Potential of using Solar Energy for Irrigation in Hilly Region of Nepal

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1. Introduction - General

Demand

GDP growth rate affected by monsoon

5.6 % (2012)
3.6 % (2013)

Status of irrigation services in Nepal

Majority of population ➔ still under poverty and suffering from hunger (insecurity of food)

Agriculture contributes to 31.7% of GDP (2012)

✓ focus on expanding sustainable irrigation services
✓ produce more food using less water through modern irrigation techniques
✓ use clean and green energy for irrigation
✓ increase the livelihood of the farmers.

1. Introduction – Nepal

Challenge ➔ to meet the growing demand ➔ limited resources ➔ sustainable development ➔ reduce the effect of climate change

• These three basic needs ➔ must be dealt together ➔ interconnected
• For example, to grow more food ➔ need more water and need more energy and all these has direct impact on the climate.

This study tries to address these three issues together

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50% Food and Agricultural Organization (FAO)

30% International Food Policy Research Institute (IFPRI)

Nepal ➔ one of the least developed countries

About 70% of population depend on agriculture

International Energy Agency (IEA)

Source: ipd.com

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2. Study Area – Hilly Region

3. Why Hilly region?

### Cultivable Land in different regions of Nepal

3.1 Why Hilly region? – Problem Statement

1. Relatively flat, large cultivable land along the banks of river are under cultivation (rain fed irrigation)

2. Irrigating using gravity flow on this upland areas are either impossible or require high cost (long canal)

3. Weak geology - risk of canal damage and washout

4. Electricity not easily available – either far from grid lines or shortage

5. Very often shortage of petrol and diesel oil (petroleum based pumps)

4. Research Objectives and Questions

1. To find suitable sites for installation of solar water pumps to irrigate cultivable lands in Hilly region of Nepal

2. To conduct detail technical and economic feasibility in one of the suitable sites
5. Assumptions and Limitations

➢ Areas below 30 m head are assumed to be irrigated through gravity flow
➢ Areas between 30 m to 200 m pumping head is assumed to be suitable for single stage pumping using solar pumps
➢ Water availability has been analyzed in basin level
➢ Costing of complete solar pump and PV modules are based on the cost provide by sales partner in Nepal for European pumps
➢ The spatial data that has been collected were from various sources. Hence, the limitation of these used data are also the limitations of this study

6. Methodology

Two different methodology, one for each objectives

Methodology for first objective – to find the potential

Acquisition and processing of data

- Solar irradiance
- Effective rainfall
- Digital Elevation Model (DEM)
- Reference evapotranspiration
- Soil data
- River data
- Type of soil

6.1 Raster dataset used for analysis

ASTER Digital Elevation Model (DEM) of Nepal

Source - Author, prepared based on data from USGS using ArcGIS

ETo map of Nepal

Source – Soil and Terrain (SOTER)

Soil map of Nepal

Major Rivers of Nepal

Source – Author, prepared based on data from DOS, using ArcGIS

6.2 Methodology – First objective in detail

- Potential areas

Goal

Selected

Criteria

Datasets

Standardization

Weighting

Weighted Overlay analysis
6.4 Methodology – First objective

This model was used to iterate the analysis for different height (10 to 800 m) and buffer distance of 500, 1000 and 2000 m

6.4 Methodology – Second Objective

Site on Gawan Khola, Sindhuli district is selected. Lorentz wants to donate two complete solar pump and irrigation system to earthquake victims of Nepal.

Location – 27°, 85°

0.5 Ha → Drip irrigation

0.5 Ha → Sprinkler

Design discharge – 25 m³/day

Gross head ~ 50 m

Pump type – Submersible pump (PS 1800 C-SJ5-12)

Panel Capacity – 2 kW

Horizontal irradiance - 5.244 kWh/m²/day

7. Result and discussion – Potential sites

Suitable site map (between 30-200 m pumping head) within buffer distance of 2000 m in Hilly region of Nepal.

Pilot Solar Water pumping system with modern Irrigation Technique is under construction.
7.2 Result and discussion – Cash flow

**Economic analysis in selected site**

Cash flow of cost and benefit with solar pump and irrigation system in different years

- **IRR:** 25%, **Payback:** 4.92 yrs
- **B/C at 10%:** 1.28, **12%:** 1.25

7.3 Result and discussion – Sensitivity analysis

**Sensitivity analysis – three cases**

7.4 Result and discussion – Cost, benefit per m³

**Benefit and cost of pumping unit volume of water for irrigation system at different elevation for 10 and 20 years**

- **Benefit:** 0.95 $/m³
- **Cost:** 0.6 $/m³ at 30 m, 0.79 $/m³ at 200 m

7.5 Result and discussion – Cost on other sites

**Remarks**

- **Cost per m³ of pumping at site with minimum horizontal irradiation in Hilly region of Nepal**
- **Very less increase in the cost (maximum 2.7%)**

<table>
<thead>
<tr>
<th>Remarks</th>
<th>Maximum Irradiance</th>
<th>Minimum Irradiance</th>
<th>Selected Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude (Lat, Long):</td>
<td>28°N, 88°E</td>
<td>27°N, 88°E</td>
<td>27°N, 85°E</td>
</tr>
<tr>
<td>Horizontal Irradiance (kWh/m²/day):</td>
<td>5.985</td>
<td>4.793</td>
<td>5.244</td>
</tr>
</tbody>
</table>

- **Site with minimum solar irradiance was taken for cost and benefit analysis**
8. Conclusion

✓ The total potential area (maximum lift of 800 m, 2000 m buffer distance) → approximately 280 thousand hectares.
✓ Installation of Solar pumps along the banks of river in Hilly region of Nepal → Feasible → IRR about 25%, payback period → about 4.9 years.
✓ Benefit that can be obtained by using one cubic meter of water for irrigation → $0.95 USD, cost of using one cubic meter of water for irrigation → $0.6 USD at 30 m to $0.79 USD at 200 m.
✓ Out of 280 thousand hectares of potential area, 120 thousand hectares (area between 30 m to 200 m elevation) of area are found to be suitable for installing single stage pumping system using solar water pumps for irrigation.
✓ Providing irrigation facilities to 120 thousand hectares of suitable land → directly benefits about 860 thousand population → saves an annual import of agricultural products equivalent to equivalent to $1.04 billion USD.
✓ Finally, it can be concluded that use of solar pumps along the river banks of Hilly region of Nepal can help for food security within the country and increase the living condition of farmers.