 8.8).

Table 8.8: Ethnic Composition by VDC

VDC	Population			
	Tamang	Dalit	Magar	Others

[71] Flemming st al., 1975; Maskey, 1992; Shah, 1995; Gurung, C. P., 2005. Terai Arc Landscape. In U. R. Sharma, & P. B. Yonzon, *People and Protected Areas in South Asia* (pp. 134-137). Kathmandu: IUCN World Commission on Protected Areas, South Asia and Resources Himalaya Foundation.

[72] ICIMOD, 2003. *Districts of Nepal, Indicators of Development Update*. Kathmandu, Nepal: ICIMOD and CBS.

	(Janajati)		(Janjati)	
Hariharpur Gadhi	3,820	71	49	65

Source: Population Census, 2001.

344. Household decisions are primarily made by the male head of the house, with women having less power in family decision making. Most water collection and fuelwood and fodder gathering is done by women, with men undertaking most of the field ploughing.

8.4 Livelihoods

345. Subsistence agriculture, consisting of irrigated and rainfed cultivation and livestock raising, is the main livelihood earning activity in the project area. In addition, many households rely on remittances provided by male household members working elsewhere in Nepal or internationally.

346. Agricultural land and livestock holdings of households in Hariharpur Ghadi VDC are summarised in Table 8.9. Ownership of agricultural land is common, with 98% of households reporting ownership. Livestock are also owned by most households, used for subsistence and income generation. Fishing provides a source of food and livelihood for some residents of Chisapani, however following construction of the Bagmati dam 38 km downstream fish numbers have declined and the fish catch has reduced as a result of this (Chisapani villagers – pers. comm.).

Table 8.9: Ownership of Agricultural Land and Livestock in Project VDC

VDC	Households Owning				Total Households
	Agricultural Land Only	Land and Livestock	Land, Livestock and Poultry	Other	
Hariharpur Gadhi	18	9	541	14	582

Source: Population Census, 2001.

8.5 Energy Supply and Use

347. The main sources of energy in the project VDC were reported to be: fuelwood for cooking and heating (almost 100% of households at an estimated rate of 13 Bhari (455 kg) per household per month[73]); biogas (from cow dung and toilets, with an average unit size of 4 m^3) for cooking (25% of households); solar power for lighting (64% of households)[74], with peak output per system between 10-30 Wp; LPG for cooking (approximately 17% of the households); and kerosene for lighting (25% of households)[75]. Households using LPG for cooking also use fuelwood for cooking, but consume only 19% of the fuelwood volume of non-LPG households.

348. The SREP household survey of 11 sampled households indicated that the average monthly household expenditure on cooking and lighting is NPR 1,676 (cooking NRS 1,364,

[73] ADB, 2012. Social Survey. *PPTA Social Survey TA-8081 NEP: Scaling Up Renewable Energy Project - Minigrid (Solar and Wind) – SWM01/SREP/2013*. Chisapani, Hariharpur Gandi – 8, Sindhuli, Nepal.: SREP ADB Team.

[74] ADB, 2012. *PPTA Technical Report - TA-8081 NEP: Scaling Up Renewable Energy Project - Minigrid (Solar and Wind) – SWM01/SREP/2013 Chisapani, Hariharpur Gandi – 8, Sindhuli, Nepal.*

[75] ADB, 2012. Social Survey. *PPTA Social Survey TA-8081 NEP: Scaling Up Renewable Energy Project - Minigrid (Solar and Wind) – SWM01/SREP/2013*. Chisapani, Hariharpur Gandi – 8, Sindhuli, Nepal.: SREP ADB Team.

lighting NPR 312). Household kerosene use for lighting averages 4 L/month. The average monthly expenditure on solar home systems per household is NPR 267.

349. Three diesel-powered rice mills used for husking are operated in Chisapani village. The mills each consume 30-60 L of diesel per month, except during the Diwali and Dashain festivals (one month) when diesel consumption rises to 100 L/month. The monthly cost of diesel per mill was reported to be NPR 4,950 (based on NPR 110 per litre).

8.6 Water Supply

350. The main supply of domestic water in Chisapani village comes from a local hillside spring in Betini. Water is reticulated by gravity from the spring by a system of polyethylene and steel distribution pipes to community taps in Chisapani. Water quality from these taps is good, but the quality of local river water for drinking is poor due to high levels of *E. coli* from livestock in the catchment and the use of watercourses for village sanitation purposes.

8.7 Transport and Local Services

351. Access to the site is primarily gained from Hetaunda Municipality (approximately 65 km west of the village) via a fair-weather (earth) road to Bhorleni village, along which regular bus services run. A section of this road is currently under construction and aims to connect Chatara of Sunsari District. Several sections of this road cross braided river channels due to a lack of bridges. Public buses connect Bhorleni village to the following VDCs: Hariharpurgadi and Mahindrejhyadi in Sindhuli District; Betini in Makwanpur District; and Milche, Dandagaun, Phalametar, Ghartichapp, Saldhara, Salme, Gokule and Banakhu in Kavrepalanchok District. Accordingly, Bhorleni village serves as the gateway for 40,511 people[76] in the project area and neighbouring VDCs. From Borleni a fair-weather (earth) road runs down to the Bagmati River, with a ford across the Bagmati River, crossing riverside cultivation land and climbing up to Chisapani. The road is mainly used by tractors due to the need to ford the river.

352. The Government school in Chisapani provides classes up to 10th grade. The village does not have a Health Post, with the nearest chemist shops and dispensary located in Bhorleni village around 15-20 minutes walk from Chisapani, where basic goods are obtained. Communication services in the project area consist of CDMA mobile telephony and a CDMA booth in Bhorleni village. Most adult residents of Chisapani own a mobile phone.

8.8 Impacts and Mitigation Measures

8.8.1 Biophysical Impacts

353. The 20 kW solar-wind power project will provide a net environmental and social benefit, while creating minor adverse impacts.

354. **Land use change:** the total land area required for project installation is estimated to be 500 m^2 (0.05 ha). Each wind turbine will be mounted on 12 m high steel towers on cultivation land, occupying a base pad area of 1 m^2. Four immature trees on the northern side of the site are likely to be removed as they partly impede the predominant wind flow. Around 20 m of power line will connect the turbines to the powerhouse, mounted on 4 m high poles that will each occupy less than 1 m^2/pole.

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[76] Population 2011, CBS, Nepal.

355. The land area required for solar panel installation is estimated to be 36 m^2 (1 m^2 per photovoltaic panel), roughly equivalent to the footprint of two local houses. A 20 m long power line will connect the solar panels to the powerhouse, strung on 4 m high poles. The solar panels will be mounted on stands on open cultivation land, while the poles will also be in located on cleared land, therefore no forest land will be converted and no existing structures will be removed. The powerhouse housing the bank of batteries will occupy around 40 m^2 (5.5 m x 7.3 m), while distribution line poles will each cover less than 1 m^2 per pole.

356. The area that will be occupied by the wind turbines, solar panels and powerhouse, totaling an estimated 500 m^2 of rainfed cultivation land, will reduce crop production by the equivalent of 115 kg of rice per annum (based on an average yield of 2.3 T/ha[77]). It is proposed that this privately-owned land owned by two landowners will be donated to the User Committee in return for a long-term project job.

Mitigation Measures

- Minimal land area will be utilized for permanent project structures, including power line RoWs.
- Care will be taken to avoid the disturbance of crops and other vegetation outside the land area required for permanent project sites.
- Temporarily disturbed land will be rehabilitated after use by removing excavated spoil and waste, and revegetating.
- Poles will be located on land with low economic value wherever possible and on the edge agricultural fields to avoid creating obstacles in plots.
- Temporary construction sites will be located on low value land where possible, and no temporary sites will be located on forested land.
- Disturbed areas will be revegetated.

357. **Spoil disposal:** small volumes of spoil will be generated from the excavation of each wind turbine foundation, limited to around 1.6-2 m^3 of spoil per foundation (allowing for bulking from the excavation of 1 m^3). Around 10-30% of this material will be topsoil and the rest will be subsoil and/or rock.

Mitigation Measures

- The site landowner will be asked if he/she wishes to use the excess spoil, and if so it will be made available free of charge.
- Only topsoil will be disposed of on cultivation land, with the permission of the landowner.
- Disposed spoil will be revegetated where possible.

358. **Habitat loss:** all project components will be constructed on cleared cultivation land apart from short sections of distribution line (primarily through a section of forest between the central and western village clusters). A 3.0 m wide cleared right-of-way (RoW) will be established and maintained under the 230/400 V power lines. The total area of forest to be cleared to establish the distribution line RoWs is estimated to be 300 m^2, but this forest type has limited habitat value due to high human use and is well represented in the local area.

Mitigation Measures

[77] MoAD, 2010. *Statistical Information on Nepalese Agriculture 2010/11*. Singhadurbar, Kathmandu, Bagmati, Nepal.

- Vegetation clearance will be kept to the minimum required to install the project, including restricting the power line RoW to the required width (1.25 m between the line and a house or tree as per the Electricity Regulation (1993)[78] plus an assumed 0.5 m to allow for line swing).
- Sites and to be cleared and individual trees to be removed will be clearly marked prior to clearance and permission will be obtained from the landowner or Community Forest User Group to remove this vegetation.
- Tree clearance will be restricted to cutting down trees to ground level, with the retention of tree stumps and roots.

359. **Noise:** the main sources of noise from wind turbines are from blade movement through the air and turbine mechanical noise. The nearest house to a turbine site is located 60 m to the south-east. Noise from turbines primarily propagates downwind, therefore downwind sites receive the greatest noise impact. Given that the predominant wind direction is from 300-350^o, the nearest cluster of houses will be in the downwind area for much of the time that the turbines are generating power. Noise levels at these dwellings are only estimated to be around 40-45 dB(A) when they are directly downwind when wind speeds are between 5-8 m/s, and less at lower wind speeds, using the Evance 9000R 5 kW turbine as an example[79]. These levels will be equal to or less than the World Bank guideline limit for residential areas of 55 dB(A) daytime and 45 dB(A) night-time. At wind speeds above 8 m/s the background noise of wind moving through trees, etc usually exceeds the noise produced by the wind turbines.

Mitigation Measures

- Construction activities will be restricted to daylight hours to minimize disturbance, and local communities will be informed of the construction schedule.
- Site turbines with a minimum setback of 50-60 m from the nearest dwelling.
- GoN health and safety regulations will be adhered to.
- Construction workers and operation staff will be provided with personal protective equipment as required.

360. **Bird mortality:** moving wind turbine blades can cause bird and bat death and injury, although this hazard is difficult to quantify. Waterbirds are thought to be at greater danger from moving blades due to their generally slower flight. The nearest waterbody to the Bagmati River, lying 200-300 m to the north, at 100 m lower elevation. Bird life on the river is sparse, mainly consisting of Indian Pond Heron (*Ardeola grayii*) and Cattle Egret (*Bubulcus ibis*). Overall the hazard to bird life from moving blades is estimated to be low, largely due to the relatively low height of the blades (maximum height 14.5 m off the ground), small swept area of the blades (5 m diameter) and the lack of birdlife.

361. **Aviation hazard:** the wind turbines (14.5 m high to blade tip) will not create an aviation hazard as the site is located in a large valley and the total height of the structure on the ridge is low. The white or off-white blades and towers will be highly visible at most times.

362. **Interference with telecommunication and television signals:** mobile phone signals are transmitted and received via a telecommunications tower located approximately 10 km to the east, in Ward 2, Hariharpurgadi VDC. None of the three village clusters are located immediately west of the turbines, but phone reception at dwellings will be monitored to identify if any loss of reception occurs. Given that several mobile companies propose to construct new

[78] Government of Nepal, 1993. *Electricity Regulation 2050*.
[79] http://www.evancewind.com/images/uploads/products/Evance_R9000.pdf

towers close to the village there is unlikely to be an impact. Television signals in the village are received by satellite dishes mounted on dwellings and the wind turbines are set back 60 m from the nearest residences, therefore the turbines will not interfere with TV signals.

363. **Waste management:** the main waste that will be produced by the project is used lead acid batteries (ULAB) that require replacing every eight years or so. Solar panels have a guaranteed life of 25 years therefore they will not produce waste for a considerable period of time unless they are physically damaged. The wind turbines do not produce waste apart from any parts that require replacement from time to time.

364. Lead acid batteries need to be recycled to avoid pollution from the lead plates and the sulphuric acid that the plates sit in. Recycling involves the recovery of lead to produce new batteries. Local scrap dealers collect lead for (i) crushing then transportation to India for processing, or (ii) local recycling in small quantities by a battery company, however, neither method is environmentally safe[80]. Informal battery recycling involves breaking open the battery case by hand and melting down the lead plates on small fires or stoves to recover it. This process poses a health hazard from: (i) inhaling lead toxins during the melting process; (ii) contact with lead particulates in battery acid; (iii) contact with or inhaling lead dust generated from dry soil contaminated with lead particulates; and (iv) ingesting contaminated water. Lead scraps left in the open also pose a health hazard from direct contact. Accordingly, disposal has to be in accordance with sound procedures to avoid human health issues and soil and water contamination.

365. Villagers in Chisapani reported that spent lead acid batteries are usually disposed of locally rather than being collected for reuse as occurs at other sites. Some surveyed households have retained used batteries inside their houses, but it is assumed that many spent batteries have been disposed of in informal landfills on the banks of Bagmati River.

366. Nepal, as a party to the Basel Convention on transboundary movements of hazardous waste and their disposal, plans to install a lead recycling plant that will operate in accordance with the Convention's rules and guidelines. AEPC is in the process of selecting a site for the plant, with sites under consideration at Biratnagar and Hetaunda. AEPC will facilitate the recycling of all SREP sub-project ULABs in this facility. This may involve a public-private partnership where ULABs are purchased at 13 District collection centres and then transported to the recycling facility. The Government is currently preparing a lead acid battery management regulation.

367. AEPC will provide an information pamphlet to the project User Committee detailing the required ULAB disposal procedure. Each battery will be labeled with a contact phone number to obtain current advice on how to safely dispose of batteries given that the first set will operate for around eight years. AEPC will also mail out any new information on safe battery disposal to the school (such as new Government regulations and recycling facilities), while it is also considering a maintenance contract with private companies using a battery voucher program to promote the central collection and recycling/reuse/disposal of battery components either through scrap dealers or solar power companies.

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[80] Wald, A., and Lemor, R., 2009. *Report on Lead Acid SHS Battery Recovery System in Nepal.* Kathmandi: German Financial Cooperation in Nepal.

368. In addition, used energy efficient (CFL and LED) bulbs pose a toxic hazard risk. These bulbs contain excessive levels of leachable lead and high levels of copper and zinc[81]. Total metal content is around 10 times higher in CFL bulbs and around 150 times higher in LED bulbs compared to incandescent bulbs, therefore it is important that they are disposed of properly.

Mitigation Measures

- Residual construction materials and waste will be collected, reused, recycled or disposed of safely, in accordance with standard and accepted safe practices.
- Non-hazardous wastes such as packaging (e.g. wooden framing around electrical components) will reused wherever possible for other purposes or disposed of by burying in a pit away from water sources and settlements.
- Pamphlets will be provided to households outlining the safe handling and disposal of used ULABs and CFL/LED lamps to prevent a risk to human health and the environment. This will include cleaning up broken bulbs by:
    - proper ventilation of rooms prior to cleaning;
    - avoid using brooms to clean up powder to avoid spreading the particles; and
    - wash hands after cleaning.

369. **Reduction in indoor and outdoor air pollution:** the replacement of kerosene lamps with solar-wind powered CFLs for household lighting will eliminate this source of indoor air pollution, while the conversion of diesel-powered rice mills to electricity will improve air quality at these facilities. A secondary source of house lighting comes from the burning of fuelwood in cooking stoves, for cooking year-round and heating in winter. Fuelwood use is likely to continue at a similar rate as these primary uses will continue.

370. **Greenhouse gas emissions reduction:** the volume of carbon emissions (CO_2) that are likely to be avoided by project power replacing (i) kerosene lighting and (ii) diesel use in the rice mills are estimated to total 2.0 T/a and 4.2 T/a respectively (Table 8.10).

Table 8.10: Estimated Annual CO_2 Emissions Avoided by Replacement of Kerosene and Diesel

Category	**Value**
Number of HHs using kerosene[1]	17
Average kerosene consumption/HH/month[1]	4 L
Total yearly kerosene consumption	816 L
Kerosene energy content per L[2]	37.0 MJ
Total energy from kerosene[3]	28.6 MMBtu
Total annual CO_2 emissions from kerosene	**2.0 T**
Yearly consumption of diesel by rice mills (3)	1,620 L
Diesel energy content per L[4]	37.3 MJ
Total energy from diesel[3]	57.2 MMBtu
Total annual CO_2 emissions from diesel	**4.2 T**

Sources:
1 - SREP Social Survey, 2012.
2 – RETRUD-03 Conference Paper, CES, TU Pg. 273.

[81] Lim, S.-R., Kang, D., Oladele, A. O., & Julie, M. S., 2012. Potential Environmental Impacts from the Metals in Incandescent, Compact Fluorescent Lamp (CFL), and Light-Emitting Diode (LED) Bulbs. *Environmental Science & Technology*.

3 – http://www.unitjuggler.com/convert-energy-from-kJ-to-MMBtu.html
4 - http://en.wikipedia.org/wiki/Energy_density

8.8.2 Socio-Economic Impacts

371. The socio-economic impacts that will occur from project construction and operation, providing a greater and more reliable power supply, will primarily be beneficial.

372. **Greater power supply and improved supply reliability:** the main benefits of an improved power supply will be:

- (ix) improved house illumination;
- (x) the option to run a range of household appliances such as a refrigerator, television and radio;
- (xi) operation of community facilities such as street lighting; and
- (xii) greater business opportunities, such as a sawmill and electric sewing.

373. The local school will not be provided with power as it is located too far from the power house site.

374. Solar-wind power will enable the operation of a range of equipment by an estimated 66 households (464 people) that is not operated in the village due to a lack of electricity, or will be replaced by the provision of electricity. Foremost among the additional facilities are room lights, televisions, computers and refrigerators, and possibly a sawmill, furniture manufacturing enterprise and irrigation pumps. Seven streetlights will be powered in the village. In addition, the three existing diesel-powered rice husking mills are each likely to be converted to electricity and run part-time. These new and replaced facilities will result in improved living conditions and increased economic activity in the village.

375. Irrigation from the Bagmati River using electric pumps powered by the project may be possible, although irrigation feasibility will have to be assessed due to a high pollutant load in river that may cause adverse health effects. Local people indicated that sludge in irrigation water sourced from the Bagmati River, containing manure, is highly productive and greatly increases crop yields.

376. **Conversion of the mills:** the three diesel-powered mills can be converted to electricity with the addition of a 10 Hp electric motor at each mill at an approximate cost of NRS 21,000-35,000/motor.

377. **Visual impact:** the visual impact of two wind turbines and 36 solar panels is considered to be low given the location in the valley at a relatively low elevation and the size of these structures.

378. **Safety hazards:** solar panels and wind turbines produce electricity at 230 V which poses a risk of electrocution if contact is made with live lines, therefore safety protection is required. Each wind turbine, the bank of solar panels and the powerhouse will each be fenced to prevent public access. All electrical equipment, power lines and cables will be insulated in accordance with standard Nepal safety requirements. This includes installation and handling safety measures such as keeping children away from the components and not wearing metallic objects/jewelry while handling equipment. Lightning protection will be provided by earthing each

turbine, the solar array and bank of batteries using a copper earth rod, with soil conductivity improved with the incorporation of coal and salt in the soil[82]. Lighting protection on the wind turbines will be provided by a conductor on top of each tower, earthed to the ground via the tower.

379. As there is no wind data available for the site, Class 1B turbines will be installed, capable of withstanding gusts of up to 50 m/s (180 km/hr). The probability of a turbine catching fire or a blade flying off a turbine is very low, but given that the turbines are located 60 m away from the nearest dwelling the hazard to human life is considered negligible.

Mitigation Measures

- The wind turbines, solar panels and powerhouse will be fenced to prevent access, with signs fitted to warn people not to enter due to the electrocution hazard.
- A general awareness program on safety will be conducted for local residents, including the issuing of a safety pamphlet to villagers specifying hazards and prohibited activities (Appendix I).

380. **Improved respiratory health:** the removal of kerosene lamps will improve air quality (reducing particulate matter and carbon monoxide levels) inside homes. As most households will continue to use wood stoves for cooking, the improvement in the overall respiratory health (i.e. reduction in respiratory irritation and possible reduction in respiratory infections) is expected to be limited as the long term effects of poor indoor air quality from wood burning at home will greatly outweigh the short-term improvement in air quality provided by the clean energy lighting. The replacement of diesel-powered mills will improve outdoor air quality near these facilities.

381. **Reduced energy cost:** 20% of the project installation cost will be provided by the community, most likely in the form of labour, with the remaining cost met by the Government. A one-off subscription cost of NPR 7,000/household will be charged to households connecting to the project that will be used to establish the project maintenance fund. On-going project running costs will primarily be met by user households and businesses, with support sought from charities to reduce these costs.

382. The monthly household cost of lighting, cooking and other energy uses currently provided by fuelwood, biogas, LPG, kerosene and diesel is predicted to decrease slightly once households commence using project electricity. The estimated monthly solar-wind project running cost (operation and maintenance cost) is NPR 320/household. Assuming that kerosene use and solar home systems will be replaced by project power, while LPG and firewood will continue at the current rate, the monthly cost of energy per household is expected to decrease slightly from a total of NRS 1,676 at present to NPR 1,668, a decrease of NPR 8.

383. It is estimated that the three diesel mills consume a total of around NPR 178,200 (NPR 59,400/mill) of diesel per year, compared with the estimated cost of project electricity to run a single mill of NPR 57,600 per year (based on total usage of 8 kWh/day charged at NPR 20/kWh (the rate charged by a solar-wind project in Nawalparasi District). It is estimated that three electric mills each running for a third of the time will be able to replace the three diesel-powered mills, therefore the net fuel saving will be around NPR 120,600/annum.

384. **Employment:** project installation will take an estimated 30 person-days, requiring skilled and unskilled labour. Project employment during operation will consist of a full-time technician

[82] SREP, 2012 – pers. comm.

and two part-time staff to read electricity meters and undertake routine inspections of the turbines, solar panels and batteries. The two part-time staff will be sourced from Chisapani village and trained as a component of the project.

9. KYANGSINGH SOLAR SUB-PROJECT

9.1 Project Description

385. The 12.6 kW Kyangsingh Solar Mini-grid (SM) Project is proposed to provide power to Kyangsingh village, Ward 8 of Gumba VDC, Sindhupalchok District, in the Central Development Region of Nepal. The project will supply an estimated 53 households, a primary school, a community building, a stupa (chorten) and street lights. Each household is anticipated to use four CFL bulbs (5-15 W) and run a radio, TV/DVD, tape recorder, two kitchen appliances/grinders, refrigerator, computer with LCD monitor, mobile phone charger and one other item (e.g. a fan) with power from the project. The primary school will be able to run four 40 W lights, a television/DVD and two computers, while the stupa will be provided with sufficient power to run four 25 W lights. Five 20 W street lights will also be powered by the project

386. Kyangsingh village consists of 53 houses mainly in a single main cluster, with some outlying houses and a nearby school. The project is designed to generate 26,579 kWh energy each year. The project was initiated by the residents of Kyangsingh village, who made representation to AEPC via Gumba VDC. These residents subsequently formed the Kyangsingh Sourya Urja Users Committee to develop the project.

387. The solar mini-grid project will consist of 45 photovoltaic solar panels each with 280 Wp capacity, providing 12.6 kWp total system capacity. The solar panels will be mounted on inclined stands around 1 m in height, connected to a bank of batteries to be housed in a nearby powerhouse (40 m^2) via an underground power line less than 20 m long. Direct current (DC) electricity from the solar panels will be used to charge a bank of 220 VRLA Gel 2 V/800 Ah sealed lead acid batteries. The batteries will have sufficient capacity to store two and a half days of project power output that will meet around six days of electricity demand. DC drawn from the batteries will be converted to alternating current (AC) using an inverter, then fed directly into the distribution line. The solar panels and powerhouse will be located on open cultivation land next each other and each component will be fenced. Power will be distributed to households and other users via single phase 230 V and three phase 400 V and overhead distribution lines that will run from the powerhouse to premises.

Table 9.1: Main Project Components

Component	Quantity	Unit	Total
Solar PV	45	280 Wp	12.6 kWp
Battery Bank	220	2V/800 Ah	220 V/1,600 Ah
DC/AC Inverter	2	20 kVA	40 kVA
Distribution System	**3 Phase**	**1 Phase**	950 m
	140 m	810 m	

388. Solar power conversion will peak during the dry season months of April when the average hours of sunshine peak at 7.5-8 hours/day, while minimum generation at less than 40% of the peak rate will occur in the monsoon month of July when the average sunshine is just 2.5-

3 hours per day. During these periods of low solar conversion it is estimated that sufficient electricity will be produced each day to power the village's daily room lighting requirement.

389. Village daily demand for electricity has been estimated at 38.0 kWh in 2013 based on 53 households plus ancillary uses, rising to 55.9 kWh in 2023 based on 64 households and ancillary uses (Table 9.2), with household demand assumed to increase by 3% per annum and business demand assumed to increase by 5% per annum. Average estimated demand per household is based on the use of a large range of appliances, but it is recognised that this is likely to be an overestimate at least in the early years as most households do not own the range of appliances included in the demand forecast. This increasing demand over the next decade will be covered by the average daily electricity generation of the project (Table 9.3).

Table 9.2: Demand Forecast

User	Daily Electricity Consumption (kWh)		
	2013	**2018**	**2023**
Households	16.6	19.3	22.3
School	1.6	1.9	2.2
Businesses	17.0	21.7	27.7
Community	1.1	1.3	1.5
Project powerhouse	1.6	1.9	2.2
Total	**38.0**	**46.0**	**55.9**

Table 9.3: Estimated Average Daily Electricity Generation

Equipment	Rated	Quantity	Total	Peak Sun	Daily Energy (kWh)
PV panels	280 kWp	45	12.6 kWp	5.78%	72.82

9.2 Description of the Environment

9.2.1 Physiographic Region, Topography and Drainage

390. The proposed project site is located in the Middle Mountains physiographic region at an elevation of 2,650 m asl. The village is situated on a steep south-west facing slope at a grade of around 20-25% that has been terraced, around 1,200 m above the Balephi River. The solar panel site lies on terraced dryland cultivated (Figure 9.1 – near the lowest house). The Balephi River valley drains to the southwest into the Bhote Koshi River, Indrawati River, Koshi River and eventually crossing the Indian boarder approximately 330 km downstream of the project site.

Figure 9.1: Kyangsingh Village – looking west

9.2.2 Climate

391. Kyangsingh has a temperate to subtropical climate, with cool to mild winters and warm summers. The area experiences strong seasonal climatic variations, with wet monsoons from June to September and dry weather from October to May. The project area has a mean maximum temperature of 22.5°C in June and mean minimum temperature of 11.4°C in January (MoFSc, 2005). Rainfall across the year is highly variable. Rainfall data from a station in Gumthang, 13.8 km south of Kyangsingh village at 2,000 m asl, indicates that average monthly rainfall varies from 22 mm in December to 1,006 mm in July (Table 9.4), with 92% falling from May to October (Department of Hydrology and Meteorology (DHM)).

Table 9.4: Average Monthly Rainfall (1991-2011)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Gumthang (mm)	32.5	49.0	51.3	130.9	317.5	629.5	948.4	1,005.5	703.2	187.1	32.4	22.4

Source: DHM 2012, Kathmandu, Nepal.

392. The sun shines on around 300 days a year. The mean daily hours of sunshine at the site vary from a minimum of 2.5-3 hours in July to 7.5-8 in April (Table 9.5), compared with the national average sunshine hours of 6.8 per day. Average daily solar radiation varies between 4.15–6.76 kWh/m^2/day, with a yearly average of around 5.24 kWh/m^2/day[83]. Local people reported that it snows for periods during the three months of December-February, reaching a depth of up to 300 mm.

[83] ADB, 2012. *PPTA Technical Report - TA-8081 NEP: Scaling Up Renewable Energy Project - Minigrid (Solar) – SMG01/SREP/2013 Kyanshingh, Gumba – 8, Sindupalchok, Nepal.*

Table 9.5: Average Daily Hours of Sunshine

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
6.0-6.5	6.5-7.0	7.0-7.5	7.5-8.0	6.5-7.0	4.5-5.0	2.5-3.0	3.5-4.0	3.5-4.0	6.5-7.0	7.0-7.5	6.0-6.5

Source: Climatic and Hydrological Atlas of Nepal, MENRIS, ICIMOD, 1996.

9.2.3 Geology and Soils

393. Site geology is made up of Higher Himalayan Crystallines consisting mainly of Preambrian high grade metamorphic rocks comprising gneisses, quartzites and marbels. Migmatites and granite gneisses are present predominantly in the upper part[84]. The main soil types are Dystrochrepts, Haplumbrepts and Haplustalfs. Small landslides have occurred in areas above the village due to heavy rainfall several years ago.

9.2.4 Land Use

394. The main land use types in the project area are: dryland cultivation (bari) on terraced hillslopes adjoining the village; forests on hillslopes, primarily above the village; and grasslands in forest clearings and on marginal land (Figure 9.2). Most Kyangsingh households own nearby bari land that provides an important source of household food and income. The main local crops are potatoes, maize and barley grown in summer taking up to nine months from sowing to harvest. Most dwellings have house gardens where a range of vegetables and herbs are grown, including local varieties of garlic (Sherpa Lahsun) and green leafy vegetables.

Figure 9.2: Kyangsingh Village Land Use Pattern

[84] HMG, 1993. Geological Map of Nepal. (K. M. Amatya, B. M. Jnawali, P. L. Shrestha, N. D. Makse, & P. Hoppe, Compilers) Survey Department, Kathmandu, Nepal.

395. The local area is dependent on pastoralism and trade in medicinal plants as crop production does not provide sufficient food throughout the year. The main livestock are goats, cattle, sheep and chauri (a cross between a yak and hill cattle). Forests, primarily on public land, are harvested for timber, fuelwood and non-timber forest products, and grazed. National forest lies to the north of the village (Figure 9.2) that is harvested for forest products (fodder, fuelwood and medicinal herb collection) and used for seasonal livestock grazing. Local forests have around 60% canopy cover, with the main species being *Quercus sps.* (Oak), *Tsuga dumosa* (Hemlock), *Pinus wallichiana* (Himalayan Pine), *Rhododendron arboreum* (Tree Rhododendron), and *Edgeworthia gaedneri* (Nepalese Paper Bush). The lekh (upper slope) of Sindhupalchok forest declined from 86% in 1978 to 65% in 1992[85], but forest cover was then reported to have increased by 20% from 2000-2005 in some areas close to the Kyangsingh village[86]. There are no community forests in the area but Kyangsingh villagers are contemplating registering the area to protect it from being over-harvested by people further afield and resulting in slope destabilization and erosion.

396. Livestock are moved from Kyangsingh to higher pastures in alpine meadows in spring, and return to the village area in autumn. Herds of water buffalo and cattle are grazed separately[87]. Many local people are dependent on trade of many medicinal plants, with the caterpillar fungi *Cordypses senensis* (Yarsa Gumba) of particular importance. The yield of this species is decreasing due to over-harvesting, premature harvesting and perhaps affected by climate[88].

9.2.5 Terrestrial Ecology

397. The proposed project site is located on southern slope of an east-west oriented ridgeline. Forests are located on steep mountain slopes adjacent to Kyangsingh village. Forest cover consists of temperate mountain *Quercus sps.* (Oak), *Abies spectabilis, Rhododendron arboretum, Berberis chitria* with around 60% canopy cover[89]. Common wildlife species found in these forests include leopard (*Panthera pardus*), fox (*Vulpes vulpes*), Kalij pheasant (*Lophura leucomelanos*), Rhesus monkey (*Macaca mulata*) and Assamese monkey (*Macaca assamensis*). Locals villagers have been facing increasing crop losses from invaders, mainly Barking Deer, Wild Boar, Mongoose and Pheasants.

398. **Protected Areas:** Gumba VDC is located within the newly declared Gaurishankar Conservation Area, primarily designated to form a corridor between Sagarmatha National Park (eastern side) and Langtang National Park (western side). The Conservation Area rises from

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85 Rayamajhi, S., Messerschmidt, D., and Jackson, W., 2000. Indigenous Livestock Grazing and Management Impacts in Upper-Slope Forests of Nepal. In C. Richard, K. Basnet, J. P. Sah, & Y. Raut (Ed.), *Grassland Ecology and Management in Protected Areas of Nepal. III*, pp. 3-31. Kathmandu: ICIMOD.

86 Mulligan, M., 2007. *VCF_change : a Google Earth visualisation of MODIS VCF tree cover change globally (2000-2005) Version 1.0.* Retrieved 05 28, 2011, from Google Earth: http://www.ambiotek.com/trees

87 Rayamajhi, S., Messerschmidt, D., and Jackson, W., 2000. Indigenous Livestock Grazing and Management Impacts in Upper-Slope Forests of Nepal. In C. Richard, K. Basnet, J. P. Sah, & Y. Raut (Ed.), *Grassland Ecology and Management in Protected Areas of Nepal. III*, pp. 3-31. Kathmandu: ICIMOD.

88 REUTERS, 2012, July 31. *The Himalayan Times*. Retrieved August 20, 2012, from Nepal harvest rush threatens "Himalayan Viagra": http://www.thehimalayantimes.com/fullNews.php?headline=Nepal+harvest+rush+threatens+%26quot%3BHimalayan+Viagra%26quot%3B&NewsID=341634

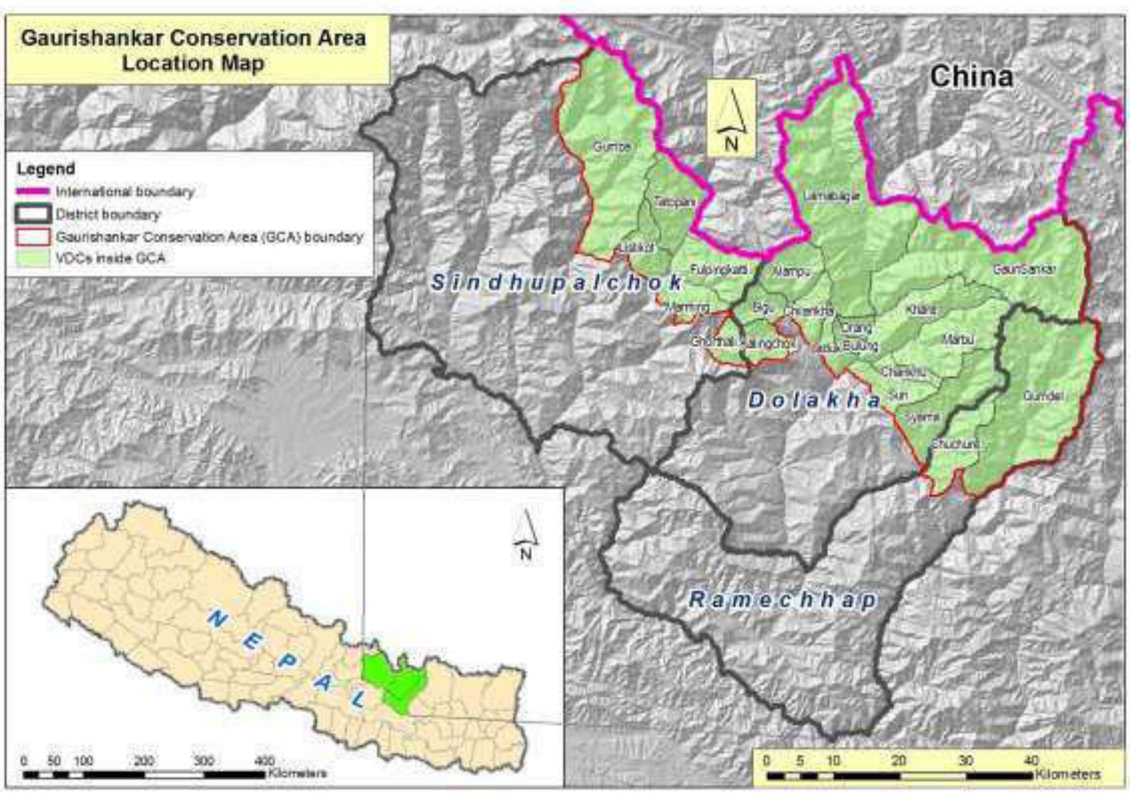
89 Mulligan, M., 2007. *VCF_change : a Google Earth visualisation of MODIS VCF tree cover change globally (2000-2005) Version 1.0.* Retrieved 05 28, 2011, from Google Earth: http://www.ambiotek.com/trees

968 m asl up to over 5,100 m asl. It covers an area of 2,177.4 km^2, consisting of shrubland (44.5%), barren land and glaciers (almost 38%), and cultivated land (8.8%)[90].

399. The GCA is proposed as IUCN protected area management category V, allowing multiple land uses. The area is being managed by the National Trust for Nature Conservation (NTNC), an autonomous not-for-profit organization, for an initial 20 year period. The GCA Scoping Study prepared by NTNC reported diverse vegetation types in this protected area, consisting of: Chir pine forest, Schima-Castanopsis forest, Alnus forest, *Pinus patula* forest, *Pinus wallichiana* forest, Rhododendron forest, *Quercus lanata* forest, Lower temperate oak forest (*Quercus semicarpifolia* forest), Lower temperate mixed broad leaved forest, Abies forest, Upper temperate mixed forest (Birch-rhododendron forest), Temperate mountain oak forest, East Himalayan Oak forest, Jupiperus forest, shrubland (*R. anthopogon* bushes,) and Moist alpine scrub. Plants found in the region are listed in Appendix J[81].

400. Fauna of importance in the GCA includes seven species of bird, three species of reptile, one amphibian and 32 species of mammal[91], as listed in the NPWC Act 1973, on the IUCN Red List and/or in CITES Appendices. Jerdons pit viper is endemic only to Simigaon, located approximately 50 km east of Kyangsingh. Snow Leopard, Clouded Leopard, Red Panda and Himalayan Musk Deer are some important species found at higher elevations.

Figure 9.3: Gaurishankar Conservation Area



Source: NTNC, 2012.

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[90] NTNC, 2009. *Scoping Study to Develop Gaurishankar into a Protected Area.* Lalitpur: NTNC.
[91] IUCN, 2010. *The IUCN Red List of Threatened Species*. Retrieved October 14, 2010, from http://www.iucnredlist.org

401. Langtang National Park lies 2 km to the north of the project site, while Sagarmatha National Park is 70 km to the east. Accordingly, all project sites are well outside these protected areas.

9.3 VDC and Project Area Profile

402. Gumba VDC has a total population of 3,431 (Table 9.6)[92], with an average household size of 5.1. Of these, an estimated 53 households will benefit from the project out of the total 674 total households in the VDC.

Table 9.6: VDC Population

VDC	Population				Total Households	Household Size
	Male	Female	Total	Sex Ratio		
Gumba	1,727	1,704	**3,431**	101%	**674**	**5.1**

Source: Population Census, 2011, CBS.

403. The dominant ethnic group in the four project VDCs are Tamangs, comprising 55% of the total VDC population. Other major groups are Sherpa (36%) and Newar (4%) (Table 9.7).

Table 9.7: Ethnic Composition by VDC

VDC	Population				
	Tamang (Janajati)	Sherpa (Janajati)	Newar (Janajati)	Chhetri	Others
Gumba	1,832	1,210	143	12	50

Source: Population Census, 2001.

404. Relative to other communities in Nepal, local women have greater power in family decision making, particularly given that most males of working age go abroad for work or education. Most water collection, fuelwood and fodder gathering activities are undertaken by women, with men undertaking most of the ploughing.

9.4 Livelihoods

405. Subsistence agriculture, consisting of livestock raising and rainfed cultivation, is the main livelihood earning activity in the project area. However, some households depend upon multiple occupations such as wage labour, service provision and petty businesses to earn their livelihood.

406. Agricultural land and livestock holdings of households in Gumba VDC are summarised in Table 9.8. Ownership of agricultural land is common, with 96% of households reporting ownership. Livestock are also owned by most households, used for subsistence and income generation.

Table 9.8: Ownership of Agricultural Land and Livestock in Project Area VDCs

VDC	Households Owning (%)				Total Households
	Agricultural Land Only	Land and Livestock	Land, Livestock and Poultry	Other	
Gumba	62	80	480	29	651

[92] Population Census, 2011.

Source: Population Census, 2001.

407. Villagers at this region have been traditionally practicing Semi to True Transhumance pastoralism and do dry land cultivation. Major food crops grown are maize, barley and potatoes. They rear large herds of cattle especially goats, sheep and Chauri. However, after incurring losses except for two households everyone sold their Chauri. Currently some members are contracting with other villages and working as a dealer to sell milk products from Chauri. The collection and trade in medicinal herbs from higher altitudes is an important income source.

9.5 Energy Supply and Use

408. The main sources of energy in Kyangsingh village were reported to be: fuelwood for cooking and heating (100% of households); home solar power for lighting (64%); kerosene for lighting (27%); and battery light (Tukimara) (9%)[93]. Household kerosene use costs around NRS 360/month (3 L by NRS 120/L), household solar power system costs around NPR 292/month, and a tukimara LED light costs around NRS 800/month (NPR 9,600/year). Discussions with local users indicate that as there are no registered community forests people freely collect fuelwood from nearby national forests. Energy efficient Tandoor stoves are used by a number of households in Kyangsing. A number of micro hydropower projects have been installed in neighbouring villages but these plants have experienced a range of problems and are only operating part-time.

9.6 Water Supply

409. The main water supply for Kyangsingh village comes from a local hillside spring. Water is reticulated from the spring by a system of polyethylene pipelines to community taps in the village, providing good quality water.

9.7 Transport and Local Services

410. Access to the site is gained via a foot trail from Jalbire VDC, that takes around 1.5 days to walk around 50 km. Access from Kathmandu to Jalbire consists of Arniko Highway till Baalephi then from Balephi to Jalbire VDC consists of All Weather Earthen Road.

411. There is one Primary Government School in Kyangsingh, Prathimik Vidhyalay, but it is currently in poor condition and regularly closed. Parents who can afford better schools send there children to outside schools. A recently inaugurated Buddhist stupa (chorten) is situated approximately 120 m above the village. During the inauguration the priest instructed local villagers to protect the forest above the stupa as it was indicated to have spiritual importance. There is no Health Post in the village, with villagers traveling to Pangarpur village (9 km away) for treatment. The communication service consists of CDMA mobile telephony which has signals available only in certain areas of grazing land above the village.

9.8 Impacts and Mitigation Measures

412. The 12.6 kW solar mini-grid project will provide a net environmental and social benefit, while creating minor adverse impacts.

[93] SREP social survey data, 2012.

9.8.1 Biophysical Impacts

413. **Land use:** the total land area required for project installation is estimated to be 300 m^2 (0.03 ha). The land area required for solar panel installation is estimated to be 45 m^2 (1 m^2 per photovoltaic panel), roughly equivalent to the footprint of four local houses. A 20 m long power line will connect the solar panels to the powerhouse, strung on 4 m high poles. The solar panels will be mounted on stands on open cultivation land, while the poles will also be in located on cleared land, therefore no forest land will be converted and no existing structures will be removed. The powerhouse housing the bank of batteries will occupy around 40 m^2 (5.5 m x 7.3 m), while distribution line poles will each cover less than 1 m^2 per pole. Mini-grid distribution lines will total around 950 m in length in the Kyangsingh settlement area.

414. The 300 m^2 area of rainfed cultivation land that will be occupied by the solar panels and powerhouse will reduce crop production by the equivalent of 70 kg of maize per annum (based on an average yield of 2.2 T/ha[94]). It is proposed that this private land owned by two landowners will be donated to the User Committee in return for permanent project jobs.

Mitigation Measures

- Minimal land area will be utilized for permanent project structures, including power line RoWs.
- Care will be taken to avoid the disturbance of crops and other vegetation outside the land area required for permanent project sites.
- Temporarily disturbed land will be rehabilitated after use by removing excavated spoil and waste.
- Power poles will be located on land with low economic value wherever possible and on the edge agricultural fields to avoid creating obstacles in plots.
- Temporary construction sites will be located on low value land where possible, and prohibited on forested land.
- Disturbed areas will be revegetated.

415. **Spoil disposal:** an insignificant volume of spoil will be generated from the excavation of the solar panel stand foundations and power poles, limited to less than 1 m^3 of spoil per foundation (allowing for bulking from the excavation of 0.5 m^3).

Mitigation Measures

- Topsoil will be disposed of adjacent to excavation on cultivation land, with the permission of the landowner.

416. **Habitat loss:** all project components will be constructed on cleared cultivation land. A 3.0 m wide cleared right-of-way (RoW) will be established and maintained under the 230/400 V power lines.

Mitigation Measures

- Vegetation clearance will be kept to the minimum required to install the project, including restricting the power line RoW to the required width (1.25 m between the line and a house or tree as per the Electricity Regulation (1993)[95] plus an assumed 0.5 m to allow for line swing).

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[94] MoAD, 2010. Statistical Information on Nepalese Agriculture 2010/12. Singhadurbar, Kathmandu, Bagmati, Nepal.
[95] Government of Nepal, 1993. Electricity Regulation 2050.

- A 60 m section of the distribution line between the powerhouse and school will be aligned to avoid scattered trees.
- Sites to be cleared and individual trees to be removed will be clearly marked prior to clearance and permission will be obtained from the landowner to remove this vegetation.
- Tree clearance will be restricted to cutting down trees to ground level, with the retention of tree stumps and roots.

417. **Protected Area:** the project is unlikely to have any impact on the Gaurishankar Conservation Area as electricity supply is unlikely to change current land and forest use activities. The only potential effect on the conservation area could come indirectly from the establishment of new electricity-powered businesses that rely upon natural resources, such as wood for sawmilling and furniture manufacturing.

418. **Waste management:** the main waste that will be produced by the project is used lead acid batteries (ULAB) that require replacing every eight years or so. Solar panels have a guaranteed life of 25 years therefore they will not produce waste for a considerable period of time unless they are physically damaged.

419. Lead acid batteries need to be recycled to avoid pollution from the lead plates and the sulphuric acid that the plates sit in. Recycling involves the recovery of lead to produce new batteries. Local scrap dealers collect lead for (i) crushing then transportation to India for processing, or (ii) local recycling in small quantities by a battery company, however, neither method is environmentally safe[96]. Informal battery recycling involves breaking open the battery case by hand and melting down the lead plates on small fires or stoves to recover it. This process poses a health hazard from: (i) inhaling lead toxins during the melting process; (ii) contact with lead particulates in battery acid; (iii) contact with or inhaling lead dust generated from dry soil contaminated with lead particulates; and (iv) ingesting contaminated water. Lead scraps left in the open also pose a health hazard from direct contact. Accordingly, disposal has to be in accordance with sound procedures to avoid human health issues and soil and water contamination.

420. Villagers in Kyangsingh reported that spent lead acid batteries are usually disposed of locally rather than being collected for reuse as occurs in other areas. Some surveyed households have retained used batteries inside their houses, but it is assumed that many spent batteries have been disposed of in informal landfills, although no batteries were observed in the village landfill on the western boundary.

421. Nepal, as a party to the Basel Convention on transboundary movements of hazardous waste and their disposal, plans to install a lead recycling plant that will operate in accordance with the Convention's rules and guidelines. AEPC is in the process of selecting a site for the plant, with sites under consideration at Biratnagar and Hetaunda. AEPC will facilitate the recycling of all SREP sub-project ULABs in this facility. This may involve a public-private partnership where ULABs are purchased at 13 District collection centres and then transported to the recycling facility. The Government is currently preparing a lead acid battery management regulation.

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[96] Wald, A., & Lemor, R., 2009. *Report on Lead Acid SHS Battery Recovery System in Nepal*. Kathmandi: German Financial Cooperation in Nepal.

422. AEPC will provide an information pamphlet to the project User Committee detailing the required ULAB disposal procedure. Each battery will be labeled with a contact phone number to obtain current advice on how to safely dispose of batteries given that the first set will operate for around eight years. AEPC will also mail out any new information on safe battery disposal to the school (such as new Government regulations and recycling facilities), while it is also considering a maintenance contract with private companies using a battery voucher program to promote the central collection and recycling/reuse/disposal of battery components either through scrap dealers or solar power companies.

423. In addition, used energy efficient (CFL and LED) bulbs pose a toxic hazard risk. These bulbs contain excessive levels of leachable lead and high levels of copper and zinc[97]. Total metal content is around 10 times higher in CFL bulbs and around 150 times higher in LED bulbs compared to incandescent bulbs, therefore it is important that they are disposed of properly.

Mitigation Measures

- Residual construction materials and waste will be collected, reused, recycled or disposed of safely, in accordance with standard and accepted safe practices.
- Non-hazardous wastes such as packaging (e.g. wooden framing around electrical components) will reused wherever possible for other purposes or disposed of by burying in a pit away from water sources and settlements.
- Pamphlets will be provided to households outlining the safe handling and disposal of used ULABs and CFL/LED lamps to prevent a risk to human health and the environment. This will include cleaning up broken bulbs by:
    - proper ventilation of rooms prior to cleaning;
    - avoid using brooms to clean up powder to avoid spreading the particles; and
    - wash hands after cleaning.

424. **Reduction in indoor and outdoor air pollution:** the replacement of kerosene lamps with solar powered CFLs for household and school lighting will eliminate this source of indoor air pollution. A secondary source of house lighting comes from the burning of fuelwood in cooking stoves, for cooking year-round and heating in winter. Fuelwood use is likely to continue at a similar rate as these primary uses will continue.

425. **Greenhouse gas emissions reduction:** the volume of carbon emissions (CO_2) that is likely to be avoided by project power replacing kerosene lighting is estimated to total 1.3 T/a (Table 9.9).

Table 9.9: Estimated Annual CO_2 Emissions Avoided by Replacement of Kerosene and Diesel

Category	Value
Number of HHs using kerosene[1]	14
Average kerosene consumption/HH/month[2]	3 L
Total yearly kerosene consumption	504 L
Kerosene energy content per L[3]	37 MJ
Total energy from kerosene[4]	17.7 MMBtu
Total annual CO_2 emissions from kerosene	**1.29 T**

[97] Lim, S.-R., Kang, D., Oladele, A. O., & Julie, M. S., 2012. Potential Environmental Impacts from the Metals in Incandescent, Compact Fluorescent Lamp (CFL), and Light-Emitting Diode (LED) Bulbs. *Environmental Science & Technology*.

1 - SREP Social Survey, 2012.
2 - UNDP, 2012.
3 - RETRUD-03 Conference Paper, CES, TU Pg. 273.
4 - http://www.unitjuggler.com/convert-energy-from-kJ-to-MMBtu.html.

9.8.2 Socio-Economic Impacts

426. The socio-economic impacts that will occur from project construction and operation, providing a greater and more reliable power supply, will primarily be beneficial.

427. **Greater power supply and improved supply reliability:** the main benefits of an improved power supply will be:

(xiii) improved house and school illumination for 235 villagers;
(xiv) the option to run a range of household appliances such as a refrigerator, television and radio;
(xv) improved school educational facilities;
(xvi) operation of community facilities including stupa and street lighting; and
(xvii) greater business opportunities, such as a sawmill and furniture manufacturing.

428. Solar power will enable the operation of a range of equipment by an estimated 53 households (235 people) that is currently not operated in the village due to a lack of electricity, or will be replaced by the provision of electricity. Foremost among the additional facilities are room lights, televisions, mixer/grinder, computers and refrigerators, and possibly a sawmill and furniture manufacturing enterprise. Five street lights will be powered in the village and the stupa will be lit during festivals and functions.

429. **Visual impact:** the visual impact of 90 solar panels is considered to be low given the height and area covered by the panels.

430. **Safety hazards:** solar panels produce electricity at 230 V which poses a risk of electrocution if contact is made with live lines, therefore safety protection is required. The bank of solar panels and the powerhouse will each be fenced to prevent public access. All electrical equipment, power lines and cables will be insulated in accordance with standard Nepal safety requirements. This includes installation and handling safety measures such as keeping children away from the components and not wearing metallic objects/jewelry while handling equipment. Lightning protection will be provided by earthing each turbine, the solar array and bank of batteries using a copper earth rod, with soil conductivity improved with the incorporation of coal and salt in the soil (SREP, 2012 – pers. comm.). The removal of kerosene lamps will remove this burning hazard and potential exposure to kerosene.

Mitigation Measures

- The solar panels and powerhouse will be fenced to prevent access, with signs fitted to warn people not to enter due to the electrocution hazard.
- A general awareness program on safety will be conducted for local residents, including the issuing of a safety pamphlet to villagers specifying hazards and prohibited activities (Appendix I).

431. **Improved respiratory health:** the removal of kerosene lamps from those households that do not have solar home systems will improve air quality (reducing particulate matter and

carbon monoxide levels) inside homes. As most households will continue to use wood stoves for cooking, the improvement in the overall respiratory health (i.e. reduction in respiratory irritation and possible reduction in respiratory infections) is expected to be limited as the long term effects of poor indoor air quality from wood burning at home will greatly outweigh the short-term improvement in air quality provided by the clean energy lighting.

432. **Reduced energy cost:** 10% of the project installation cost will be provided by the community, most likely in the form of labour, with the remaining cost met by the Government. A one-off subscription cost of NPR 7,000/household will be charged to households connecting to the project that will be used to establish the project maintenance fund. On-going project running costs will primarily be met by user households and businesses, with support sought from charities to reduce these costs.

433. The monthly household cost of lighting, cooking and other energy uses currently provided by fuelwood, and kerosene is predicted to decrease slightly once households commence using project electricity. The estimated monthly solar mini-grid project running cost (operation and maintenance cost) is NPR 320/household. Assuming that kerosene use and solar home systems will be replaced by project power, and fuelwood use will continue at the current rate, the monthly cost of energy per household is expected to decrease slightly from a total of NRS 1,750 at present to NPR 1,720, a small saving of NPR 30.

434. **Employment:** project installation will take an estimated 30 person-days, requiring skilled and unskilled labour. Project employment during operation will consist of a full-time technician and two part-time staff to read electricity meters and undertake routine inspections of the turbines, solar panels and batteries. The two part-time staff will be sourced from Kyangsinghe village and trained as a component of the project.

10. ENVIRONMENTAL MANAGEMENT PLAN

435. This EMP provides a guide to those parties responsible for Project environmental management. The aims of the EMP are to: summarise the environmental management measures to be implemented during the Project pre-construction, construction and implementation phases; outline the roles of the main parties involved in Project environmental management; set out a supervision, monitoring, auditing and reporting framework for Project environmental management; and provide a cost estimate of the environmental management.

10.1 Implementation Responsibilities

436. The key institutions involved in Project management and implementation, including the environmental assessment and review process for sub-projects, are DEEUs, RSCs, AEPC and the PIU, VDCs, etc., as described below.

MoEnv

437. MoEnv serves as the EA for the Project and chairs the existing NRREP Steering Committee, which will also serve as the Steering Committee for the Project. The Steering Committee includes representatives from Ministry of Finance (MOF), Ministry of Energy (MOE), MoEnv, and AEPC as members. MoEnv will also provide oversight to AEPC and will also be responsible for reporting to the ADB.

AEPC/PIU

438. AEPC will be the Project IE, supported by the REREAP PIU established within AEPC and a technical consultant team funded by the Project. The PIU will be responsible for overseeing sub-project compliance with environmental and social safeguard requirements based on the EARF provisions that include: (i) sub-project selection taking into account environmental screening criteria; (ii) sub-project environmental assessments prepared in the form of an IEE (category B sub-projects) or desktop assessment (category C sub-projects) in accordance with the requirements set out in this EARF; (iii) appropriate public consultations and disclosures; (iv) effective management of the grievance redress mechanism; and (v) EARF compliance reported in the environmental monitoring report. The PIU or its appointed technical consultants will conduct routine visual inspections of construction activities, including site pegging, vegetation clearance, earthworks, etc.

439. Regional Service Centers (RSC), funded by NRREP and covering all rural areas in Nepal, will be engaged to provide implementation support at the field level. New RSCs and additional experts for existing RSCs will be recruited if required.

VDCs

440. For each IEE, the RSCs along with VDCs will take the lead in organizing the benefiting communities, and will support AEPC and the PIU, during public consultation. VDCs will provide the PIU with available baseline data, and/or assist the PIU in obtaining required baseline data. As beneficiaries of the improvement works, it is the duty of the villagers to participate actively in public consultations and social surveys.

Consultants, Construction Contractors, Equipment Suppliers, and Other Service Providers

441. Consultants will be contracted by AEPC as required to assist in the preparation of the pipeline of sub-projects. This will include consulting services to complete IEEs and desktop environmental assessments for individual sub-projects.

442. Construction contractors, equipment suppliers, and other service providers will be engaged to install sub-projects. Construction contractors will have primary responsibility for environmental and social management and worker health and safety at sub-project construction sites under their control. They will be required to adhere to AEPC’s environmental, health, and safety (EHS) guidelines and implement relevant sub-project environmental and social management measures prior to and during construction. This will include implementing controls such as spoil disposal, reconnection of cut services, and revegetation to stabilize sites. They will also be responsible for the provision of appropriate personal protective equipment (e.g., hard hats, safety boots, and hearing protection) to their workers. Equipment suppliers and other service providers are expected to adhere to best EHS management practices consistent with the scope of their activities.

Asian Development Bank

443. ADB will (i) review the draft EARF and its subsequent update as necessary; (ii) review the Project IEE prior to ADB Board consideration; (iii) periodically review sample sub-project IEEs and desktop environmental assessments; (iv) review Project monitoring reports; and (v) officially disclose environmental safeguards documents on its web site in accordance with the ADB *Public Communications Policy* (2011). ADB will also review REA Checklists for proposed MMHP sub-projects to enable it to provide guidance to AEPC/PIU on SPS (2009) requirements.

10.2 Environmental Management Measures

444. The environmental management measures to be implemented during pre-construction, construction and operation are summarised separately for (i) MMHs (Table 10.1), and (ii) SWMs (Table 10.2), given the differences in the design and mitigation measures required for these different types of sub-project.

Table 10.1: Summary of Environmental Management Measures for Mini-Micro Hydropower

Environmental Issue	Mitigation Measure	Implementation Responsibility[1]	Monitoring Responsibility
E-CONSTRUCTION			
P management measures	• Incorporate site and project specific environmental mitigation measures into the sub-project EMP.	PIU	PIU
roval - Wildlife Reserves and fer Zones	• Where sub-project facilities are proposed within a wildlife reserve or buffer zone and the clearance of forest, acquisition of land, or use of a quarry site is proposed, obtain written approval from the relevant GoN authority for the proposed activities.	PIU	PIU
eam protection	• Design the diversion weir with wing walls and aprons adequate to prevent bank erosion and excessive streambed scour.	PIU	PIU
imum environmental flow	• Design the weir and operating regime to incorporate the year-round release of a minimum environmental flow from the weir, equivalent to at least 10% of the average monthly flow rate of the driest month.	PIU	PIU
s of houses, other structures, ductive land and forest	• Avoid all houses and other buildings in the layout of generating facilities and power lines, except where no alternative exists.	PIU	PIU
	• Minimise land utilized for project structures, with only the essential area taken (including establishing stable cut batters and fill embankments).	PIU	PIU
	• Align power line routes to (i) follow trails wherever possible for ease of construction and maintenance, (ii) avoid houses and other structures; (iii) avoid forest and shrubland wherever possible; and (iv) avoid crossing the middle of cultivation plots wherever possible.	PIU	PIU
	• Identify excess spoil disposal areas on site land or on nearby unproductive land.	PIU	PIU
d stability	• Design excavated cuttings and fill embankments with grades to achieve stable slopes.	PIU	PIU
ety	• Incorporate safety features into sub-project design, including: - caps/lids at points over the headrace canal to maintain paths/trails that cross this structure; - fencing the intake, settling basin and forebay to prevent unauthorized access; - consider fencing the headrace canal to prevent people and livestock falling in – larger canals and sections of canal adjacent to community areas, schools, etc; - a trashrack over the penstock intake in the forebay to prevent people and animals being drawn into the penstock; - security fencing around the powerhouse and switch yard; - safety housing around turbine moving parts in the powerhouse; - lightning protection and earthing as required on electrical equipment.	PIU	PIU
n migration	• Design a fishway on a sub-project diversion weir to trial fishway effectiveness for upstream fish movement.	PIU	PIU
NSTRUCTION			
nstruction hours	• Restrict construction activities to daylight hours, with local communities informed of the schedule.	CC	PIU
cess	• Use established roads and tracks for construction and maintenance access wherever possible, with new accessways restricted to foot track construction.	CC	PIU
mmunity and private facilities l services	• Take care not to cut or degrade village water supply during construction.	CC	PIU

Environmental Issue	Mitigation Measure	Implementation Responsibility[1]	Monitoring Responsibility
	• Immediately reconnect/reinstate essential facilities (e.g. water supply pipelines, power lines, trails/paths) that are cut/moved during construction as soon as possible. This may involve temporary reconnection during construction followed by permanent reinstatement once construction has been completed.	CC	PIU
	• No temporary placement of fill in drains/canals where impeded drainage could cause flooding or disrupt irrigation. Any fill accidently deposited in drains/canals removed immediately.	CC	PIU
s of productive land, land urbance, damage to crops, nage to existing services and lities	• Construction techniques (generally hand construction) to minimize ground disturbance on adjoining land.	CC	PIU
	• Time construction activities on cropping land to avoid disturbance of field crops within one month prior to harvest when possible.	CC	PIU
	• Locate temporary construction sites (for material storage, concrete mixing, etc) on land with lower production value (e.g. degraded land, grassland) where possible, with no temporary sites on forested land.	CC	PIU
	• Excavate construction material (sand and rock) from project sites or existing extraction sites/quarries wherever possible.	CC	PIU
	• Locate power poles on land with low economic value wherever possible.	CC	PIU
	• Where power poles have to cross cultivation, locate them on the edge of fields/cultivation bays wherever possible to avoid creating an obstacle.	CC	PIU
sion, sedimentation and water lity	• Restrict in-stream excavation to dry season months (October to May).	CC	PIU
	• Protect stream water quality during in-stream excavation of weir foundations (e.g. channel diversion, no stockpiling of spoil within/next to the diverted flow).	CC	PIU
getation clearance	• Retain shrubs and grasses in the RoW wherever possible whilst providing required electrical safety clearance.	CC	PIU
	• Mark vegetation to be removed prior to clearance, and strictly control clearing to ensure minimal clearance.	CC	PIU
	• Restrict RoW tree clearance to cutting trees off at ground level or pruning as appropriate, with tree stumps and roots left in place and ground cover (i.e. grass and low shrubs) left undisturbed as far as possible.	CC	PIU
	• Felled trees and other cleared or pruned vegetation (wood, branches and foliage) retained by owner of the vegetation (including Community Forest Users Groups) for his/her use, or removed if requested by owner.	CC	PIU
	• Prohibit construction workers from harvesting or collecting fuelwood and other forest products, and hunting wildlife, in the project area during their employment, apart from locally employed staff continuing current legal activities.	CC	PIU
psoil reuse	• Strip and stockpile topsoil separately from subsoil to enable re-use for surface revegetation.	CC	PIU
oil disposal	• Dispose of excess spoil at approved sites where land degradation and erosion will not occur, including on degraded land, or landforming next to project structures or adjacent sites requested by the local community or adjoining landowner.	CC	PIU
e revegetation	• Topsoil and seed all landformed and disturbed areas with a cover crop and perennial grass mix to establish long-term surface stability, in line with the landowner's intended land use, including the rehabilitation of temporary construction sites to pre-construction condition following use.	CC	PIU
ter quality decline and soil tamination	• Securely store fuel and other hazardous materials above flood level and at least 20 m from any waterbody, watercourse, canal or storage pond.	CC	PIU
rker safety	• Adhere to GoN health and safety regulations.		PIU

Environmental Issue	Mitigation Measure	Implementation Responsibility[1]	Monitoring Responsibility
	• Provide health and safety induction training to all construction workers and supervisory staff.	CC	PIU
	• Provide public health information to the construction workforce prior to the commencement of on-site work, primarily covering the prevention of HIV/AIDS.	CC	PIU
	• Provide standard PPE to all construction workers and supervisory staff, appropriate to their tasks.	CC	PIU
	• Construction workforce facilities to include proper sanitation, water supply and waste disposal facilities.	CC	PIU
mmunity access and safety	• Permanently cap points along water the headrace canal to reinstate access paths/tracks and reduce the risk of people falling into these structures where high pedestrian activity occurs (e.g. adjacent to village meeting areas and schools).	CC	PIU
	• Where designed, fence out hazardous open water-bearing project structures (i.e. intake channel, settling basin, forebay, and possibly large headrace canals and the tailrace outlet) to prevent unathorised access.	CC	PIU
	• Erect security fencing around the powerhouse and switchyard to prevent unauthorized access.	CC	PIU
	• Install lightning protection and earthing on all required electrical equipment.	CC	PIU
	• Install warning signs on all hazardous electrical equipment, the powerhouse and switchyard fences, power poles, etc.	CC	PIU
st and noise	• Locate concrete mixing away from residences to reduce the potential for dust and increased noise at dwellings.	CC	PIU
ERATION & MAINTENANCE			
ety	• Provide PPE to operation staff as appropriate for different tasks.		PIU
	• Maintain security fencing and warning signs to ensure the powerhouse, switch yard and any other fenced areas are secure.	OC	PIU
imum environmental flow	• Release at least the minimum environmental flow year-round from the weir as stated in the IEE (at least 10% of the average monthly flow rate for the driest month).	OC	PIU
er bank erosion and river bed ur	• Regularly inspect river banks immediately downstream and upstream of the diversion weir for erosion during and after the monsoon and immediately after any other major stream flow event.	OC	PIU
	• Construct additional bank and bed protection if required.	OC	PIU
diment flushing	• Flush sediment from the settling basin and forebay back into the stream only when the stream has a high suspended sediment load (during the monsoon season or large storm flows at other times of the year).	OC	PIU
zardous materials storage	• Securely store fuel and other hazardous materials in a locked area, above flood level and at least 20 m from any waterbody or watercourse.	OC	PIU
ste management	• Segregate wastes and safely store them prior to disposal/recycling, including spent oils, grease, oily rags, used parts, etc.	OC	PIU
	• Dispose of or recycle waste as appropriate.	OC	PIU
mage to adjacent facilities and ctures	• Periodically repair any facilities disturbed/disconnected by project structures or activities as soon as damage occurs, including: - reinstating irrigation canals, drains, etc if damaged by landslides, erosion caused by the project, etc; - stabilizing erosion caused by overflows from the settling basin, headrace canal, forebay etc, and safe diversion of future flows.	OC	PIU
s of and damage to trees, itat loss	• Strictly clear/prune trees and shrubs in accordance with electrical safety requirements to maintain the RoWs of operating power lines.	OC	PIU
	• Permit cropping within the RoWs.	OC	PIU

PIU = Project Implementation Unit (or a PIU-assigned party such as a consultant);

CC = Construction Contractor;
OC = Operation Contractor;
REREAP = Renewable Energy for Rural Energy Access Project;
AEPC = Alternative Energy Promotion Centre.

Table 10.2: Summary of Environmental Management Measures for Solar/Wind Mini-Grids

Environmental Issue	Mitigation Measure	Implementation Responsibility[1]	Monitoring Responsibility
E-CONSTRUCTION			
P management measures	• Incorporate site and project specific environmental mitigation measures into the sub-project EMP.	PIU	PIU
proval in Wildlife Reserves and fer Zones	• Where sub-project facilities are proposed within a wildlife reserve or buffer zone and the clearance of forest or acquisition of land is proposed, obtain written approval from the relevant GoN authority for the proposed activities.	PIU	PIU
s of houses, other structures, ductive land and forest	• Avoid all houses and other buildings in the layout of facilities and power lines, except where no alternative exists.	PIU	PIU
	• Minimise land utilized for project structures, with only the essential area taken.	PIU	PIU
	• Align power line routes to (i) follow trails wherever possible for ease of construction and maintenance, (ii) avoid houses and other structures; (iii) avoid forest and shrubland wherever possible; and (iv) avoid crossing the middle of cultivation plots wherever possible.	PIU	PIU
	• Identify excess spoil disposal areas on site land or on nearby unproductive land.	PIU	PIU
d stability	• Design excavated cuttings and fill embankments with grades to achieve stable slopes.	PIU	PIU
se	• Site turbines with a minimum setback of 50-60 m from the nearest dwelling.		PIU
ety	• Incorporate safety features into sub-project design, including: - security fencing around the powerhouse, switch yard and open water structures; - lightning protection and earthing as required on electrical equipment, including each wind turbine.	PIU	PIU
NSTRUCTION			
nstruction hours	• Restrict construction activities to daylight hours, with local communities informed of the schedule.	CC	PIU
cess	• Use established roads and tracks for construction and maintenance access wherever possible, with new accessways restricted to foot track construction.	CC	PIU
mmunity and private facilities l services	• Take care not to cut or degrade village water supply during construction.	CC	PIU
	• Immediately reconnect/reinstate essential facilities (e.g. water supply pipelines, power lines, trails/paths) that are cut/moved during construction as soon as possible. This may involve temporary reconnection during construction followed by permanent reinstatement once construction has been completed.	CC	PIU
	• No temporary placement of fill in drains/canals where impeded drainage could cause flooding or disrupt irrigation. Any fill accidently deposited in drains/canals removed immediately.	CC	PIU
s of productive land, land urbance, damage to crops, mage to existing services and lities	• Construction techniques to minimize ground disturbance on adjoining land.	CC	PIU
	• Time construction activities on cropping land to avoid disturbance of field crops within one month prior to harvest when possible.	CC	PIU
	• Locate temporary construction sites (for material storage, concrete mixing, etc) on land with lower production value (e.g. degraded land, grassland) where possible, with no temporary sites on forested land.	CC	PIU

Environmental Issue	Mitigation Measure	Implementation Responsibility[1]	Monitoring Responsibility
	• Excavate construction material (sand and rock) from project sites or existing extraction sites/quarries wherever possible.	CC	PIU
	• Locate power poles on land with low economic value wherever possible.	CC	PIU
	• Where power poles have to cross cultivation, locate them on the edge of fields/cultivation bays wherever possible to avoid creating an obstacle.	CC	PIU
getation clearance	• Retain shrubs and grasses in the RoW wherever possible whilst providing required electrical safety clearance.	CC	PIU
	• Mark vegetation to be removed prior to clearance, and strictly control clearing to ensure minimal clearance.	CC	PIU
	• Restrict RoW tree clearance to cutting trees off at ground level or pruning as appropriate, with tree stumps and roots left in place and ground cover (i.e. grass and low shrubs) left undisturbed as far as possible.	CC	PIU
	• Felled trees and other cleared or pruned vegetation (wood, branches and foliage) retained by owner of the vegetation (including Community Forest Users Groups) for his/her use, or removed if requested by owner.	CC	PIU
	• Prohibit construction workers from harvesting or collecting fuelwood and other forest products, and hunting wildlife, in the project area during their employment, apart from locally employed staff continuing current legal activities.	CC	PIU
psoil reuse	• Strip and stockpile topsoil separately from subsoil to enable re-use for surface revegetation.	CC	PIU
oil disposal	• Dispose of excess spoil at approved sites where land degradation and erosion will not occur, including on degraded land, or landforming next to project structures or adjacent sites requested by the local community or adjoining landowner.	CC	PIU
e revegetation	• Topsoil and seed all landformed and disturbed areas with a cover crop and perennial grass mix to establish long-term surface stability, in line with the landowner's intended land use, including the rehabilitation of temporary construction sites to pre-construction condition following use.	CC	PIU
ter quality decline and soil ntamination	• Securely store fuel and other hazardous materials above flood level and at least 20 m from any waterbody, watercourse, canal or storage pond.	CC	PIU
rker safety	• Adhere to GoN health and safety regulations.		PIU
	• Provide health and safety induction training to all construction workers and supervisory staff.	CC	PIU
	• Provide public health information to the construction workforce prior to the commencement of on-site work, primarily covering the prevention of HIV/AIDS.	CC	PIU
	• Provide standard PPE to all construction workers and supervisory staff, appropriate to their tasks.	CC	PIU
mmunity access and safety	• Erect security fencing around the powerhouse and switchyard to prevent unauthorized access.	CC	PIU
	• Install lightning protection and earthing on all required electrical equipment.	CC	PIU
	• Install warning signs on all hazardous electrical equipment, the powerhouse and switchyard fences, power poles, etc.	CC	PIU
st and noise	• Locate concrete mixing away from residences to reduce the potential for dust and increased noise at dwellings.	CC	PIU
	• Restrict construction activities to daylight hours, with local communities informed of the schedule.	CC	PIU
ERATION & MAINTENANCE			
ety	• Provide PPE to operation staff as appropriate for different tasks.	OC	PIU
	• Maintain security fencing and warning signs to ensure fenced areas are secure.	OC	PIU

Environmental Issue	Mitigation Measure	Implementation Responsibility[1]	Monitoring Responsibility
zardous materials storage	• Securely store fuel and other hazardous materials in a locked area, above flood level and at least 20 m from any waterbody or watercourse.	OC	PIU
ste management	• Segregate wastes and safely store them prior to disposal/recycling, including spent oils, grease, oily rags, used parts, etc.	OC	PIU
	• Dispose of or recycle waste as appropriate.	OC	PIU
mage to adjacent facilities and ictures	• Periodically repair any facilities disturbed/disconnected by project structures or activities as soon as damage occurs, including: - reinstating irrigation canals, drains, etc if damaged by landslides, erosion caused by the project, etc; - stabilizing erosion caused by overflows from the settling basin, headrace canal, forebay etc, and safe diversion of future flows.	OC	PIU
s of and damage to trees, bitat loss	• Strictly clear/prune trees and shrubs in accordance with electrical safety requirements to maintain the RoWs of operating power lines.	OC	PIU
	• Permit cropping within the RoWs.	OC	PIU

PIU = Project Implementation Unit (or a PIU-assigned party such as a consultant);
CC = Construction Contractor;
OC = Operation Contractor;
REREAP = Renewable Energy for Rural Energy Access Project;
AEPC = Alternative Energy Promotion Centre;

10.3 Environmental Management Cost Estimates

Environmental Management Cost Estimates

445. Project environmental management costs incurred for: (i) REREAP Project management; and (ii) implementation sub-project mitigation measures.

1. Project Management

446. Overall Project environmental management will involve sub-project screening and impact assessment (including input into sub-project design), impact assessment review, input into contract conditions, monitoring construction activities, monitoring project operation, periodic reporting, and the preparation of extension material (on community safety, battery recycling, etc). Each of these activities is likely to be undertaken by REREAP project environment staff, apart from the preparation of IEEs for environmental category B sub-projects (primarily MMHs located on streams) and sub-project monitoring during construction and operation that are likely to be performed by external environmental consultants.

447. Preliminary cost estimates for the REREAP team's overall environmental management activities and contractor tasks are provided in Table 10.3. These estimates are based on a 5-year (60 month) implementation period covering the screening, planning, construction and initial operation of each sub-project, assuming that 20 sub-projects each require the preparation of an IEE (environment category B) and 333 sub-projects each require the preparation of environmental desktop assessment (environment category C).

Table 10.3: Summary of Environmental Management Measures for Solar and Solar-Wind Mini-Grid

Activity	Units	Unit Cost (US$)	Total Cost (US$)
REREAP Project Team			
Screening of potential sub-projects	Environment Manager	1,600/person/	96,000

Preparation of 333 Environmental Checklists (Cat. C)	(1 full-time x 60 months) Environment Officer (2 full-time x 60 months)	month 1,100/person/ month	132,000
Review of 20 IEEs (Cat. B)			
Grievance redress mechanism management			
Sub-project construction monitoring[1] - 20% of MMHs, 5% of SMs and SWMs			
MMH operation monitoring - 20% of MMHs			
Review of consultant environmental monitoring reports			
Annual reporting			
Preparation of extension material			
Travel costs and per diems	60 months	700/month	42,000
Environmental consultants			
Preparation of 20 IEEs (Cat. B)	20	7,000	140,000
Sub-project construction monitoring[1] - 80% of MMHs, 95% of SMs and SWMs	Environmental Consultant (2 full-time x 60 months)	1,500/month/ person	
MMH operation monitoring - 80% of MMHs			
Water quality monitoring – lower part of dewatered zone for each MMH sub-project	25 MMHs x 2	300	15,000
Travel costs and per diems	60 months	1,500	90,000
Sub-Total	**-**	**-**	**515,000**
Contingency (10% of total estimated costs)	-	-	51,500
Total	**-**	**-**	**566,500**

1 - visual inspection of construction – twice for MMHs, once for SMs and SWMs.
2 - visual inspection of MMH operation – once 12-15 months after commissioning.
Note: costs assume National staff and consultants; staffing levels are subject to revision. The cost of ADB oversight (including consultants directly appointed by the ADB) is not included.

2. Sub-Project Management Measures

448. General and site-specific environmental and social mitigation measures required for sub-project construction (e.g. spoil disposal, reconnection of cut services, slope stabilization, provision of personal protective equipment) and the follow-up maintenance and repair of works (e.g. revegetation of failed slopes/works) have not been estimated as these measures will be funded as a component of (i) each MMH turnkey contract, or (ii) each solar-wind mini-grid and solar mini-grid contract.

449. For the MMHs follow-up remedial works are usually required in the 1-2 years following construction, such as slope re-planting where revegetation has been unsuccessful or additional bank protection at the weir.

450. The only specific mitigation measure that is proposed and will fall outside standard contracted environmental management activities and works is the fishway that has been recommended to be trialed on an MMH weir. The estimated cost of the design and installation of this structure is $10,000, to be installed as part of the weir civil works. On-going monitoring by a fish ecologist during construction and twice a year (once during the monsoon and once in the mid dry season) over the initial three year operation, and the preparation of a report on the findings of the effectiveness of the fishway is estimated to cost $16,000.

11. CONSULTATION, INFORMATION DISCLOSURE, AND GRIEVANCE REDRESS MECHANISM

11.1 Consultation and Information Disclosure

451. ADB's SPS (2009) requires projects to carry out meaningful public consultation on an ongoing basis. All sub-projects will be community-initiated and community-based, and as such consultation is built into and central to the sub-project design process from initiation onwards. Public consultation will: (i) begin early and carry on throughout the project cycle; (ii) provide timely disclosure of relevant information, understandable and accessible to people; (iii) ensure a free and un-intimidated atmosphere without coercion; (iv) ensure gender inclusiveness tailored to the needs of disadvantaged and vulnerable groups; and (v) enable the incorporation of all relevant views of affected people, and stakeholders into project decision making, mitigation measures, the sharing of development benefits and opportunities and implementation issues. The PIU and any appointed environmental assessment consultants will be open to contact/consultation by the public on environmental assessment matters during sub-project IEE and desktop environmental assessment preparation and design investigations.

452. All communication handouts shall be written in Nepali and all consultations will be documented. All relevant views raised during consultation shall be reported in the environmental assessment report, and considered in sub-project design and reflected in the environmental management plan as appropriate. Attendance sheets and notes of consultations shall be included in the environmental assessment report as proof that consultation/s had been held.

453. Information disclosure will follow the procedure for ADB environment category B projects, and AEPC equivalent procedures. It is the policy of the ADB to have environmental assessment reports made available/accessible to the general public. The following EA-related documents will be posted on the ADB website: i) draft EARF, before Project appraisal; ii) Final or updated EARF, upon receipt; iii) overall project IEE report and EMP. Hard copies of the EARF and IEE reports (in English and Nepali) will be made available for perusal at the ADB Office in Nepal, at AEPC head office, and at other locations accessible to stakeholders (to be determined by the PIU).

11.2 Grievance Redress Mechanism

454. AEPC has an existing procedure to receive inquiries and complaints about project-related activities (developed for other donor-funded projects), and to respond to such inquiries and complaints. As the sub-projects are community-originated and community-based, consultation is built into and central to the sub-project development process.

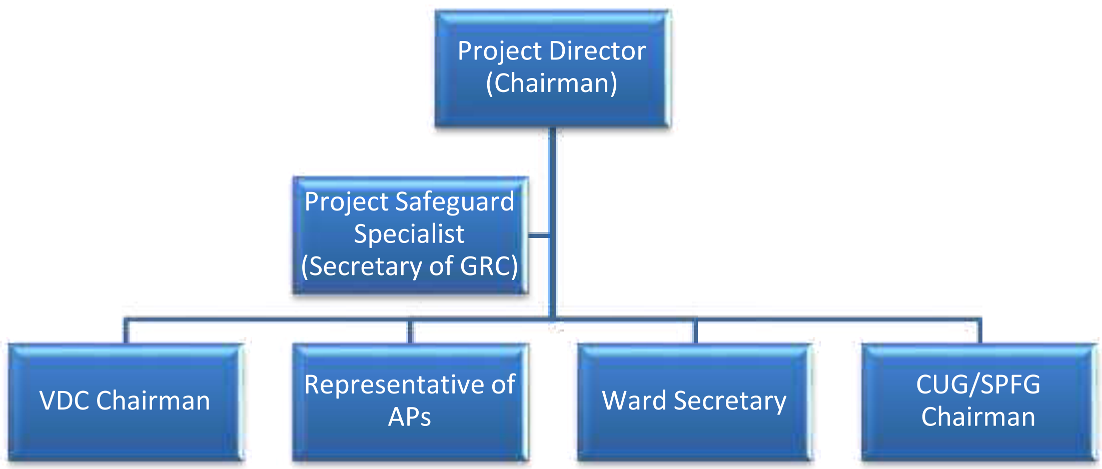
455. A grievance redress mechanism (GRM) will be established to receive and facilitate the resolution of affected persons (AP) concerns, complaints, and grievances on project implementation and operational issues, including negotiated/voluntary land donation, relocation, income restoration, environmental management and other construction and operation related issues. The GRM is designed to be proactive and accessible to all APs to address their concerns grievances and issues effectively and swiftly, in accordance with ADB SPS (2009). RSC will inform the community about the GRM during the first stage of community mobilization. The GRM is based on five consecutive levels of action aimed at resolving issues as soon as possible and within a set time frame, as described below.

456. **First level of GRM:** The the first level of intervention to address grievances and complaints will be through the VDC. Many grievances can be resolved by providing correct and complete information early in the sub-project development process. The RSC representing the EA/PM or PIU will deploy the CM to listen to and provide information to APs to try to resolve their issues. The CM may seek the assistance of the project safeguards specialists to help resolve the issue. The CM will keep record: (i) the name of person(s) making the complaint, (ii) the date the complaint was received, (iii) nature of the complaint, (iv) location, and (v) how the complaint was resolved (if resolved). These reports will be submitted to the EA and the project safeguard specialist on a monthly basis.

457. **Second level of GRM:** If the grievance remains unresolved the CM will forward the complaint to the EA/PM and project safeguard specialist. The person filing the grievance will be notified by the CM that his/her grievance was forwarded to the EA/PM and project safeguard unit. Grievances will be resolved through consultation and interaction with APs with support of CUGs/SPFG. The EA will answer queries and find resolution for grievances regarding various issues including social, or livelihood impacts and environmental impacts. The project safeguard specialist will undertake the corrective measure/s in the field within seven days of the decision. The project safeguard specialist will fully document the following information: (i) the name of person/s, (ii) date of the received complaint, (iii) nature of the complaint, (iv) location, and (v) how the complaint was resolved (if resolved).

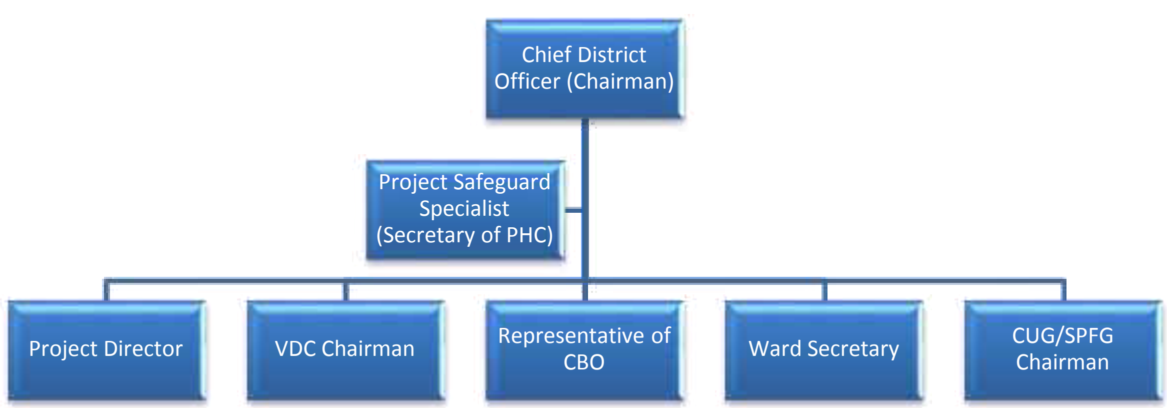
458. **Third level of GRM:** If the grievance remains unresolved, it will be referred to Grievance Redressal Committee (GRC). The GRC will be headed by the PM, with other members consisting of chairman of the sub-project VDC, Ward Secretary, representative of APs and Chairmen of CUGs/SPFGs. The affected person will be given the opportunity to present his/her concerns/issues at the GRC. The GRC will meet when necessary, with all costs of each hearing borne by the project. The GRC will suggest corrective measures at the field level and issue directions that these measures are implemented within 15 days. The project safeguard specialist will act as the GRC secretary, responsible for processing and placing all papers before the GRC, recording decisions, issuing minutes of the meetings, and taking follow-up action to see that formal orders are issued and the decisions are carried out. The structure of VDC-level GRC is illustrated in Figure 11.1

Figure 11.1: VDC-Level Grievance Redress Committee



459. **Fourth level of GRM:** If the above process fails to adequately resolve the concern/grievance to satisfactory of the AP, the AP can seek DDC intervention to resolve the issue by requesting the GRC Secretary to forward the matter to the DDC-level PHC. The PHC will be represented by the CDO (Chairman of PHC), PM of EA, Project Social Safeguard Specialist (Secretary of PHC), concerned VDC Chairman, concerned Ward Secretary, concerned CUG Chairman, and a member of the CBO. The affected person can present his/her concerns/issues at the PHC. The PHC will meet when necessary, with all costs of the hearing borne by the project. The PHC will suggest corrective measures at the field level and issue directions that should implement the directions within 30 days of the decision taken. The project safeguard specialist will work as the secretary of the PHC and will be responsible for processing and placing all papers before the PHC, recording decisions, issuing minutes of the meetings, and taking follow-up action to see that formal orders are issued and the decisions are carried out. The structure of the district-level PHC illustrated in Figure 11.2

Figure 11.2: District-Level Grievance Redress Committee



460. **Fifth level of GRM:** If all of the above resolution methods fail, the AP can seek legal redress through Nepali's judicial system or appropriate administrative system.

12. INSTITUTIONAL ARRANGEMENTS AND RESPONSIBILITIES

461. The key institutions involved in Project management and implementation, including the environmental assessment and review process for sub-projects, are MoSTE, AEPC and its Project Management Unit (PIU), VDCs, etc., as described below.

MoSTE

462. MoSTE chairs the existing NRREP Steering Committee will also serve as the Steering Committee for the Project. The Steering Committee includes representatives from Ministry of Finance (MOF), Ministry of Energy (MOE), MoEnv, and AEPC as members.

AEPC/PIU

463. AEPC will be the Project Executing Agency (EA), supported by the REREAP PIU established within AEPC and a technical consultant team funded by the Project. The PIU will be responsible for overseeing sub-project compliance with environmental and social safeguard requirements based on the EARF provisions that include: (i) sub-project selection taking into account environmental screening criteria; (ii) sub-project environmental assessments prepared in the form of an IEE (category B sub-projects) or desktop assessment (category C sub-projects) in accordance with the requirements set out in this EARF; (iii) appropriate public consultations and disclosures; (iv) effective management of the grievance redress mechanism; and (v) EARF compliance reported in the environmental monitoring report. The PIU or its appointed technical consultants will conduct routine visual inspections of construction activities, including site pegging, vegetation clearance, earthworks, etc.

464. Regional Service Centers (RSC), funded by NRREP and covering all rural areas in Nepal, will be engaged to provide implementation support at the field level. New RSCs and additional experts for existing RSCs will be recruited if required.

VDCs

465. For each IEE, VDCs will take the lead in organizing the benefiting communities, and will support the PIU, during public consultation. VDCs will provide the PIU with available baseline data, and/or assist the PIU in obtaining required baseline data. As beneficiaries of the improvement works, it is the duty of the villagers to participate actively in public consultations and social surveys.

Consultants, Construction Contractors, Equipment Suppliers, and Other Service Providers

466. Consultants will be contracted by AEPC as required to assist in the preparation of the pipeline of sub-projects. This will include consulting services to complete IEEs and desktop environmental assessments for individual sub-projects.

467. Construction contractors, equipment suppliers, and other service providers will be engaged to install sub-projects. Construction contractors will have primary responsibility for environmental and social management and worker health and safety at sub-project construction sites under their control. They will be required to adhere to AEPC's environmental, health, and safety (EHS) guidelines and implement relevant sub-project environmental and social management measures prior to and during construction. This will include implementing controls such as spoil disposal, reconnection of cut services, and revegetation to stabilize sites. They will also be responsible for the provision of appropriate personal protective equipment (e.g., hard

hats, safety boots, and hearing protection) to their workers. Equipment suppliers and other service providers are expected to adhere to best EHS management practices consistent with the scope of their activities.

Asian Development Bank

468. ADB will (i) review the draft EARF and its subsequent update as necessary; (ii) review the Project IEE prior to ADB Board consideration; (iii) periodically review sample sub-project IEEs and desktop environmental assessments; (iv) review Project monitoring reports; and (v) officially disclose environmental safeguards documents on its web site in accordance with the ADB *Public Communications Policy* (2011). ADB will also review REA Checklists for proposed MMH sub-projects to enable it to provide guidance to AEPC/PIU on SPS (2009) requirements.

13. MONITORING AND REPORTING

469. The PIU will prepare an overall Project monitoring report every six months during Project implementation and submit this to the ADB. The PIU will also prepare environmental management reports in accordance with the Project IEE and environmental management plan every six months during construction (or at the end of construction when it takes less than six months), and once between 6-12 months after the commencement of sub-project operation. The environmental management reports will cover EMP implementation, focusing on compliance and any needed corrective actions. Public consultation will be conducted as necessary during construction. ADB will conduct periodic review missions which will include a review of safeguard implementation issues.

14. CONCLUSION AND RECOMMENDATION

470. Rural communities in Nepal, comprising about 83% of the national population, primarily rely on fuelwood and other traditional biomass for energy, with only 49% of the rural population is connected to the grid. The main energy sources in isolated rural communities are: fuelwood for cooking, heating and lighting; other types of biomass for cooking and heating (e.g. dung, crop residue); kerosene for lighting; diesel to run a limited range of equipment (e.g. huller mills for husking grain); and dry cell batteries for torch light. Some off-grid households have home solar power systems primarily for lighting 1-2 rooms and charging mobile phones, while some households have bio-gas plants to supply gas for cooking.

471. Off-grid consumer access to a reliable and affordable energy supply will, by necessity, involve a combination of traditional biomass and modern RE systems and services. The connection of small, isolated and dispersed settlements to the electricity grid is not cost effective compared to village-based RE facilities. In addition, grid connection by an extensive system of transmission lines would result in high transmission losses, would be expensive and would be difficult to maintain. Underlying this, grid connection would not address the existing shortfall in electricity supply in Nepal, particularly the seasonal supply shortfall that occurs when hydropower generation is low late in the dry season.

472. REREAP implementation will involve the installation of around 6.0 MW of renewable energy plants, consisting of an estimated 100 SWM sub-projects and 20 MMH sub-projects over a five year period. The primary benefit of the installation of these plants will be increased and more reliable energy supply to an estimated 34,440 households in 200 villages, thereby improving the quality of life of around 189,400 people (based on an assumed average ousehold size of 5.5 people).

473. In addition, an estimated 100 schools will be powered by the Project, with several thousand students receiving better classroom illumination and educational facilities powered by electricity. It is also estimated that around 30 health posts will be electrified, allowing these facilities to run a refrigerator, sterilizer and other basic equipment to improve the health care services provided to around 5,000 people. Around 100-200 new small private enterprises are expected to establish using Project power supply, while some local businesses will convert from fossil fuel use to electricity, thereby improving the reliability and efficiency of there commercial activities. In addition, the 200 supplied villages will be able to run street lights. Secondary Project benefits of note will include local employment during sub-project construction and operation, and a reduction in GHG emissions by around 494 T/a CO_2e. It is also expected that households will receive a small reduction in their overall energy costs.

474. The adverse environmental and socioeconomic impacts from the construction and operation of 100 SWM plants and 20 MMH plants are anticipated to be relatively minor given the scale and dispersed location of sub-projects across Nepal. The main adverse impacts of these plants are expected to be:

475. **Loss of productive land**: the land take for the entire Project for all plant structures (excluding mini-grid RoWs) is small, estimated to be around 23 ha. This will consist of an estimated 12.6 ha of cultivation, 3.5 ha of riverine features, 3.5 ha of shrubland, 2.3 ha of forest and and 1.1 ha of grassland. The total land area likely to be used for mini-grid RoWs is estimated to be 117 ha. Most of this land will remain under current use (i.e. cultivation, grassland, barren land, open areas within settlements, riverine areas), but an estimated 20% of the area (23.4 ha) will consist of forest and shrubland that will have to be cleared to establish mini-grid RoWs.

476. **Terrestrial habitat loss** – an estimated 29.8 ha of higher value habitat consisting of forest and shrubland is likely to be removed from Project plant sites and within mini-grid RoWs. Most of this area will consist of modified habitat given the high rate of forest harvesting that has typically occurred near settled areas over an extended period of time.

477. **Altered stream flows, and effects on aquatic ecology and river uses**: it is estimated that 16 MMH plants will utilize in-stream diversions on upper catchments, with average annual flows likely to range between 2-20 m^3/s in most instances. Each stream diversion is expected to reduce flows along an average stream length of 1,200 m between the diversion weir and tailrace outlet, affecting a combined stream length of around 19.2 km.

478. **Reduced/disrupted fish migration/movement**: fish movement is expected to be modified along the 19.2 km of partly dewatered streams primarily in the dry season when flow reduction will be greatest. The upstream movement of fish past diversion weirs is also likely to result, but the total loss of aquatic habitat to affected fish species is extremely difficult to accurately estimate.

479. Most adverse environmental and socioeconomic impacts can be avoided or adequately mitigated through good sub-project design and the impalementation of management practices during sub-project construction and operation.

480. It is recommended that a fishway be trialled on a MMH sub-project with an in-stream diversion where the upstream migration of fish is known to occur and may be improved by this structure.

APPENDICES

Appendix A: Mini-Micro Hydropower Mini-Grid Sub-Project Development Procedure

DDC/VDC Level Demand Assessment by AEPC/RSC

Community level energy demand assessment
Community interest in equity contribution assessment
Pre-feasibility study to design project size to meet demands of households and productive energy

Subproject Detailed Feasibility Study (DFS)

Engagement of DFS preparation consultants by AEPC/RSC
Submission of DFS report by consultants
Establishment of Technical Review Committee in AEPC
DFS approved by AEPC
UC and AEPC to share cost of DFS

SuDDC/VDC Level Demand Assessment by AEPC/RSC

Community level energy demand assessment
Community interest in equity contribution assessment
Pre-feasibility study to design project size to meet demands of households and productive energy use

tion in cash
(Sources of contribution: equity, debt etc)
CEF managed by AEPC
Subproject approval

Subproject Procurement

Bidding documents preparation by AEPC/RCS with support of PIC
ADB approval of bid documents
E-Bidding process for selection of Turnkey contractor
AEPC Review Committee for bid evaluation (AEPC/PIU, UC) with support of PIC
ADB approval of bid evaluation report
Turnkey Contractor Selected – Agreement between EPC contractor and AEPC

Subproject Construction & Commissioning

AEPC/RSC manage turnkey contractor
Independent verification of project construction based on approved criteria
For ADB fund, disbursement per provisions of bidding documents, in compliance with ADB Loan Disbursement Handbook.
For CEF, disbursement per provisions of bidding documents, in line with ADB fund disbursements
Completion certificate issued by AEPC after

Management and O&M of Power System

Turnkey contractor for training UC on O&M
AEPC/RSC support training of UC for plant Management
Plant O&M contract for large projects (>100 kW)
AEPC approval of O&M contract
UC hires manager to collect tariffs
Operator to operate the plant

CEF-Community Energy Fund; DDC-District Development Committee; DFS-Detailed Feasibility Study; PIC-Project Implementation Consultant; PIU-Project Implementation Unit; RSC-Regional Service Centre; UC-User Community;

Appendix B: Solar-Wind Mini-Grid Sub-Project Development Procedure

DDC/VDC Level Demand Assessment by AEPC/RSC

Community level demand assessment

Community interest in equity contribution

Awareness creation of new program publicizing need to get UC applications submitted by a specific due date with UC commit Subproject Construction & Commissioning

AEPC/RSC manage turnkey contractors

↓

Subproject Approval

Engagement of DFS preparation consultant by AEPC/RSC

Submission of DFS report by consultant

Establishment of Technical Review Committee in AEPC

UC and AEPC to share cost of DFS

Final DFS approved by AEPC

Provisional approval of subproject subject to meeting selection criteria and UC creating a CEF

CEF bank a/c with UC and AEPC as co-signatories

AEPC approval of bank ac/ and financial audit controls

UC deposits the contribution in cash (Sources of contribution: equity, debt etc)

CEF managed by AEPC

Subproject approval

↓

Subproject Procurement by Bundling and Batches

Applications of approved subprojects from multiple UCs bundled

Bidding documents preparation for turnkey package (design, supply and install) in 2 batches by AEPC

ADB approval of bidding documents

Bidding documents issuance and contractors submission of bids

Review Committee for bid evaluation

ADB approval for bid evaluation reports (technical and financial) per ADB guidelines

Contract agreement singed between AEPC and Turnkey contractors

↓

Subproject Construction & Commissioning

AEPC/RSC manage turnkey contractors

Disbursement per provisions of bidding documents, in compliance with ADB Loan Disbursement Handbook.

For CEF, disbursement per provisions of bidding documents, in line with ADB fund disbursements

Completion certificate issued by AEPC after commissioning

↓

Management and O&M of Power System

Turnkey contractor support training of UC for plant Management and O&M

UC to O&M the plant and collect tariffs

CEF-Community Energy Fund; DDC-District Development Committee; DFS-Detailed Feasibility Study; PIC-Project Implementation Consultant; PIU-Project Implementation Unit; RSC-Regional Service Centre; UC-User Community;

Appendix B: Sub-Project Selection Criteria

The following criteria will guide the identification of potential sites for subprojects to be implemented under the ADB/REREA Project. The selection criteria draw on the guidelines and project selection criteria developed by AEPC for renewable energy projects.

Selection Criteria	Micro-Mini Hydropower	Solar and/or Wind Mini-Grid
Technical	Adequate flow in the river, adequate head at the site and stable terrain. The installed capacity of the plant is conventionally calculated on the basis of flow for 11 months. For these mini hydro plants this criteria should be relaxed to 6 months exceedance. The project design of the mini-grid shall be grid compatible.	No proven resource of micro hydro power resource nearby. Adequate solar and wind energy resources. Wind resource data to be measured at least for one-year (that includes all the seasons), at height 10 m or above the ground level. For hybrid project, the annual averaged wind power density should be more than 35 W/m2 at hub height, and solar irradiance should be more than 4 kWh/m2/day The project design of the mini-grid shall be grid compatible.
Economic	EIRR for the project shall not be less than 12%	EIRR for the project shall not be less than 12%
Environmental	Environmental mitigation measures should be included in the detailed feasibility study report	Environmental mitigation measures should be included in the detailed feasibility study report. Particularly battery management process/guideline should be included in the mini-grid solar/wind package
Resettlement	Sub-projects shall not involve resettlement of local people, nor relocation of existing dwellings	Sub-projects shall not involve resettlement of local people, nor relocation of existing dwellings
Community Willingness & Contribution	The community should demand the system and contribute no less than 30% of the total procurement cost in line with the Renewable Energy Subsidy Policy. The contribution should be in cash to be deposited in the account managed by AEPC prior to subproject approval by AEPC. Any acquired land for the subproject shall be contributed by the communities. The community should provide evidence of their contribution to the project to be considered for support under the project	The community should demand the system and contribute at least 10% of the procurement cost in cash. The cash shall be deposited in the account managed by AEPC before subproject approval. Any acquired land for the subproject shall be contributed by the communities. The community should provide evidence that the contribution from communities are assured to be considered for support from the project.
Productive Use of Electricity	The proposed scheme must include a feasible business plan.	The proposed scheme must include a feasible business plan.

	At least 20% of the installed capacity should be used for productive uses.	At least 20% of the installed capacity should be used for productive uses
Multiple Use of Water	The targeted communities shall get water right clearance from concerned department and shall demonstrate that there is no issue of using water for power generation Multi-purpose projects that use water for irrigation and drinking water in addition to power generation should get high priority	Not applicable
Water Use and Land Use	There should be no conflict on the water and land use rights in the source stream/river. The community is solely responsible to resolve conflicts, if any, before implementation. The community has to provide evidence in writing from the concerned offices stating their rights for water and land use	There should be no conflict on land use rights for the project site. The management committee is solely responsible to resolve conflicts, if any, before implementation. The committee has to provide evidence in writing stating their right to use the land
Accessibility	The project will ensure that the project site will not be connected to the national grid in the next 5 years. The project site shall be accessible to at least fair roads within half day walking distance	The project will ensure that the project site will not be connected to the national grid in the next 5 years The project site shall be accessible to at least fair roads within half day walking distance
Gender and Social Inclusion	The targeted communities will preferably be composed of socially excluded groups of people and shall commit to include them in every project related activity	The targeted communities will preferably be composed of socially excluded groups of people and shall commit to include them in every project related activity
Sustainability of Project Operations	The community/users group should have clear procedures for project management and Operation & Maintenance of the project The plant operators should be trained and capable to operate and maintain the power plant by the time the manufacturer hands over the power plant	The community/users group should have clear procedures for project management and Operation & Maintenance of the project The plant operators should be trained and capable to operate and maintain the power plant by the time the manufacturer hands over the power plant

Appendix C: MMH Rapid Environmental Assessment Checklist

Instructions:

(i) The project team completes this checklist to support the environmental classification of a project.

(ii) This checklist focuses on environmental issues and concerns. To ensure that social dimensions are adequately considered, refer also to ADB's (a) checklists on involuntary resettlement and Indigenous Peoples; (b) poverty reduction handbook; (c) staff guide to consultation and participation; and (d) gender checklists.

(iii) Answer the questions assuming the “without mitigation” case. The purpose is to identify potential impacts. Use the “remarks” section to discuss any anticipated mitigation measures.

Project Title: REREAP NEPAL:

A. Basic Project Design Data

1. Rated power output (MW) = ____________________________
2. Weir height (m) = ____________________________
3. Weir pond surface area (ha) = ____________________________
4. Diversion type: Stream / river ☐ Irrigation channel ☐

Environment Categorisation Notes

Category B – if the sub-project has any of the following features:
- Located in a sensitive landscape
- Stream/river diversion, resulting in the partial dewatering of a river section for at least part of the year
- Downstream water/river uses compromised by project-induced flow changes

Category C – if the sub-project has both of the following features:
- Irrigation channel diversion
- Not in a sensitive landscape

SCREENING QUESTIONS	Yes	No	REMARKS
B. Site Sensitivity Is the weir and/or other project facility within or adjacent to any of the following areas?			
▪ Protected area			
▪ Buffer zone of protected area			
▪ Special area for protecting biodiversity			
▪ Primary forest			
▪ Range of endangered or threatened animals			
▪ Unregulated river			
▪ Undammed river downstream of the proposed weir/weir			
▪ Unique or aesthetically valuable landform or waterbody			
▪ Wetland			
▪ Area used by indigenous peoples			
▪ Cultural heritage site			
C. Potential Environmental Impacts **Is the Project likely to cause…**			
PHYSICAL			
▪ alteration of stream flows - e.g. daily or seasonal changes, diversion around / dewatering of a stretch of river?			
▪ high daily flow range from peaking operation of the powerhouse?			
▪ dryness (less than 50% of dry season mean flow) over a long downstream river stretch?			
▪ cumulative effects due to project forming part of a cascade of weirs?			
ECOLOGICAL			
▪ decline or change in fisheries below the weir due to: reduced low flows; large daily river flow fluctuations; destruction of fish breeding and nursery grounds?			
▪ reduction/prevention of fish migration due to weir barrier?			
SOCIOECONOMIC			
▪ adverse effect on people's sustenance and livelihoods due to downstream flow changes?			
• social conflicts due to the hiring of workers from other regions?			
community health and safety risks due to the transport, storage, use and/or disposal of materials likely to create physical, chemical and biological hazards?			
• risks to community safety due to accidental and natural hazards, especially where project structures or components are accessible to the community or where project operation (e.g. downstream releases) or structural failure could injure the community?			

Climate Change and Disaster Risk Questions The following questions are not for environmental categorization. They are included in this checklist to help identify potential climate and disaster risks.	**Yes**	**No**	**Remarks**
• Is the Project area subject to hazards such as earthquakes, floods, landslides, tropical cyclone winds, and climate changes (see Appendix I)?			
▪ Does the Project use or depend on resources which could be affected by climate change such as changes in temperature, precipitation, or extreme events (e.g. increased erosion which reduces generation efficiency, glacial melt which could affect generation potential)?			
▪ Are there any demographic or socio-economic aspects of the Project area that are already vulnerable (e.g. high incidence of marginalized populations, rural-urban migrants, illegal settlements, ethnic minorities, women or children)?			
▪ Could the Project potentially increase the climate or disaster vulnerability of the surrounding area (e.g. by diverting water from areas where drought is increasing, or encouraging settlement in earthquake zones)?			

Note: Hazards are potentially damaging physical events.

Appendix D: IEE Table of Contents (for Category B sub-projects)

1. **Executive Summary**
2. **Policy, Legal, and Administrative Framework**

   Nepal and ADB requirements and guidelines

   International agreements
3. **Description of the Project**

   Project ownership and maintenance

   Summary of project structures and operating regime

   Power supply arrangements
4. **Description of the Environment**

   Hydrology – average monthly river flow/s, monsoon season % of flow, etc

   Geology and land stability

   Land use on project sites

   River use in the dewatered section and further upstream

   Terrestrial ecology

   Conservation / Protected Areas
5. **Anticipated Environmental Impacts and Mitigation Measures**

   Potential adverse impacts – river diversion/dewatering, compromised river uses, affected aquatic ecology, spoil disposal

   Likely project benefits – direct and indirect
6. **Information Disclosure, Consultation, and Participation**

   Project community initiation

   Consultation and participation during project design and proposed during construction and operation

   Information disclosure – to date and proposed
7. **Environmental Management Program**

   Environmental and social measures to be implemented

   Monitoring
8. **Conclusions and Recommendations**

Appendix E: Environmental Assessment Checklist (for Category C sub-projects)

Sub-Project Name: --

Location: ----------------------------------- village

Ward No. ------, ------------------------- VDC, ---------------------- District

1. Project Description

Total capacity: -------- MW

Solar panels:
- number --------
- capacity/panel -------- Wp

Wind turbines:
- number --------
- capacity/turbine -------- kW
- tower height -------- m
- blade length -------- m

Powerhouse area: -------- m^2

Distribution line length: -------- m

2. Project Site

Total structure footprint: -------- m^2

Distribution line RoW area: ---------- m length x 3 m wide RoW = -------- m^2

Land type:	cultivation	forest	shrubland
	grassland	yard	degraded land
Ownership:	private	government	community
Protected Area (PA) or PA buffer zone:	yes	no	

If yes, name & describe (distance & location relative to site, etc): --

----

Other unique values on site or nearby: primary forest unique / aesthetically valuable landform cultural heritage site other

If yes, name & describe (value, distance & location relative to site, etc): ---

----

----

3. Benefits

Power supply:

- households -------
- institutions School/s ---

  Health post/s ---

- businesses ---

- community facilities (e.g. street lights) ---

  ----

4. Adverse Impacts

Forest clearance: ------- m^2 for main structures

------- m^2 for distribution line RoW

Any conservation significant species to be cleared: yes no

If yes, name species & describe significance: ---

Turbine noise:

- sound pressure level --------- dB(A)
- closest residence --------- m
- residence down wind for part of year yes no
- estimated max. noise at residence --------- dB(A)

Appendix F: Micro-Mini Hydropower Fish Impact Scoping Study

1. Introduction

Aquatic life, particularly fish, is usually directly adversely affected by the operation of hydropower dams and weirs constructed on rivers and streams. The extent and significance of these adverse impacts vary greatly depending upon the type and size of hydropower project (run-of-river or storage peaking generation; intrabasin or interbasin transfer; the volume and timing of the generation diversion; reservoir area, depth, and live and dead storage volumes; height of the dam/weir; etc) and the nature of the riverine system that is being affected. Common changes to riverine habitat created by hydropower projects include:

- **a physical barrier to fish migration/movement** – created by the dam/weir;
- **altered downstream river flows** – daily and/or seasonal flow changes, including a dewatered river section with reduced flows between the dam/weir and tailrace outlet; and
- **a deeper water habitat** - in the reservoir/pondage created by the dam/weir, thereby replacing moving water habitat with deeper, relatively still water potentially suitable for other species.

The Scaling Up of Renewable Energy Project (SREP) proposes to install around 20-25 mini/micro hydropower (MMH) projects to generate renewable energy for remote communities that are not connected to the electricity grid. These small projects will be run-of-river type, most likely ranging between 10-600 kW, whilst averaging around 100 kW. The projects will be installed in populated rural areas that are not connected to the electricity grid, generally between 600-3,000 m asl. Projects are likely to divert water by either:

(i) **in-stream location** – the larger MMHs are likely to have a concrete diversion weir of between 1-2 m height forming a very small weir pond upstream of each weir; or

(ii) **irrigation canal location** – many of the smaller MMHs will divert water from an existing irrigation canal.

The location of small MMH weirs in streams have the potential to block fish movement, particularly upstream fish movement, while the operation of these projects has the potential to degrade aquatic habitat along the short de-watered stream section between the diversion weir and the tailrace outlet. Irrigation channel diversions can create further dewatering of a stream if additional water is diverted at the source, but the adverse impacts of these types of projects will generally be less adverse on aquatic ecology as no new block will be created in the source watercourse.

Nepal's Himalayan river system differs from other geographic regions. Rivers and streams in the mountains and hills have high velocity flows due to the steep grade of these watercourses, and have shallow stony bottoms. Some migratory fish species (long and short distance) swim upstream during the rainy season (monsoon – mid June to the end of September) primarily to spawn, then return downstream each year. Any physical barrier in the stream or river system has the potential to block or severely reduce upstream fish movement, although the extent of this impact depends upon the height and configuration of the barrier and downstream changes to river flows.

The general features of two proposed SREP hydropower projects, Sani Veri (600 kW) and Simrutu (200 kW), located in the hills of Rukum District in the Mid-Western Development Region, have been used as indicative MMH stream diversion projects to assess likely project impacts and design management measures. Both projects are run-of-river, proposed to divert flows around 950 m and 1,200 m of stream respectively. They are located on the upper catchments of small rivers/streams at elevations of 2,100 m asl and 1,100 m asl respectively, with average annual flows of 16.3 m^3/s (2.3-56.6 m^3/s) and 0.5 m^3/s (0.35-5.5 m^3/s) respectively. The proposed concrete diversion weir heights are 2 m and 1 m respectively. Annual fish migration (upstream and downstream) occurs in these streams, with migration being an ecological imperative for the fish population, particularly diadromous species. All SREP MMH projects are likely to be located between 600-3,000 m asl.

2. Fish Species in Nepal

A total of 217 native fish species have been identified in Nepal, of which five are endemic[98]. Fish are distributed from the lowest elevation in Nepal (around 60 m asl) through the Middle Hills and up to the High Himalaya to around 4,000 m asl. Of these species, 59 are coldwater species found in mid-hill, hill and mountain streams and lakes.

Fish species typically found between 600-3,000 m asl are *Schizothorax plagiostomus*, *S. richardsonii*, *Neolissocheilus hexagonolepis*, *Schizothoraichthys* spp., *S. esocinus*, *Tor* Species, *Puntius chilinoides* (karange), *Labeo angra* (thed), *L. dero* (gardi), *Barilius* spp. (fageta), *B. bendelisis*, *B. vagra*, *B. barila* and *B. bola, Chagunius chagunio* (*kubre*), *Clupisoma garua* (jalkapur), *Bagarius yarellii* (gonch - the largest river fish), *Garra* species, *Glyptothorax* species (sucker catfish), *Psilorhynchus pseudecheneis* (stone carp), *Garra gotyla* (stone roller), and *Noemacheilus* species (loach)[99] These fish species can tolerate a wide range of water temperature (from 10-30°C), but in water with a high dissolved oxygen level, low carbon dioxide concentration, high transparency, low productivity and sparse vegetation most live in water temperatures between 10-20°C. These fish species move upstream and downstream seasonally, depending on breeding and feeding habits.

2.1 Migratory Fish Species

Globally, about 8,000 fish species live in freshwater, around 12,000 species live in the sea, and about 120 species regularly move between freshwater and sea water[100]. Anadromous fish species migrate towards freshwater for reproduction and grow in the sea, whereas catadromous fish species migrate to the sea for breeding and back to freshwater to grow. Migratory fish require different environments to complete their life cycle for reproduction, production of juveniles, growth and sexual maturation. Migration depends on the fish species, with species categorized as long distance migratory, short distance migratory and resident.

Nepal Migratory Species

[98] Shrestha, T.K., 2008. *A Study of Fishes of the Himalayan Waters*. In Ichthyology of Nepal. Himalayan Ecosphere, Kathmandu, Nepal. 389 pp.

[99] Edds, D.R., 1989. *Multivariate Analysis of Fish Assemblage Composition and Environmental Correlates in a Himalayan River - Nepal, Kali Gandaki/Narayani*. Ph.D. Thesis. Oklahoma State University, U.S.A.

[100] Cohen, D.M., 1970. How Many Recent Fish are There? In: *Proceedings of the California Academy of Science. Vol 38: 341-345.*

Long distance migration: the main long distance migratory fish species in Nepal are Golden Mahseer (*Tor* tor, *T. putitora*), giant catfish or Gounch (*Bagarius yarellii*), Jalkapoor (*Pseudeutropius* spp.*, Clupisoma* spp. and freshwater eel (*Anguilla bengalensis*). These species migrate upstream to spawn during high river flows in the monsoon season (mid-June to September) and migrate downstream to feed and grow in autumn (October-November) after river flows have decreased. Some long distance migratory species can leap up to 4.5 m in height (e.g. Mahseer).

Short distance migration: short distance migratory fish species are Copper mahseer or Katle (*N. hexagonolepis*), and Gardi (*Labeo dero*), Thed (*L. angra*), Kalbasu/black rohu (*L. calbasu*), Hande (*L. pangusia*), Snow trout (*Shizothorax* spp., *Schyzothoraichthys* spp.) etc. Some of these species can leap up to 3 m in height (e.g. Snow trout).

While the long distance and short distance migratory fish species listed above occur from 600-3,000 m asl, migration depends on the nature of the river/stream and flow of water. Mahseer, giant catfish, Jalkapoor and freshwater eel move upwards primarily where there is a large volume flow with a high flow velocity and high oxygen content in the water. These species do not migrate in low volume flows. Accordingly, fish diversity and population size decreases at higher altitudes.

Nepal Resident Species

Resident fishes are Buduna (*Garra gotyla*), Phageta (*Barilius vagra*, *B. bendelisis*), Garahi (*Channa punctatus*), Bam (*Amphipnous cuchia*,) and Tiger loach (*Botia* spp.*)*, Gadela (*Nemacheilus* spp.), Stone eel or chuche bam (*Mastacembelus armatus*), Minor carp (*Puntius ticto*), Chalwa (*Oxygaster bacaila*), Stone carp (*Psilorhynchus pseudecheneis*), water catfish or Kavre *(Glyptothorax* spp.), and Kavre *(Pseudecheneis sulcatus*). These fishes creep and crawl and can tolerate still or stagnant water in impoundments to some extent, and are able to live and breed in the tailwater from the tailrace outlet and in the discharge from spillways.

The same resident species do not occur in all streams with the same altitude due to ecological and physical differences in riverine conditions, including differences in available natural food sources.

3. Potential Project Effect on Migratory and Resident Fish Species

The potential adverse impacts of small run-of-river hydropower projects relate to:

(iv) blocking fish migration by creating a barrier from the diversion weir;
(v) dewatering a section of river between the diversion weir and tailrace outlet; and
(vi) altering fish habitat by creating a weir pond where sediment build-up will occur.

Weir barrier: long and short distance migratory species and resident species will be potentially affected by the installation of the 1-2 m high diversion weirs. A weir can create a physical barrier that restricts the range of some fish species to the zone below the weir, reduce spawning success due to the loss of access to spawning habitat upstream of the weir. A weir can also cause injury as a result of the repeated attempts of fish to jump this obstacle. Predation of fish may also increase as fish gather below the impassable barrier, ultimately resulting in reduced fish stocks.

Most migratory fish species move upstream into clearer water with higher oxygen levels, including stretches of stones and gravels suitable for spawning during the monsoon. Some migratory species will be able to pass upstream over these low weirs when larger flows (particularly during the monsoon) occur, and flows between the weir and tailrace outlet are only marginally reduced. Other migratory species will be incapable of passing over the weir at these times, and many species will be affected by reduced stream flows between the diversion weir and tailrace outlet during the dry season depending upon the volume and timing of the flow reduction.

Migratory fish species with sucker-like mouths can climb vertical weir walls and rocks, although when they leap downstream they often become victim to predation. Fish species such as *Glyptothorax* spp. and *Pseudecheneis sulcatus* present in the hill region migrate upstream with the help of sucker-like apparatus, but other migratory species that move by leaping and swimming are unable to climb upstream.

Most resident fish species will be unable to swim upstream over 1-2 m high concrete weirs as they cannot leap to that height. Additionally, some resident species will be adversely affected by altered habitat (water quality, breeding grounds and aquatic fauna) immediately upstream and downstream of the weir, although a number of resident species are known to tolerate stagnant/still water and live and spawn in tailrace outlet flows and below the spillway of hydropower projects.

In addition, a major effect of mini and micro hydropower projects on fish populations can be a reduction in fish mortality during fish passage downstream through the turbines. Migratory and resident fish trying to move downstream could can be drawn into the penstock and pass through the turbines. The provision of screens of sufficiently small mesh size on the weir intake may prevent fish entry into the turbines, although screens are easily blocked and therefore require regular maintenance. Intake water velocity equal to or less than 1.5 m/s is usually low enough to prevent the entrainment of fish onto screens.

It should be noted that some of the main fish species require strong flowing water to swim upstream (i.e. *Tor* spp, *Bagarius yarellii*, *Pseudeutropius* spp., *Clupisoma* spp. and *Anguilla bengalensis*) and hence favour stronger flowing rivers, therefore the impact of mini-micro hydropower weirs on small upper catchment streams on these species is likely to be low as these species are less likely to uses these watercourses.

A likely negative effect of 1-2 m high diversion weirs on aquatic habitat is the accumulation of sediment in the weir pond during the monsoon, but this will be restricted to a stream distance of around 100-200 m. Excess macrophyte growth in the weir pond due to a change from lotic (moving) to lentic (still) floral and faunal elements (primarily at warmer lower altitudes) will be limited given the relatively shallow depth and small volume of water detained in the pond for a short period of time.

River dewatering: during the dry season, particularly in the driest months from January to March, the partial dewatering of the stream section between the diversion weir intake and tailrace outlet has the potential to substantially degrade this riverine habitat and reduce access to spawning and nursing grounds. The low flow condition may physically inhibit large fish from passing downstream, and therefore may need to be increased to allow fish passage.

Water quality: weirs can affect the quality of aquatic ecosystems by altering river water temperature, flow regimes, dissolved gas content and other ecological parameters, thereby affecting fish diversity and population size. Given the size and depth of the SREP MMH weirs, the residence time of water stored by the weir will be minimal therefore little impact on water quality is expected.

4. Mitigation Measures

Hydropower projects in Nepal have generally been established on river stretches where fish migration occurs and have thus affected migration. Most, if not all, SREP MMH stream diversions will be located on stream sections where fish migrate, as is the case for the Sani Veri and Simrutu projects. The diversion of stream flows to generate power will in effect dam the streams, directly and indirectly adversely affecting the movement of both migratory and resident fish species. While the adverse impact of medium to large hydropower projects (generally 50 MW capacity and greater) on large rivers may justify the establishment of fish hatcheries to offset fish loss caused by the projects, such a measure is not justified for MMHs due to the high establishment and operating cost and difficult logistics involved. In contrast, fishways may be a cost effective mitigation measure for SREP MMHs given the low height of the weirs (whereas these structures are difficult to make effective on the medium to high dams of large hydropower projects).

4.1 Fishways

The installation of small fishways on MMH diversion weirs may assist upstream fish movement. Several fishways have been installed in Nepal but they were not designed for local conditions and are not functioning. Reasons for their failure are undocumented. Fishways have been designed for specific species in developed countries, but none have been designed for Nepal's unique species, river channels and river system features. In addition, there are no known examples of effective fish ladders in the Indian or Pakistan Himalaya.

Fishways were developed in the first half of the 20th century. Flow patterns and turbulence in fishways provide swimming conditions suitable for some fish species to move up a gradient[101]. Fishway types include: (i) vertical slot; (ii) pool-and-weir; (iii) denil; and (iv) culvert[102]. The first three types are similar, with each creating pools in their structures. Pool-and-weir and denil (or its revised version) fishways are the most frequently used fishways in North America and Europe[103], with pool-and-weir fishways commonly used on small hydropower projects.

Pool-and-weir fishways have been widely used in Norwegian rivers with up to 1 m high weirs separating each pool[104]. These fishways consist of a channel with two or more weirs at regular intervals on a specific slope, providing interconnected resting pools that also serve as takeover areas. Water flows from one pool to another over each weir, improving the

[101] Yagci, O., 2009. *Hydraulic Aspects of Pool-Weir Fishways as Ecologically Friendly Structure*. Elsevier, Ecological Engineering, page 36-46.
[102] Yagci, O., 2009. *Hydraulic Aspects of Pool-Weir Fishways as Ecologically Friendly Structure*. Elsevier, Ecological Engineering, page 36-46.
[103] Therrien, J. and G.B. Genivar, 2000. *Fish Passage at Small Hydro Sites*. IEA Technical Report. Consulting Group Inc., Québec City, Québec Canada.
[104] Brittain, J.E., 2003. *Weirs as a Mitigation Measure in Regulated Rivers - The Norwegian Experience*. Canadian Water Resources Journal, 2003, 28(2): 217-229, 10.4296/cwrj2802217.

migration of fishes that are not able to jump over the project diversion weir/dam. The design of a pool-and-weir fishway (Figure 12.2) by Asserude, R.G., (1982-1985) and Asserude and Osborn (1985) has been recommended for the seasonal movement of the migratory fishes. This simple type of fishway has the advantage of allowing the upstream movement of more diverse types of migratory and resident fish species. Fish locomotion can occur by creeping, swimming, leaping and jumping. Golden mahseer, copper mahseer, snow trout, catfish, river carps and other species will have free movement over pool steps of 1.0-2.5 m height, but some species require lower height steps to be able to move upstream. According to Larinier and Marmulla (2003), the ideal height of pools should be no more than 0.30 m, although this design has not been used in Nepal.

Vertical slot fishways (Figure 12.1) are also suitable for low height weirs and low water discharges. This fishway is similar to a pool-and-weir system, except that each "dam" has a narrow slot in it near the channel wall. This allows fish to swim upstream without leaping over an obstacle. Vertical-slot fishways tend to handle seasonal fluctuations in water levels on each side of the barrier.

Pool-and-weir and vertical slot fishways are suitable for mini and micro hydropower projects, but fishing has to be strictly prohibited at the weir and in the dewatered river section, and the fishway needs to be fenced to prevent fishing as fish are easily removed when moving upstream through the fishway or congregating below the weir.

Fish rarely use fishways to descend downstream, possibly due to the difficulty in locating this pathway and the relatively small proportion of the river flow passing down the fishway compared with the flow passing over the weir[105]. However, during the dry season some resident species will migrate downstream via the fishway, so the optimum flow should be released through the fishway. With a reduced flow during the dry season, fishes may be stranded in pools below dam and fishers will take advantage of this by fishing out the stream unless this is prohibited and policed.

Figure 12.2: Pool-and-Weir Fishway

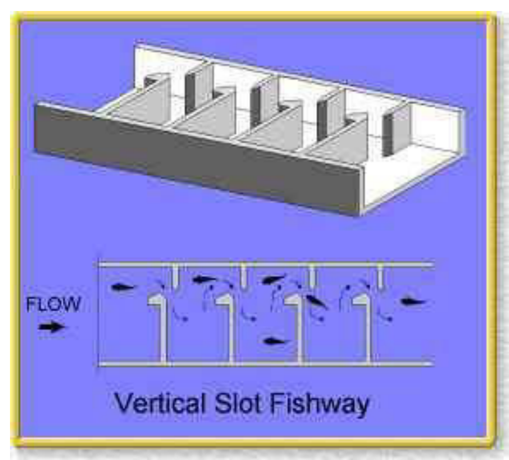


Figure 12.1: Vertical Slot

These fishway designs may be subject to filling with sediment each year and therefore will probably require manual cleaning at least once per annum soon after the monsoon.

[105] Justin, O'C., D. O'Mahony, and J. O'Mahony, 2003. *Downstream Movement of Adult Murray-Darling Fish Species*. Final Report to Agriculture, Fisheries and Forestry Australia, Arthur Rylah Institute, Heidelberg, Victoria.

Few fishways have been installed in Nepal on weirs, barrages or dams. Existing fish ladders in Nepal are not functioning, like the fishway on the Koshi Barrage in eastern Nepal that has instead become a fishing spot as this is not being prevented. The barrage was installed in 1963 but it is uncertain when the fishway was installed.

Recommendation

The SREP MMH sub-project features and stream conditions in Nepal that need to be accounted for when considering the installation of fishways on diversion weirs include:

- there are no successfully operating fishways in Nepal;
- each MMH sub-project is very low cost, therefore a fishway has to affordable relative to the total sub-project cost;
- many SREP MMHs will be located in small upper catchments where fish diversity and the number of migratory species is low; and
- fish moving through the fishway are at a very high risk of being caught by fishermen unless fishing is prohibited and this is policed.

Given the small size of many of the streams that the SREP MMH projects are likely to be located on, and the likely prevalence of resident species over migratory species in these stream reaches, it is recommended that a pool-and-weir fishway with 0.3 m high steps be trialed on a SREP MMH sub-project. The ideal site for the fishway trial would be where:

- a greater number of fish species and higher value species occur whose movement may be improved by the fishway (usually associated with a greater average stream flow);
- fish movement is not already prevented or substantially reduced by existing downstream hydropower projects or diversions;
- at a lower altitude where the potential benefit of the fishway is greater;
- a reasonable downstream release from the weir during the dry season is proposed. The minimum volume of this flow is difficult to quantify, but according to[106] an attracting flow is 0.3 m^3/s, although the higher the percentage of natural flow released through the fish pass, the greater the attraction;
- local people fully support the fishway and agree to prohibit fishing on this structure and immediately upstream and downstream of the weir and tailrace outlet.

For example, the Simrutu MMH is unsuitable to trial a fishway as the proposed dry season flow to be released from the weir is very small at just 0.01 m^3/s (10 L/s). The proposed minimum average monthly flow from Sani Veri MMH is 0.52 m^3/s minimum flow, therefore sufficient flow exists to operate the fishway.

Based on the success of the trialed fishway a decision can then be made on whether to retro-fit fishways or not on a project-by-project basis.

[106] Borghetti, J.R., Nogueira, V.S.G., Borghetti, N.R.B., Canzi, C., 1994. *The Fish Ladder at the Itaipu Binacional Hydroelectric Complex on the Parana River, Brazil*. Regulated Rivers: Research & Management 9: 127-130.

4.2 Fish Hatchery

A fish hatchery and restocking program can be an effective method of restocking river sections upstream of weirs with fish species that are eliminated or suffer a population reduction caused by the weir barrier. Such initiatives are usually only implemented on large hydropower projects where there is sufficient budget to fund this measure and the cost-benefit justifies its implementation. For example, the Kaligandaki "A" Hydropower Project, a 144 MW run-of-river project with a 44 m high dam commissioned in 1982, established a successful fish hatchery and restocking program in western Nepal at 1,088 m asl.

Given (i) the low height of the SREP MMH weirs, (ii) the generally small size of streams that will be affected, (iii) the total cost of each MMH project compared with the cost of a hatchery and restocking, and (iv) the isolated and dispersed location of these projects to one another, a hatchery and restocking program for any of the MMHs is not a realistic option as it is a relatively high cost measure that would involve difficult logistics to restock isolated streams.

4.3 Riparian (Environmental) Flow

A constant flow release from the weir into the dewatered zone between the weir and tailrace outlet is recommended at 10% of the average annual flow to support microflora, aquatic insects and fish, based on research by[107]. Where a fishway is installed this flow should be released down the fishway to provide sufficient flow for fish movement. This flow rate compares with the minimum environmental flow specified for hydropower projects under the *Hydropower Development Policy, 2001*, that requires a release to maintain the sustainability of aquatic ecosystems and other river uses, specified as being "*at least ten per cent of the minimum monthly average discharge of the river/stream …*".

5. Conclusion

The diversion of a stream with a 1-2 m high concrete weir will have direct and indirect negative effects on aquatic organisms, particularly fish. Stream diversion for hydropower generation will create an obstruction in the watercourse, potentially blocking the upstream and downstream movement of some fish, changing the aquatic ecosystem in the weir pond (generally covering between 50-200 m of stream) from a lotic to lentic condition, and altering fish habitat (particularly between the weir and the tailrace outlet – up to around 1,200 m of stream). Some fish species will favour this altered environment and some will be adversely affected by it.

The impact of the proposed MMHs on small upper catchment streams on some major fish species (i.e. *Tor* spp, *Bagarius yarellii*, *Pseudeutropius* spp., *Clupisoma* spp. and *Anguilla bengalensis*) will be low as these species favour strong flowing water to migrate upstream, conditions that are not present in many of the smaller streams that will be diverted.

To minimize the adverse impact on the fish population at the project site and upstream, a pool-and-weir fishway appears to be suitable to allow the upstream and downstream movement of a range of fish sizes and types, from small to large fish that move by creeping,

[107] Ploskey, G.R., J. Kim, M.A. Weiland, J.S. Hughes, E.S. Fischer, 2007. *Re-Analysis of Hydroacoustic Fish-Passage Data from Bonneville Dam after Spill-Discharge Corrections. Final Report.* Prepared for the U.S. Army Corps of Engineers, Under a Related Services Agreement With the U.S. Department of Energy, Contract DE-AC05-76RLO1830.

leaping, swimming or jumping. The pool-and-weir fishway is suitable for *Labeo angra* (spp.), L. *dero*, Catfish (*Bagarius* spp), Catfish (*Glyptothorax* spp.) and *Anguilla bengalensis* that can creep and crawl through the concrete passage. The interconnected resting pools in this type of fishway allow fish to rest and overtake other fish. The recommended height of each weir step is up to 0.3 m based on[108]. Given that fishways have not been used in Nepal, it is recommended that a pool-and-weir fishway be trialled on a SREP MMH, designed for the specific.

Maintenance of the fish passage is needed at least once a year to clear it of any obstructions, particularly immediately after the monsoon. The fishway also needs to be fenced to prevent access, and fishing has to be strictly prohibited at the weir and in the dewatered river section.

A minimum year-round environmental release of water from the weir is recommended, equivalent to at least 10% of the annual average flow rate and is an optimum amount water flow[109]. The higher the percentage of natural flow passing through the fishway, the greater the likelihood that fish will pass through the fishway. This requirement is needed particularly during the dry season as fishes will get stranded in pools immediately below the tailrace outlet and potentially below the weir during periods of reduced flows, and fishers will take advantage and fish out the entire areas.

[108] Larinier M. and G. Marmulla. 2003. *Fish Passes: Design, Dimensions and Monitoring*. FAO/DVWK. Rome. 119 pp.

[109] Ploskey, G.R., J. Kim, M.A. Weiland, J.S. Hughes, E.S. Fischer, 2007. *Re-Analysis of Hydroacoustic Fish-Passage Data from Bonneville Dam after Spill-Discharge Corrections. Final Report.* Prepared for the U.S. Army Corps of Engineers, Under a Related Services Agreement With the U.S. Department of Energy, Contract DE-AC05-76RLO1830.

Appendix G: List of Important Animal Species in Dhorpatan Hunting Reserve

Common Name	Scientific Name	IUCN Status	CITES Code
Snow Leopard	*Uncia uncial*	EN	I
Common Leopard	*Panthera pardus*		I
Red Panda	*Ailurus fulgens*	V	III
Musk Deer	*Moschus chrysogaster*	EN	I
Barking Deer	*Muntiacus muntjak*		
Bharal	*Psetuidois nayaur*		
Himalayan Thar	*Hemitragus jemlahicus*	K	
Himalayan Serow	*Naemorhedus sumatraensis*	T	I
Himalayan Ghoral	*Naemorhedus goral*		I
Wild Boar	*Sus scorfa*		
Himalayan Black Bear	*Selenarctos thibetanus*	V	I
Grey Wolf	*Canis lupus*	V	I
Wild Dog	*Cuon alpinus*		II
Common Mongoose	*Herpestes edwardsii*		III
Hare	*Lupus nigricollis*		
Red Fox	*Vulpes vulpes*		
Jackal	*Canis aureus*		III
Bat	*Cynoptents sphirus*		
Pica	*Ochotomica roylet*		
Common Langur	*Presbytis entellus*		I
Rhesus Monkey	*Macaca mullata*		
Indian Porcupine	*Hystrix indica*		
Bush Rat	*Golunda ellioti*		
Lynx	*Felis lynx*	E	II
Shrew	*Anathana ellioti*		
Yellow Throated Martin	*Martes flavigula*		III
Clouded Leopard	*Neofelis nebulosa*	V	I
White Bellied Rat	*Niviventer niviventer*		
Leopard Cat	*Felis bengalensis*		I
Urasian Pigmy Srew	*Sarex minudus*		

Appendix H: List of Important Plant Species in Gaurishankar Conservation Area

Scientific Name	Common Name
Abies spectabilis	Gobre Salla
Quercus semecarpifolia	Khasru
Quercus lanata	Banjh
Rhododendron arboreum	Lali gurans
Rhododendron barbatum	Chimal
Pinus wallichiana	Salla
Jasminum humile	Jai
Ilex dipyrena	Seto khasru
Edgeworthia gaedneri	Argeli
Dhapne bholua	Lokta
Berberis chitria	Chutro
Rosa sp	Jangali gulaf
Valeriana jatamansii	Sugandhawal

Appendix I: Public Awareness Safety Pamphlet

Appendix J: References

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