Modeling for Small Hydropower: Policy and Technology

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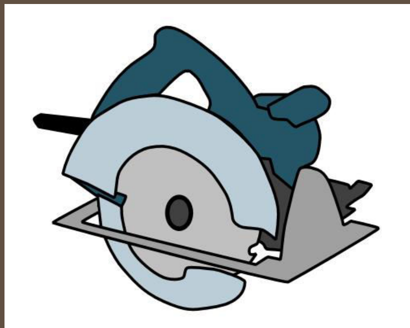
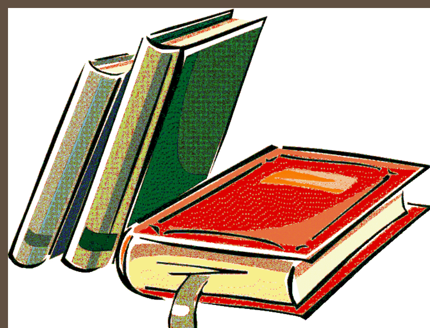
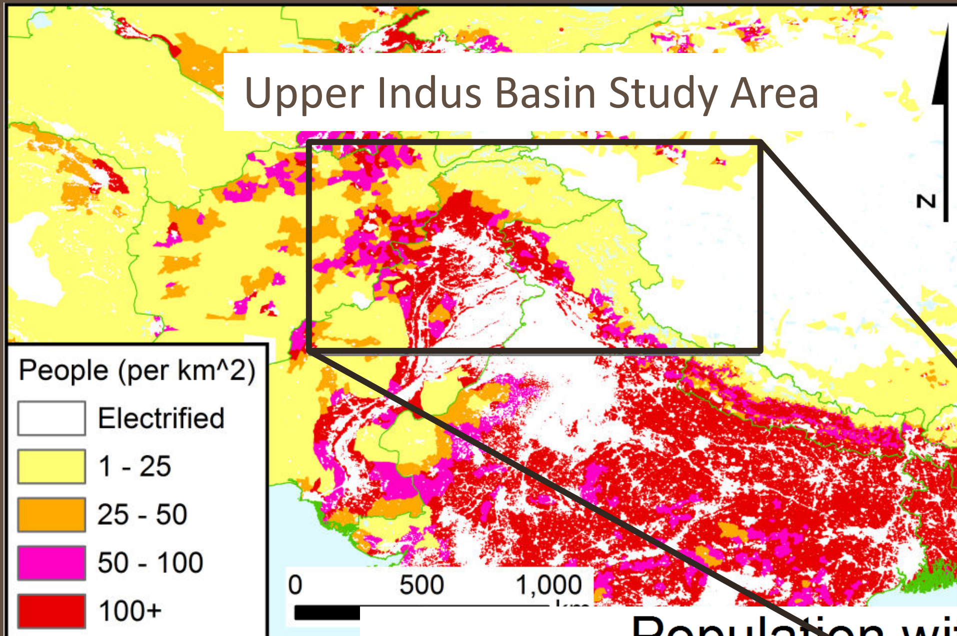


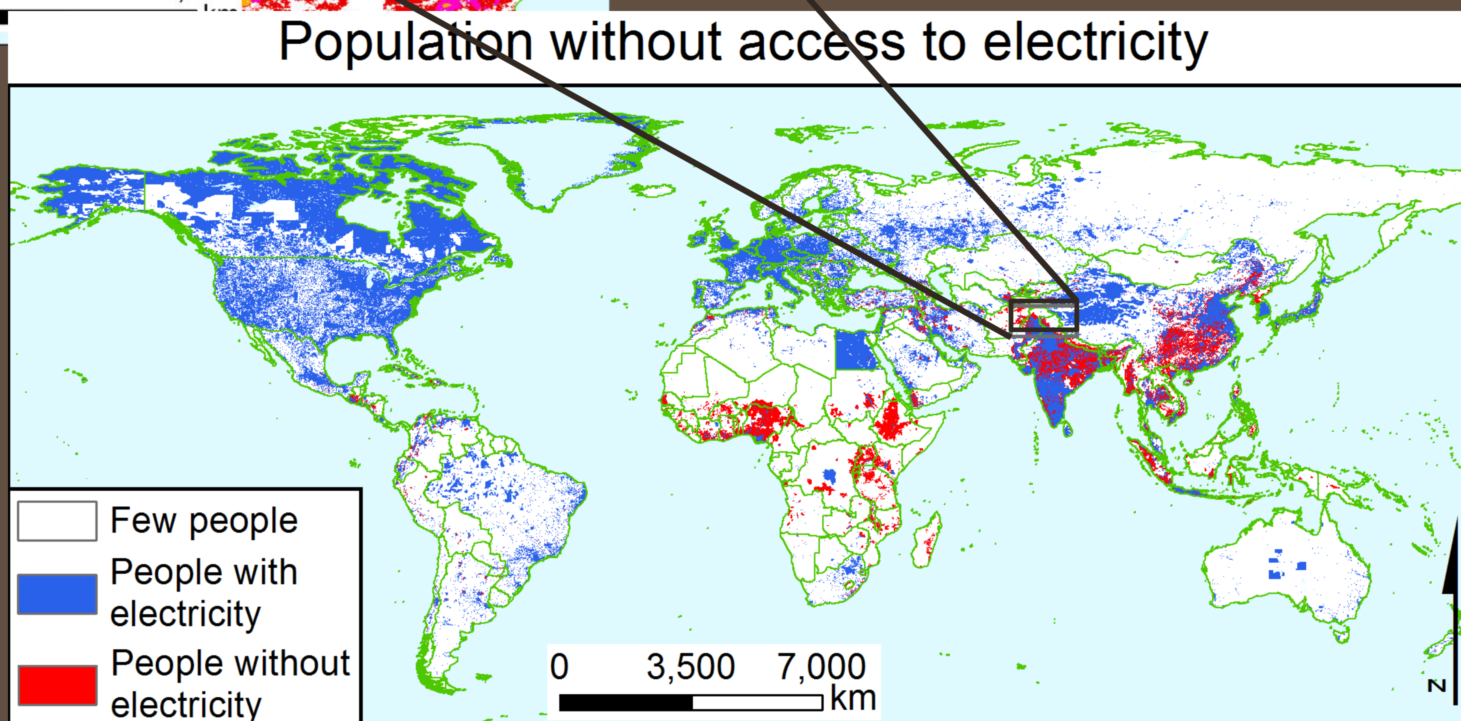

Broad spectrum of known benefits of access to electricity, but 1.3 billion people globally still do not have such access

"Energy access for all" is Goal 7 of UN 2030 Sustainable Development Goals

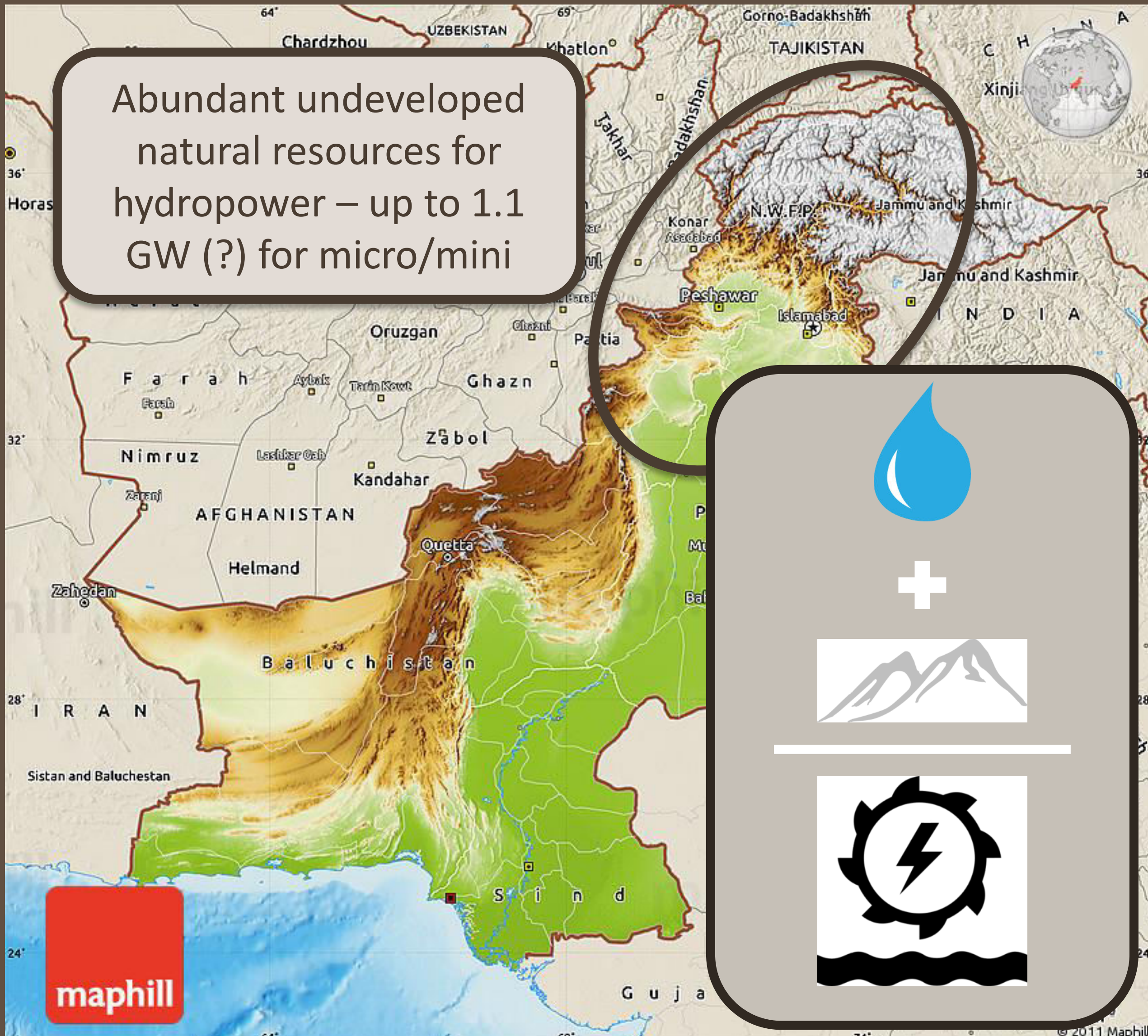


Largest areas of need for electrification are in sub-Saharan Africa and South Asia

(International Energy Agency, 2016)



Abundant undeveloped natural resources for hydropower – up to 1.1 GW (?) for micro/mini



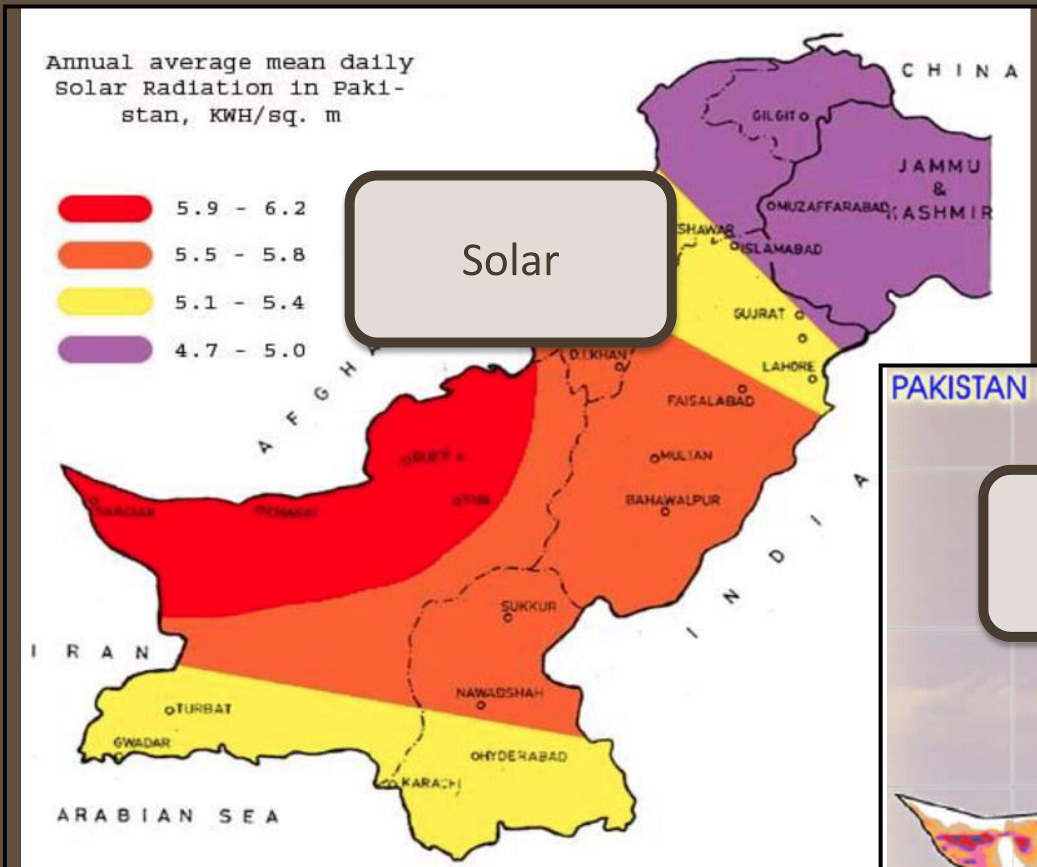
3-5 GW shortage

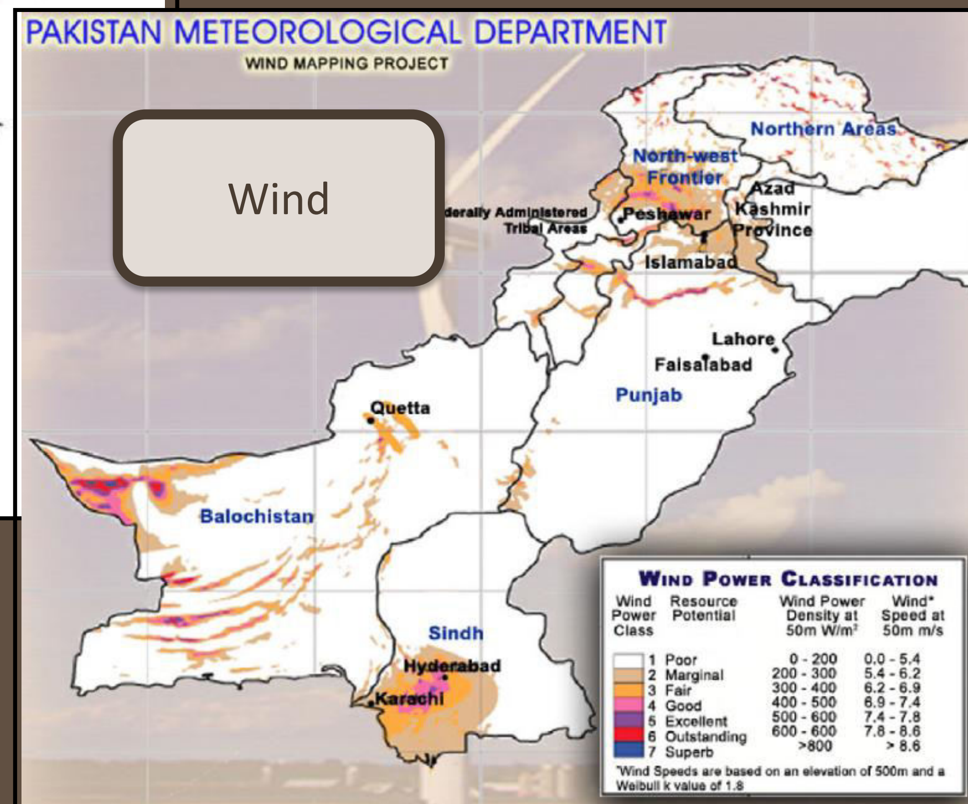
82 million

In rural areas, 54% of population

Hydro: 30% of portfolio

(Harijan et al., 2009)
(Zuberi et al., 2013)
(Ahmad, 2013)





(Khan et al., 2005)
(Asif , 2009)

<u>Goal</u>:

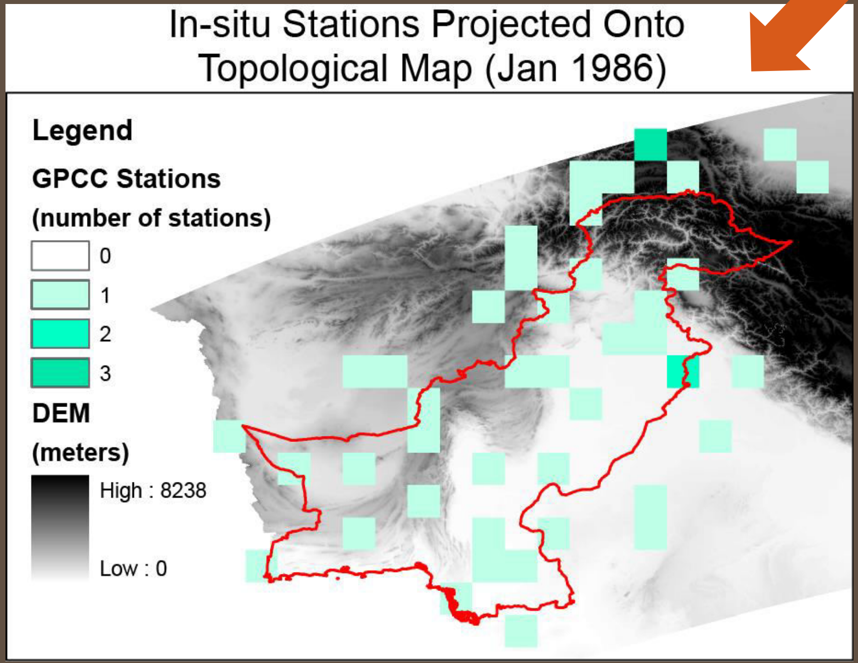
To develop science-based modeling tools to assess *water availability* and run-of-river *hydropower potential*

<u>Challenges:</u>

assess individual sites and/or regional area

data-sparse environment

climate change impacts



Why are these tools useful? → How do they work? → Is there demand?

- Climate (Precip, Temp) Grids*
- Water Resource Availability*
- Hydropower Potential*
- Climate Change Impacts

More accurate estimates can lead to better planning (investment, technology selection, policy needs)

How?

Precipitation and temperature at finer scale (1 km) than generally available*

Hydrologic model (for data-scarce region)*

Digital elevation model

Hydropower Potential Assessment Tool (HPAT)*

* indicates that we developed modeling tools for these purposes (Mosier et al., 2013; Mosier et al., 2016a, 2016b)

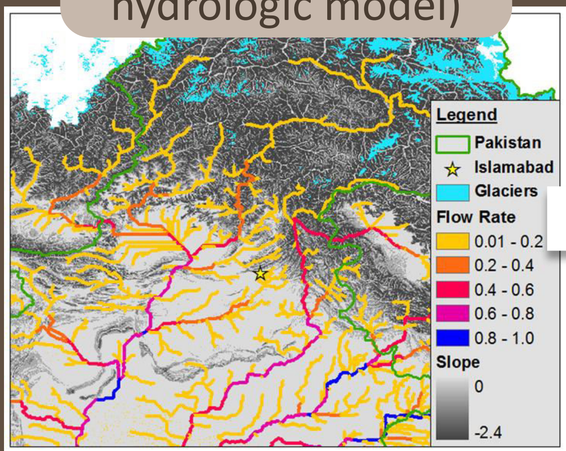
Is there demand?

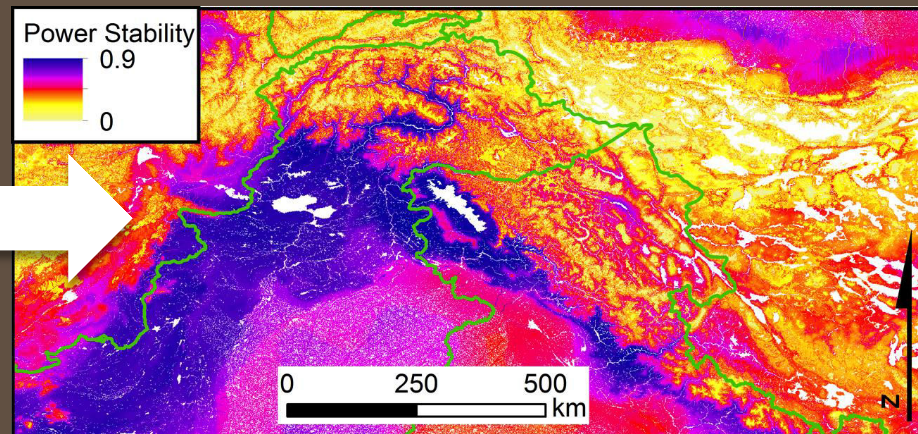
Within one week of press release for Hydro Power Assessment Tool (HPAT)*, >80 requests from across the globe

Climate and hydro tools available at *Globalclimatedata.org*

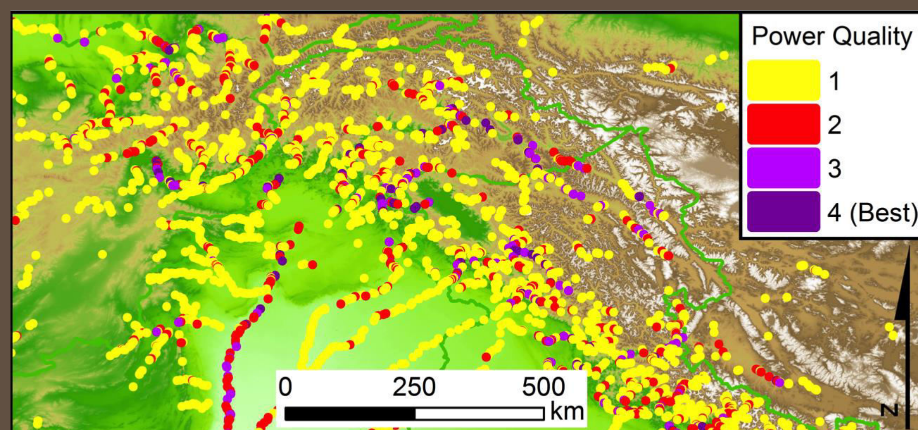
Application of Hydropower Potential Assessment Tool in Pakistan

Calculated streamflow (from hydrologic model)





Stability Metric over annual cycle (1=most stabile 0=least stable)



Power Quality = Amount * Stability

Our toolbox

Technical

- Modeling tool (HPAT) enables assessment across entire regions
  - Amount of power available
  - Stability (throughout year)
  - Quality = Amount * Stability
  - Climate Change Impacts on site quality

+

Policy/Legal

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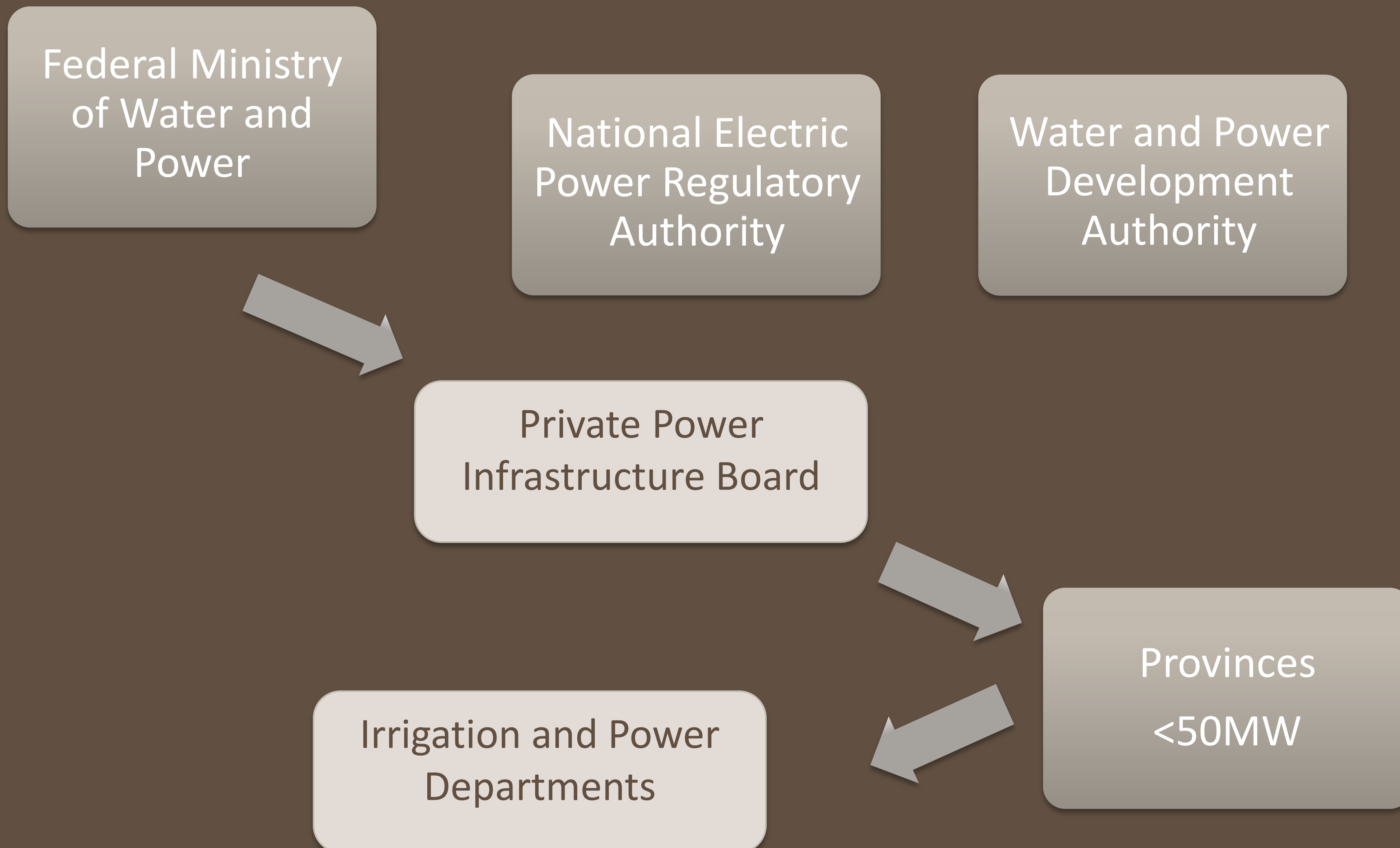
Policy/Legal

- Local licensing - subsidiarity
- Tariff design incentivizing investment
- Educated/knowledgeable workforce

Pakistan's Federalism System of Energy Regulation



The Policy/Legal Toolkit

- Subsidiarity - local licensing and permitting
- Tariff design incentives
- Educated/knowledgeable workforce and utilizing local resources

Subsidiarity

- Least/lowest centralized authority capable of undertaking licensing and regulation
- Small renewable energy projects generally benefit from subsidiarity
- If authority has sufficient toolset
  - Financial resources to establish
  - A stable, but flexible regulatory framework and rate design; and
  - An educated workforce and local resources

Stable Regulatory Framework

- Local licensing
- Tariff Design

Local Licensing/Regulation

- Pakistani provinces control licensing and promotion of small renewable energy >50MW
- To encourage private power investors, provinces - through their Irrigation and Power Departments - should make accessible a set of guidelines for development
- Examples:
  - Private Power Infrastructure Board – Pakistan
  - Federal Energy Regulatory Commission – USA

Tariff Design

- Rates have historically been artificially low with government subsidies
- Recently National Electric Power Regulatory Authority issued new rate designs raising industrial customer rates by 44% and residential customer rates by 32% (except the poorest quintile)
- For small hydropower >25MW
  - Guaranteed a rate of return equal to or better than Thar coal
  - Approved net metering

Utilizing Local Resources

- Capital cost of small hydropower varies, but is generally $1M = $1.4M per MW, with payback occurring within 5-7 yrs
- Utilizing local design, parts, and labor can cut those costs significantly
- Examples:
  - Technical Education and Vocational Training Authority - Khyber Pakhtunkhwa
  - Barefoot College - India

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Thank you!

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Summary: Useful science-based tools, such as those providing high-resolution climate data, water availability and assessment of hydropower potential, *can be developed and are in demand even in data-scarce regions*

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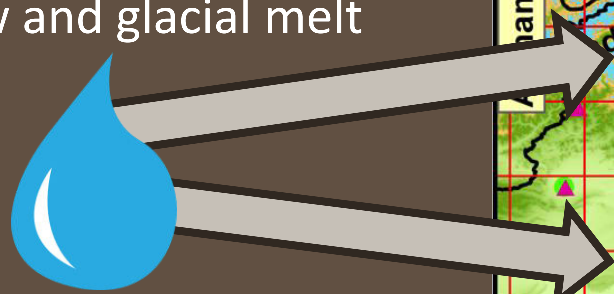
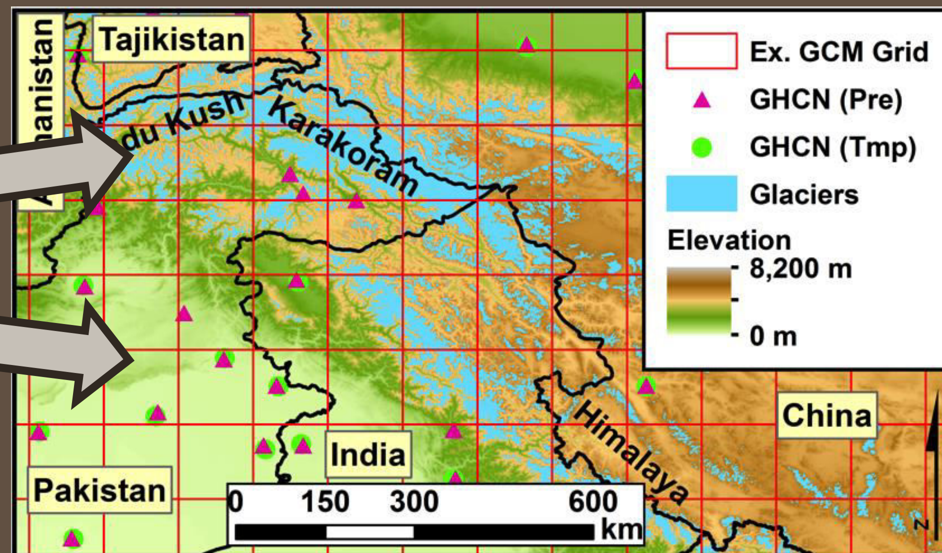
Evans Family Fellowship
OSU Humanitarian Engineering Program
USAID

Climate Change Impact on "Asian Water Towers"

~50% more discharge generated in upper reaches by snow and glacial melt





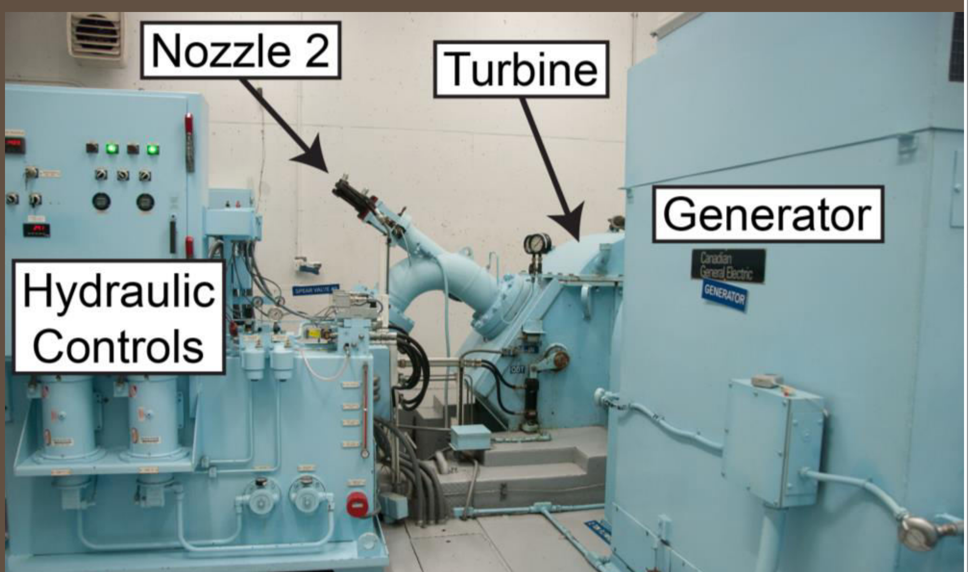
(Immerzeel et al., 2010)
(Winiger et al., 2005)

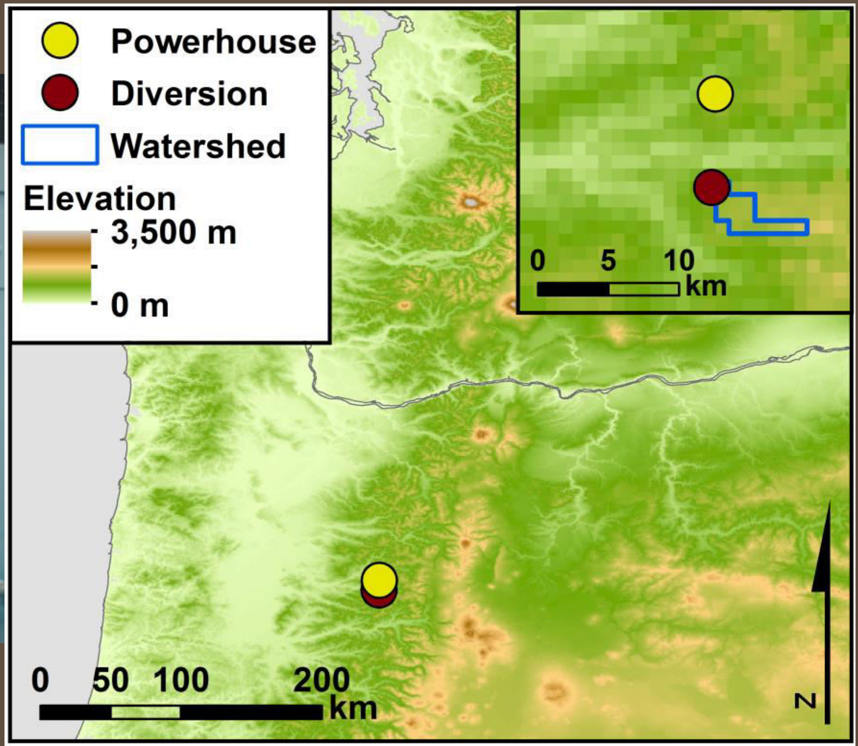
Indus Irrigation Scheme: ~50% of runoff from snow and glacier melt

Indus: Feed 26 million fewer in 2050 than 2010

Benchmarked Hydro Power Assessment Tool (HPAT) for Falls Creek, Oregon, USA

- Easily make field measurements
- Common characteristic: Snow acts as natural storage reservoir

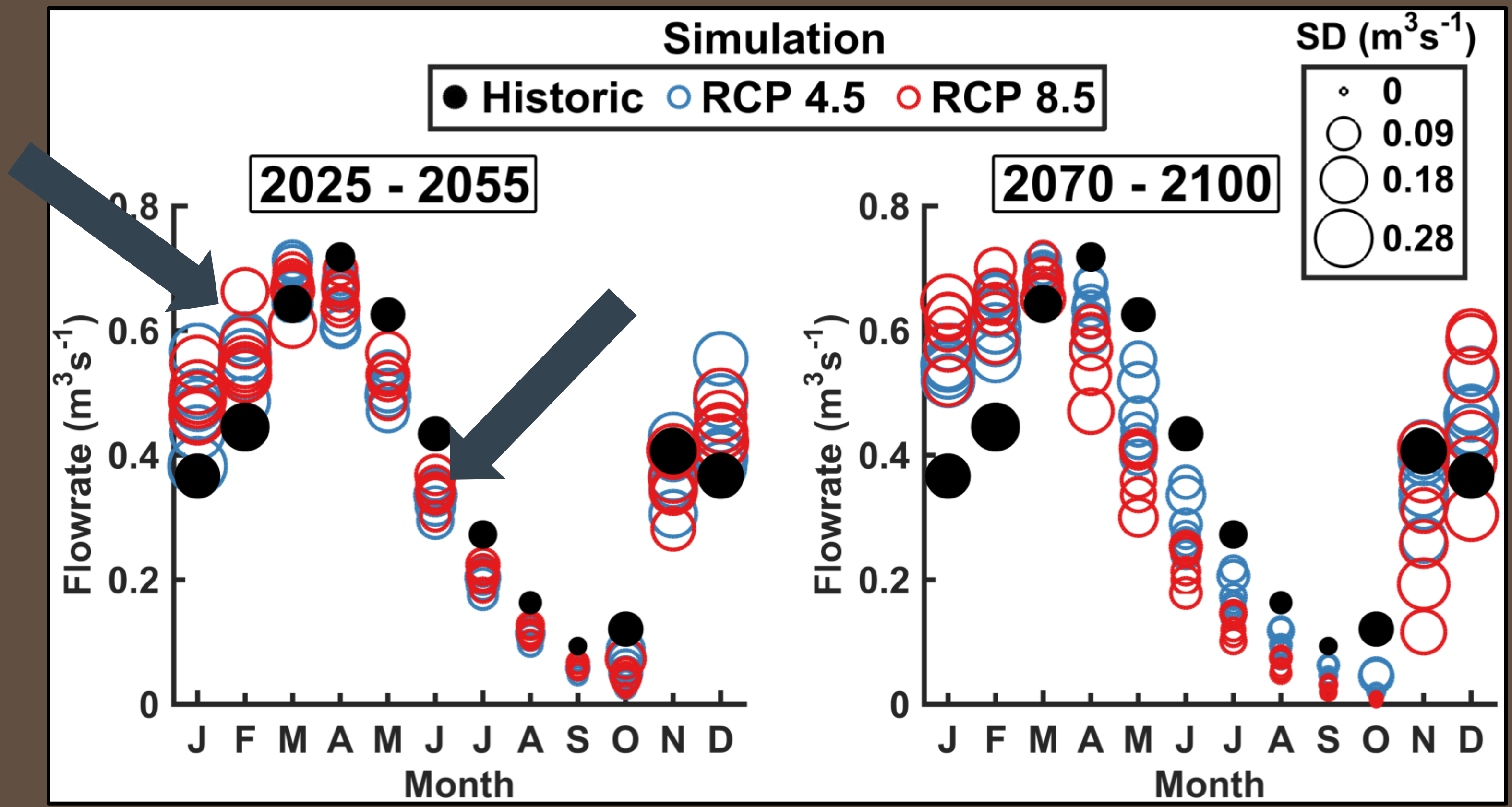




(Mosier et al., 2016)

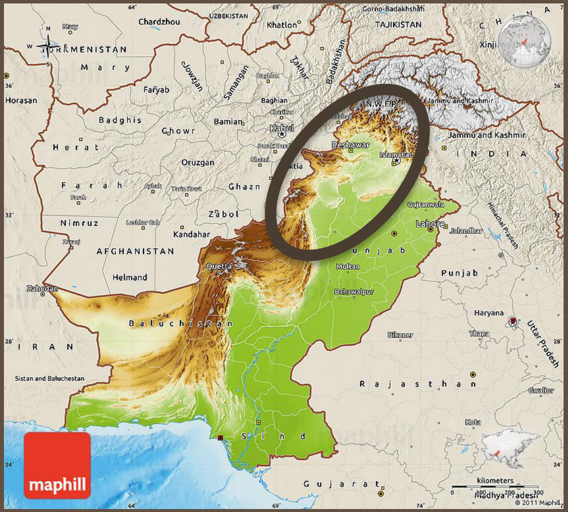
Projections are for increased winter flows and decreased spring and summer flows (Falls Creek Hydro, Oregon, USA)

RCP 4.5 ≈ 2 °C of warming
RCP 8.5 ≈ 4 °C of warming ("business as usual")



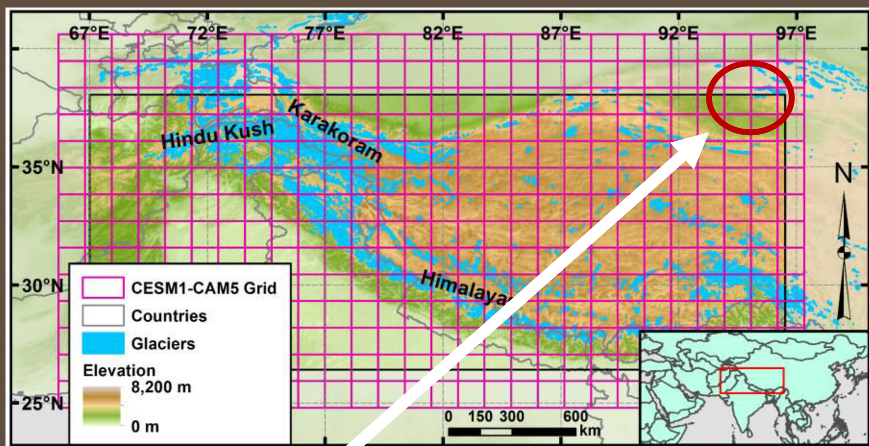
What's next?

Detailed application of HPAT here with field testing



Study factors (technical and non-technical) limiting effective use of distributed micro hydro power

How?

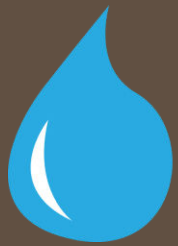


Resolution of freely available climate data was too coarse to be useful

Precipitation and temperature (1 km grid)*

Hydrologic model (for data-scarce region)*

Digital elevation model



Hydropower Potential

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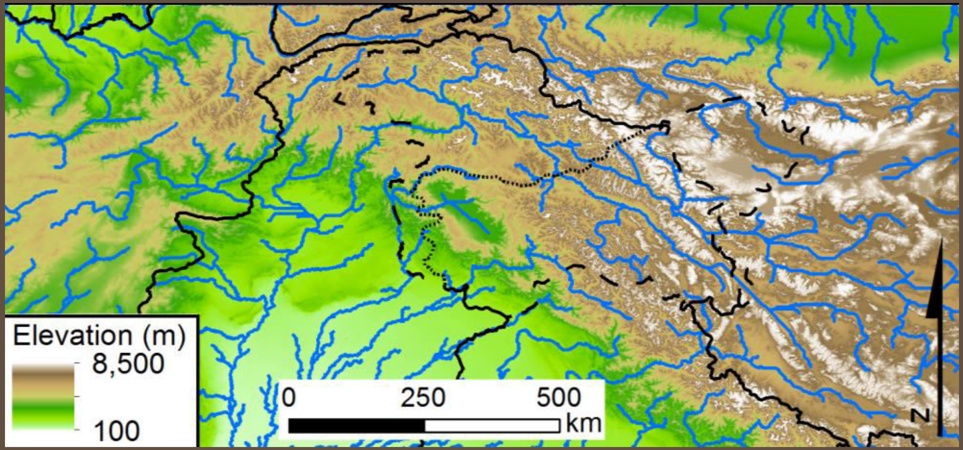
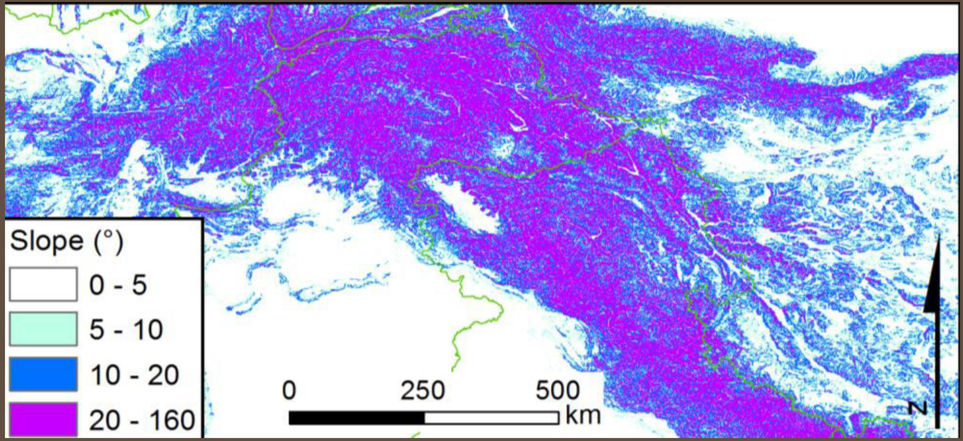
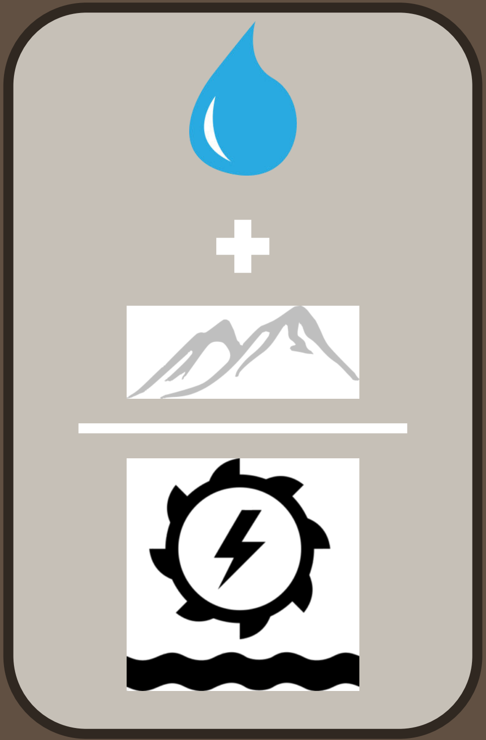
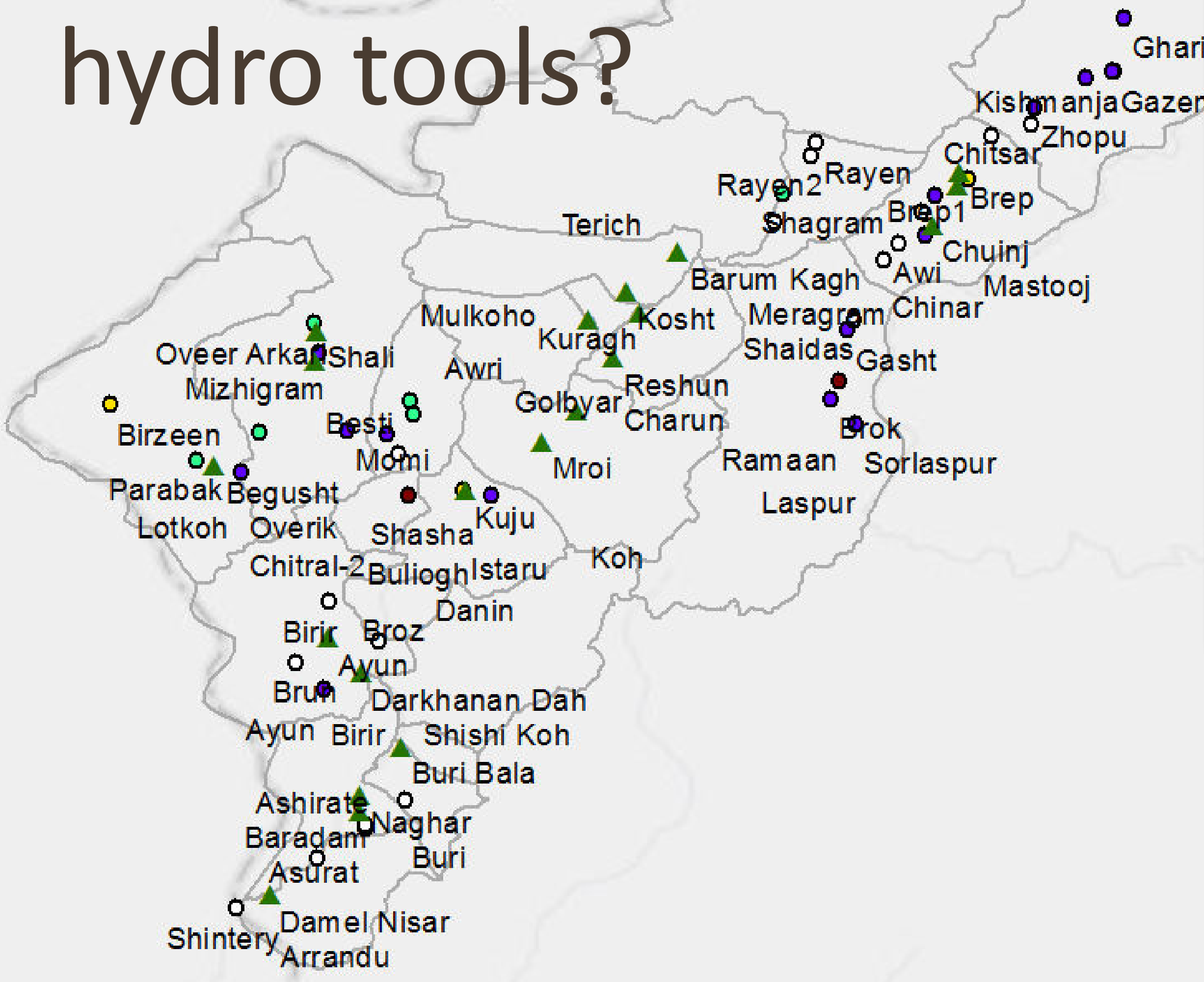






Natural resources in Upper Indus Basin are well-suited to small-scale hydropower – our toolbox can help effectively plan development

Why – small hydro tools?



Chitral District, KPK
~170 Micro Hydel Plants (MHPs) installed.

1. How many make sense?
2. Are they resilient to climate change?
3. Are they effective in meeting community needs?

(Ayub, 2016)