Jaclyn Bandy
jaclynbandy@gmail.com
jaclyn.bandy@uni-hohenheim.de

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Spring Restoration through Sustainable Land Management (SLM) in the mid-hills of the Indian Himalaya

A case study in the Gorang Valley, Uttarakhand

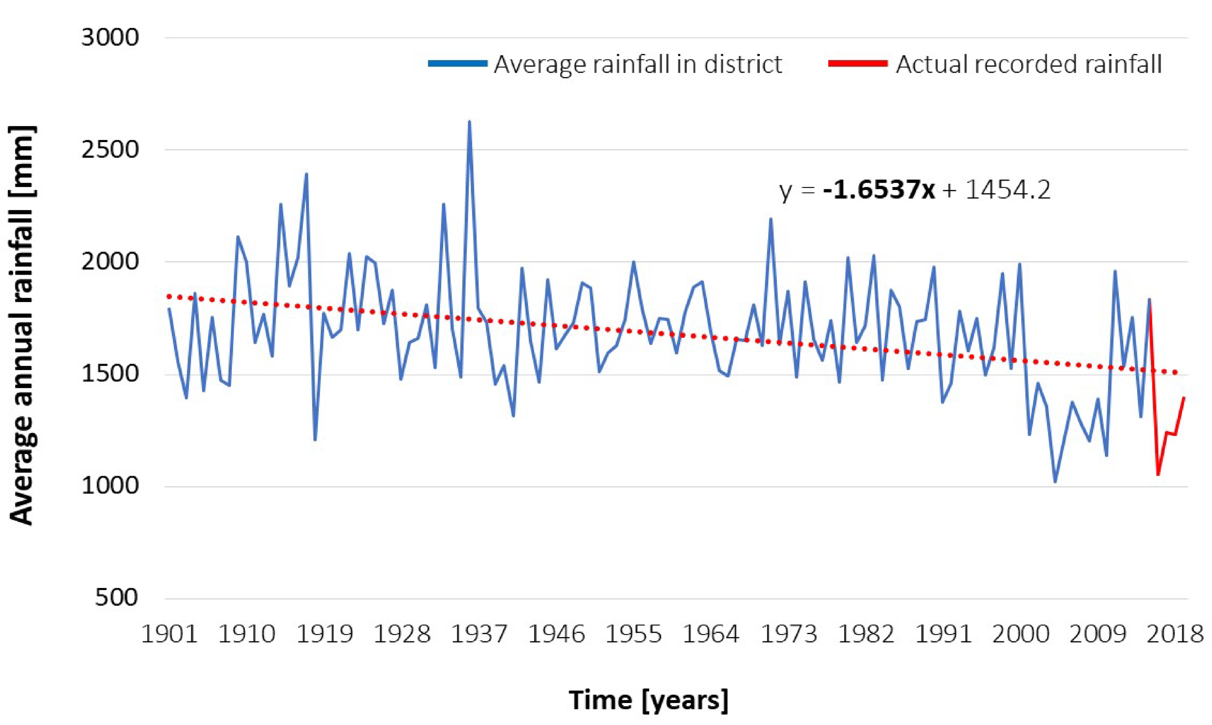
Jaclyn Bandy, Agriculture Science and Resource Management for the Tropics and Subtropics; University of Bonn, Germany
Hanspeter Liniger, WOCAT (World Overview of Conservation Approaches and Technologies); University of Bern, Centre for Development and Environment, Switzerland
Ranbeer Rawal, G.B. Pant National Institute for Himalayan Environment and Sustainable Development (GBPNIHESD); Almora, Uttarakhand, India
Rajesh Joshi, GBPNIHESD; Sikkim Regional Centre, Sikkim, India
Sanjeev Bhuchar, International Centre for Integrated Mountain Development (ICIMOD), Watershed Management; Kathmandu, Nepal

SITUATION / BACKGROUND

- Springs contribute to streams and rivers that support **225 million people** in the Himalayan region and **1.65 billion** people downstream.[1]
- Of the estimated **3 million springs** in the Indian Himalaya, roughly **60%** have dried up or become seasonal in the last decades, leading to acute **water and food insecurity**.[2]
- There is a **lack of hydrological data** on springs, and the **impacts of vegetation, surface- and groundwater interactions** on spring flows are not well understood.[3]
- It is hypothesized that the drying of springs is due to:

1) **forest degradation** and the **spread of Chir pine** (*Pinus roxiburghii*)[4,5]
2) **increased climatic extremes / variability** (i.e., temperature / rainfall)[5,6,a]
3) **increased urban development,** socioeconomic changes and **land abandonment**.[6-8]

Average district and actual recorded rainfall in the study site [a]



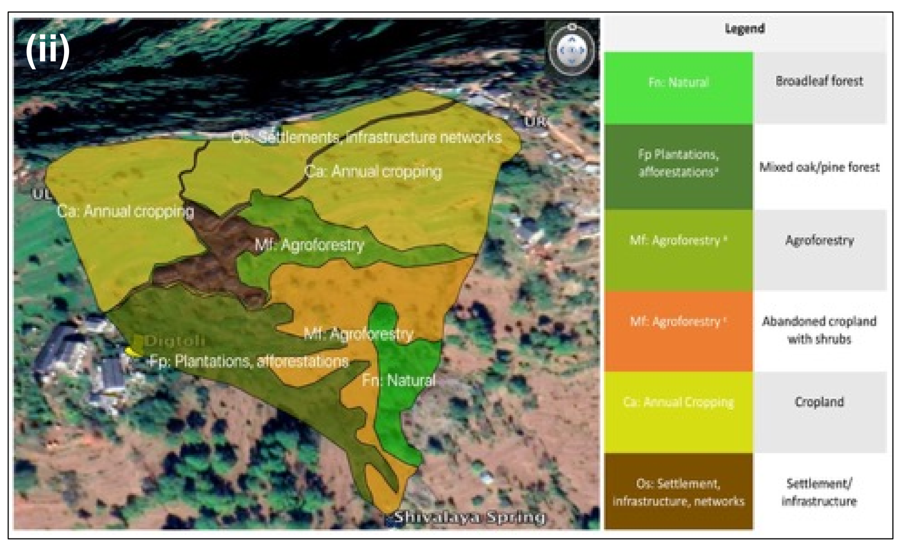
RESEARCH QUESTIONS

- How does **surface runoff** and **groundwater recharge** compare under different **land use / land cover (LULC)** types?
- What is the **runoff / groundwater recharge potential** of **mapped 'springsheds'** (micro-watersheds) in the study site?
- Which **land management practices** are effective for spring restoration / protection?

METHODS

- Prior **spring identification, monitoring discharge / daily rainfall** in the Gorang Valley[9]
- **Community-established protocol / interventions** for spring restoration (2016)[9]
- **Evaluation of intervention effectiveness** [(i)] with WOCAT Questionnaires (2019)[10]
- **LULC classification / springshed mapping** [(ii)] (Aerial imagery, Google Earth Pro)[11, 12]
  - → **Water balance** (Curve-number method, QGIS, SLM Watershed Tool)[12,13]
  - → **Estimation of runoff**, **groundwater recharge (GW)**, **soil-water changes** and **evapotranspiration (Eta)** for each LULC type using local daily rainfall data[13,14]

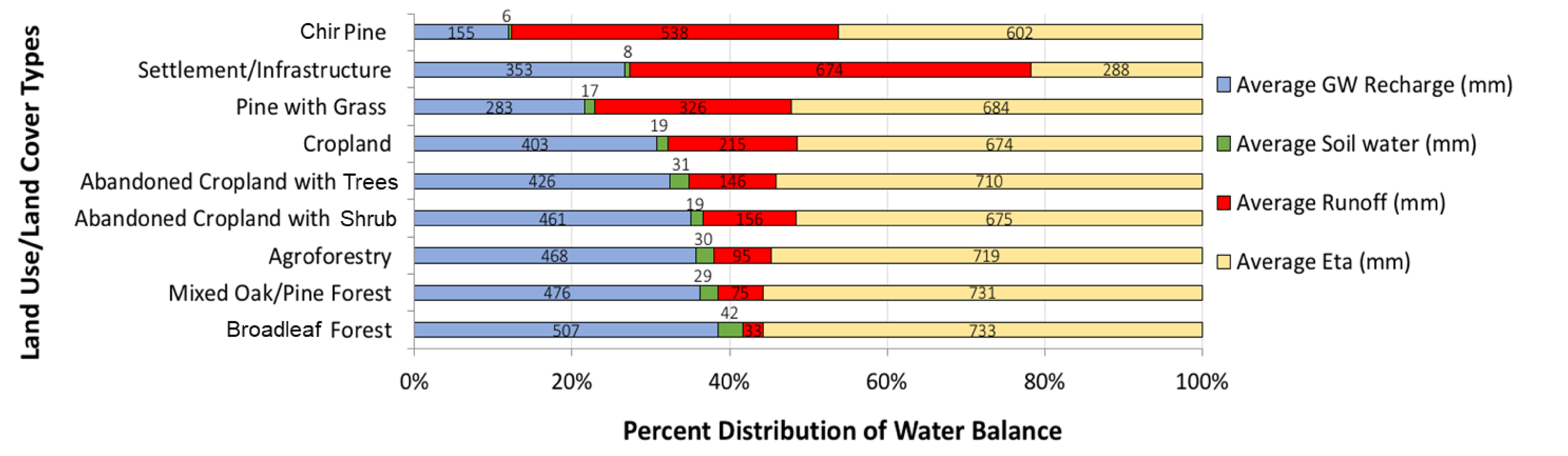
Focal discussion group with land users



Land use / land cover map (LULC) of local springshed

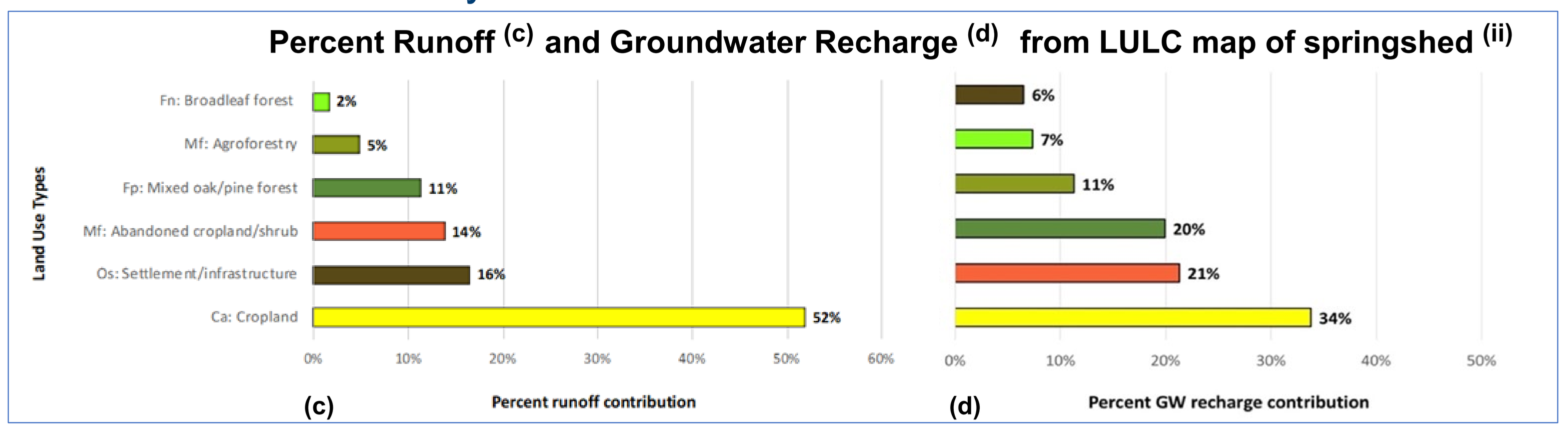
RESULTS

Modelled water balance variables for each LULC type in % of rainfall (June 2016 - June 2020)

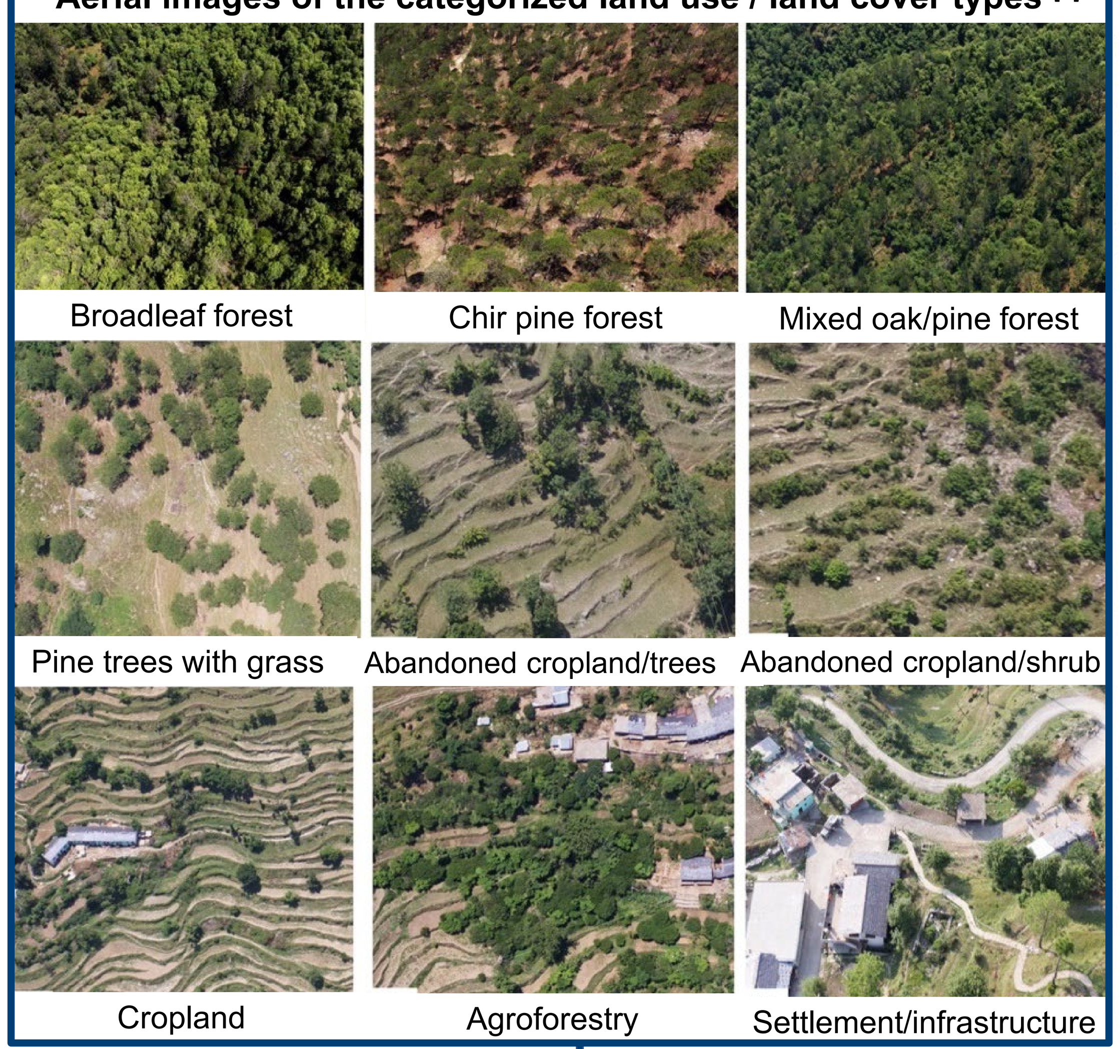


- **Chir pine forests** generated **high runoff** (41 % of the rainfall, 538 mm $year^{-1}$), and produced the **lowest groundwater recharge** (12 %, 155 mm $year^{-1}$) from an average rainfall of 1324 mm $year^{-1}$.

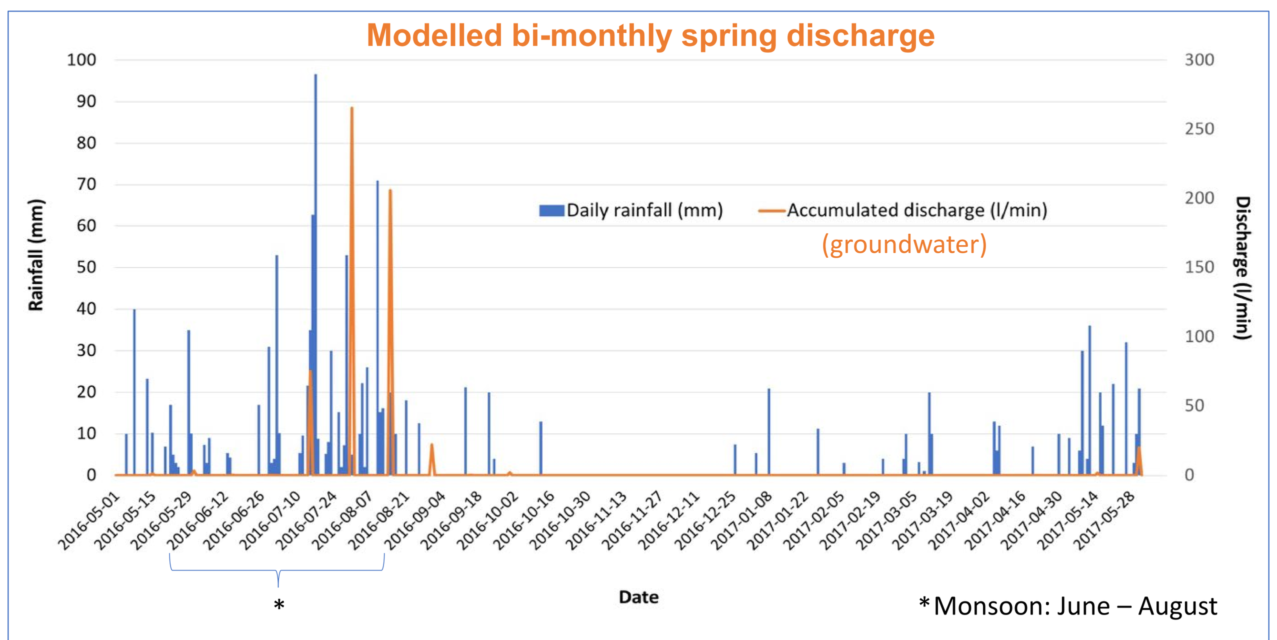
Percent Runoff [(c)] and Groundwater Recharge [(d)] from LULC map of springshed [(ii)]

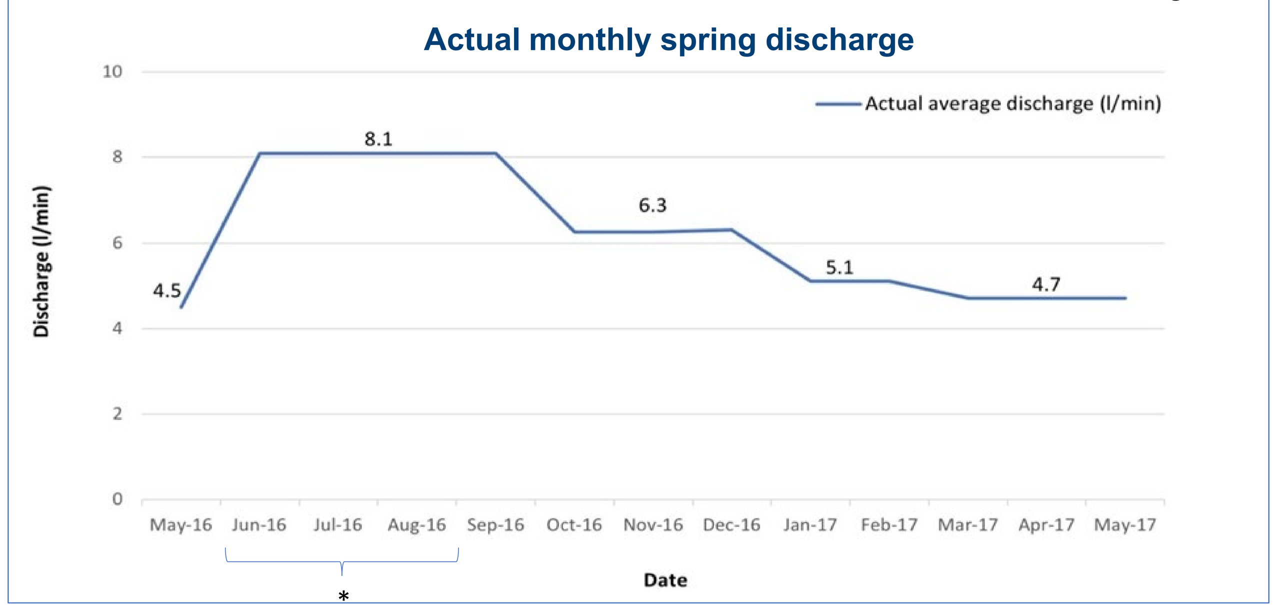


Aerial images of the categorized land use / land cover types [(b)]



- **Cropland** contributed to both the highest groundwater recharge and runoff potential in the **mapped springshed [(ii)]**.





- Modelling showed that **groundwater mainly accumulated during monsoon** (June – August), and **actual spring discharge** was sustained year-round.
- After 3 years of implementation, land users [(i)] reported a **30 % increase in spring discharge** during the dry season with the following interventions:

1. Regenerating broadleaf trees, regulating fodder / fuelwood extraction, grazing management [(c)]
2. Establishing recharge structures (ponds, trenches, check walls / dams) [(b)]
3. Upscaling productive / protective agriculture practices (agroforestry, terrace reinforcement, rain / spring water harvesting, homegardens, mulching) [(c)]

DISCUSSION & CONCLUSION

- **Chir pine encroachment** and **climate extremes** are contributing to the drying of springs in the case study site.
- It is critical to **capture monsoon rainfall, protect / restore broadleaf forests** and understand **land use / land cover impacts** on springsheds for effective spring restoration and **livelihood security** in the Indian Himalaya.

Traditional spring water harvesting with a 1,000 year old *Naula* (stepwell) [b]

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IMAGE SOURCES

[a] Tyagi N, Narayan R. 2019. Pithoragarh Temperature and Rainfall Data 1901-2016. State Climate Change Center, Uttarakhand. Patni, Digtoli Local Rainfall Data, 2016-2019.
[b] Liniger, H.P.
[c] Bandy, J.