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INDUS BASIN INITIATIVE

Harnessing solar energy for alternative irrigation supply in cold, arid climate zones

Factsheet on solar-powered irrigation potential and operational requirements based on pilot interventions in Gilgit-Baltistan, Pakistan

Communities in Gilgit-Baltistan predominantly depend on subsistence-based agriculture. Yet only 2% of the total land area is cultivable, out of which only about half is under cultivation since traditional glacier-fed channels are the major source for irrigation. Consequently, agricultural productivity is not sufficient to sustain the growing population – with Gilgit-Baltistan remaining a food-insecure region – or for commercial profitability.

To compound matters, glacier retreat and glacier surface lowering due to climate change and frequent disasters over the last decade have damaged and disconnected irrigation networks conveying glacial meltwater to the fields. River irrigation remains difficult since much of the arable land is situated at an altitude higher than the main river.

Here, renewable energy solutions such as solar pumps could be highly useful. Gilgit-Baltistan is endowed with ample solar energy potential (average daily irradiation is 3.35 kWh/m^2/day annually and 4.36 kWh/m^2/day in summer). Harnessing this abundant and free solar energy to lift river water and utilizing efficient irrigation methods such as micro-irrigation could help expand cultivation and agricultural production.

Solar energy for irrigation

Under the "Agricultural Water, Energy, and Hazard Management for Improved Livelihood in the Upper Indus Basin, Pakistan" project, ICIMOD piloted community-led, climate-smart water management technologies in Passu and Morkhun villages, Gilgit-Baltistan, to limit overdependence on glacial-fed irrigation and to harness untapped water and land resources in the region. In this local-consortium model of partnership, the Gilgit-Baltistan chapter of WWF-Pakistan mobilized the local community while the Pakistan Council of Research in Water Resources (PCRWR) and the Mountain Agricultural Research Centre (MARC) provided technical support to establish the pilot sites.

In Morkhun, the piloted solar pump lifts water at a rate of 10 litres/minute from the Khunjerab River to two storage tanks (2,000 litres each) placed around 250 feet uphill. A drip irrigation system efficiently supplies water for irrigating apple orchards on 2.5 hectares of land. A similar intervention package was also piloted in Passu with the water delivery head of 100 feet and without the storage tanks. A preliminary but comprehensive cost–benefit analysis of each pilot has shown that the piloted package has been highly successful, with a positive net present value of PKR 4,297,273 (USD 1 ≈ PKR 170 as of October 2021) for 20 years with a discount rate of 12.25% and assuming that plants will start fruiting in the next four years.

The piloted intervention package experienced challenges mainly due to sediment load in the river water. Local wisdom and technological customization, such as filtration of lifted water and use of non-pressure compensating emitters to avoid clogging, helped overcome these challenges. Thus, successful installation and operation of this intervention package requires careful pre-feasibility studies of the sites and local customization.

Pilot details

Location
Passu and Morkhun, Upper Hunza, Gilgit-Baltistan, Pakistan

Rainfall
<250 mm annually

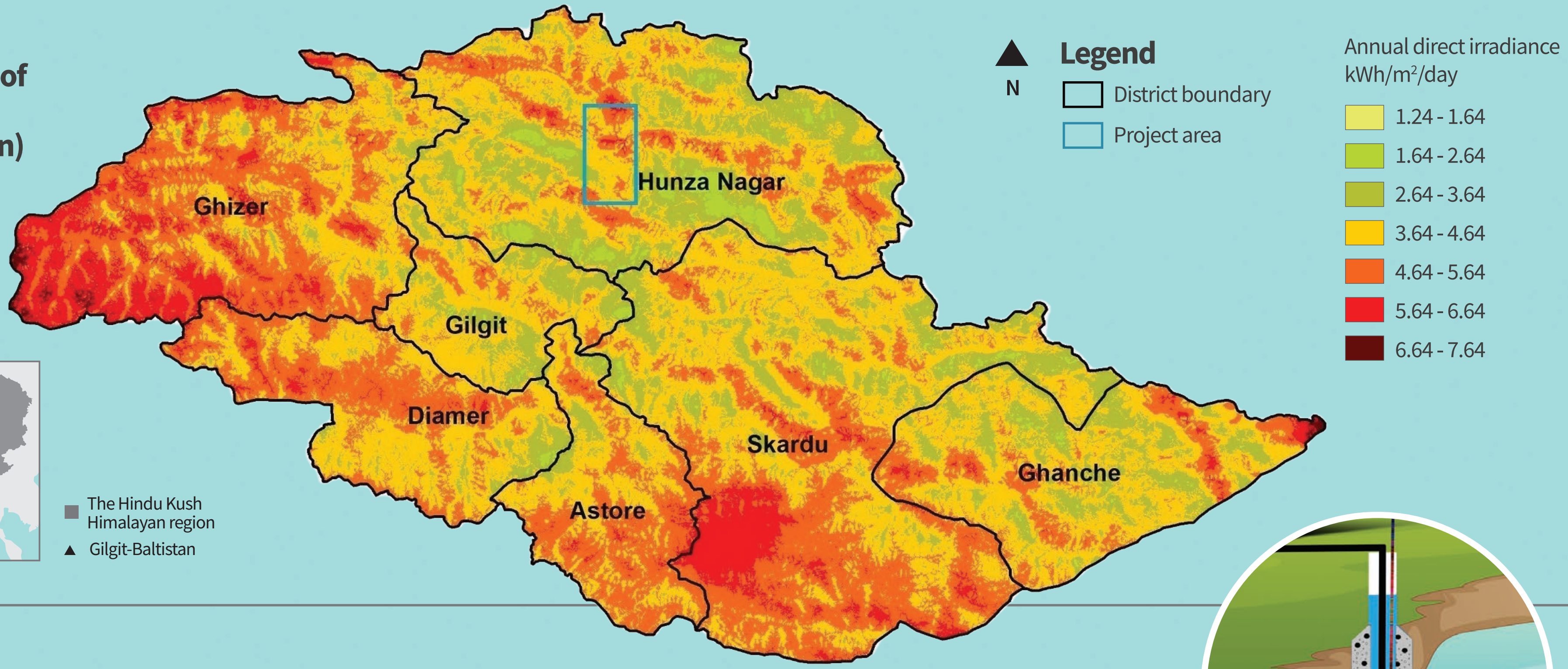
Average landholding
0.5–1 hectare

Climate
Cold, arid

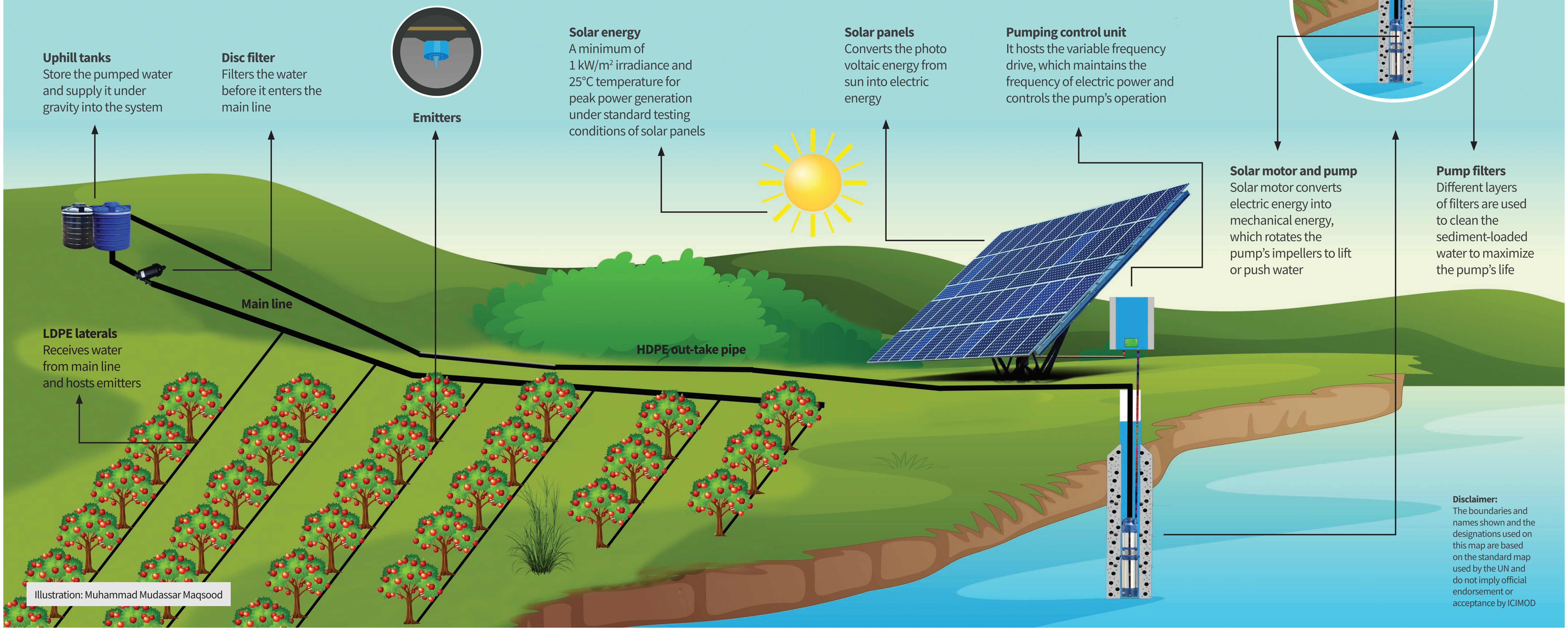
Altitude
2,000–3,000 masl

Piloting year
2016–17

Average daily irradiance map of Gilgit-Baltistan (summer season)



Components and working mechanism



Disclaimer:
The boundaries and names shown and the designations used on this map are based on the standard map used by the UN and do not imply official endorsement or acceptance by ICIMOD

Maintenance

- Frequently clean the solar panels and conduct site inspections
- Clear air locks in the delivery pipes
- Clean the water storage tank on a bi-monthly basis
- Clean and flush the disc filters and emitters on a bi-monthly basis
- Flush main and submain pipelines and laterals before the beginning of winter
- Clean the pump filters to ensure least drawdown in the filter casing
- Lay down the laterals under top soil layer to protect from harsh weather

Costs

- Estimated ex-works cost of a pumping unit is about PKR 225/Watt. A 2 kW pump costs 450,000 PKR.
- PKR 40,000–60,000 for the water storage and distribution apparatus
- PKR 70,000–120,000 per acre for the drip irrigation system

Key benefits

- Climate-smart alternative to fossil fuels which helps in promoting low-carbon irrigated agriculture
- Reliable option for far-flung and disconnected areas
- No need for external power except solar energy
- Comparatively more efficient than diesel or gasoline engine-driven pumping units
- Can be moved to any desired location if mounted on a trailer

Flexibility of design

- Solar pumps are available in different capacities ranging from 1 kW to 150 kW.

Factors to consider

- The initial capital costs of solar pumps are high. Exploring funding for the initial stage of the project can help wide adoption of the technology.
- At least 1 kW/m^2 irradiance is required to generate the peak power of solar modules. Under overcast conditions, the efficiency reduces exponentially.
- Photovoltaic modules work best at 25°C. The power reduces by 10%–25% with increase in temperature.
- The impellers are very sensitive to suspended solids and bentonite clay. Rivers with higher sediment load require special filtration arrangements and frequent maintenance.
- Dust can reduce the output power of photovoltaic modules. Thus, frequent cleaning of solar panels is recommended.
- Seasonal changes in pumping head can lead to fluctuating discharges.
- Community engagement with periodic capacity building trainings from inception to operationalization is crucial for the sustainability of solar pumps.

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For further information

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