APRIL 2020 **#2**

WOCAT

“Blue life-points” in the mountains and lowlands. Spring in Bhurmuni Village, Gorang Valley, Uttarakhand. (Photo: H.P. Liniger)

SLM POLICY BRIEF

Spring revival with Sustainable Land Management (SLM) practices in the mid-hills of Uttarakhand, India: Northwestern Himalayas

The Himalayan region, often referred to as the sacred “Water Towers of Asia”, directly support a population of over 240 million people[1] .Between 60-80% of the population is estimated to depend on springs as a source of water for drinking, domestic purposes, sanitation and general livelihoods[1,17]. Of the estimated 3 million springs in the Indian Himalayan Region (IHR), roughly 60% have dried up or become seasonal in the past two decades as a result of land use change, climate change and other environmental factors[2]. The trend of drying up springs has serious consequences not only for mountain communities, but also for downstream populations who depend on river flows supplied by mountain springs[10]. However, sustainable land management (SLM) practices have great potential to rejuvenate springs, sustain agriculture, preserve biodiversity and increase climatic resilience in Uttarakhand.

Key message

- Of the estimated 3 million springs in the Indian Himalayan Region (IHR), roughly 60% have dried up or become seasonal.
- Land use changes related to the overexploitation of natural broad-leaved forests and encroachment of pine forests have been identified to be the core reason for depleting spring flows. Climate change is further exacerbating the situation.
- Through community forest management and village participation–particularly women and children who fetch water– spring flows can be rejuvenated through restoration and conservation of broadleaf forests, springshed protection, and water harvesting with ponds and trenches.
- It is critical to further identify, assess and disseminate effective and inclusive springshed management (SSM) approaches and technologies. Synergies between community-based organizations, research institutions and government departments must quickly evolve in the IHR.

BOX 1: Definitions

Springshed: an area within a ground or surface water catchment that contributes to spring flow.

Onsite impacts: spring water availability, quantity/quality of fodder, fuel, and other forest products, biodiversity; reduction of fire risk and land degradation.

Offsite impacts: downstream water availability, drinking water, irrigation, quality for hydropower; risk reduction floods, landslides.

Importance of Springs

For thousands of years people in the HKH region have relied on springs to meet their daily needs. Even today, an estimated 260,000 springs provide about 90% of the drinking water to 10.3 million people in Uttarakhand[3]. Springs are the "blue life-points" for the rural communities in the Himalayan region, as they are the main source of water for the household, irrigated agriculture and livestock production. Although the area of cultivation has decreased by about 10%[13], agriculture and animal production remain the primary sources of income for about 70% of people in the Himalayas[3]. To support these activities, the majority of the population relies on the wealth of resources from forests (for fuel, fodder and timber). Forests remain socially and environmentally interlinked with people in hill regions, playing an important role in the economic welfare and development of the region. Local communities also attribute the forest (Hindi: *jungle*) as the foundation for spring sanctuaries[18].

Uttarakhand State's Water Crisis – the drying up of springs

Since the beginning of the 21st century, Uttarakhand has faced an increasingly acute water crisis. Fewer than 50% of the people receive adequate quantities of safe drinking water[3]. The availability of potable water during the dry season in rural areas can drop to 25-30 liters per day[6,17]. In 2019, it was estimated that over 50% of Uttarakhand's springs have dried up or become seasonal[2]. It is widely accepted that climate change, land use change, unplanned development activities, and lack of resource management due to outmigration from rural to urban areas and mountains to lowlands are responsible for diminishing spring flows[7]. However, there is a lack of data and investigations on how land management practices impact springs. Therefore a case study in the Gorang Valley, located in the Himalayan town of Pithoragarh, Uttarakhand was conducted to determine how different land uses and management practices affect spring discharge.

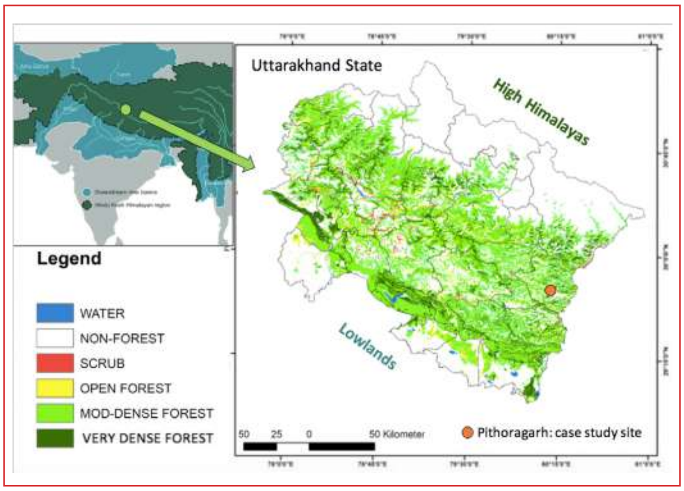

Figure 2. Map of the Uttarakhand (*51,955 km²*) State of India [4]. The recorded forest area is 24,240 km², which constitutes 47% of total geographical area of the state[5].

The role of climate change in spring flow regimes

While some estimates suggest that the Himalayan region is warming at rates two to three times faster than the global average[8,19], an average increase of only 0.35°C (half the global average of 0.7°C) was recorded over the past century in Pithoragarh. In 2016, Pithoragarh observed a record breaking maximum temperature of 23.5°C and minimum temperature of 13.1°C[9] (Figure 3).

Long-term rainfall records indicate that Pithoragarh receives an annual average rainfall of 1692 mm (Figure 4), however precipitation varies depending on altitude, slope aspect and monsoon patterns.

From 1950 to 2016, average annual rainfall declined by 120 mm, and the lowest precipitation on record occurred between 2001 and 2010[9]. Reduced rainfall and increased temperatures are contributing to decreased spring flows, however the issue of drying springs was recognized before the turn of the century. Other factors besides climate change are significantly impacting spring flows.

Onsite impacts of land use change

Of the 22.6 million hectares classified as forest area in the Indian Himalayas, about 27% is under open forests with less than 40% canopy density[5]. Relentless collection of firewood, tree leaf fodder, and leaf litter from forest floor by local people is claimed as one of the main causes of degradation[10]. Today, the region struggles to meet their fuel and fodder requirements due to seasonal shortages[10]. Sustainable forest management can sustain long-term provision of these essential resources, however the dissemination of SLM practices in rural areas has been insufficient. A steady decline in broadleaf forests and increase in pine forests is partially due to the extensive propagation of Chir pine (*Pinus roxiburghii*) during the British rule. Anthropogenic activities followed by invasion of early succession shrubs (*Lantana camara*) are also rapidly changing the forest surface characteristics[10,11].

Chir pine propagates aggressively and sheds flammable pine needles, which are acidic in nature and decompose slowly, making it difficult for vegetation to grow. Pine needle cover on bare soil can result in extreme surface temperatures of over 70°C

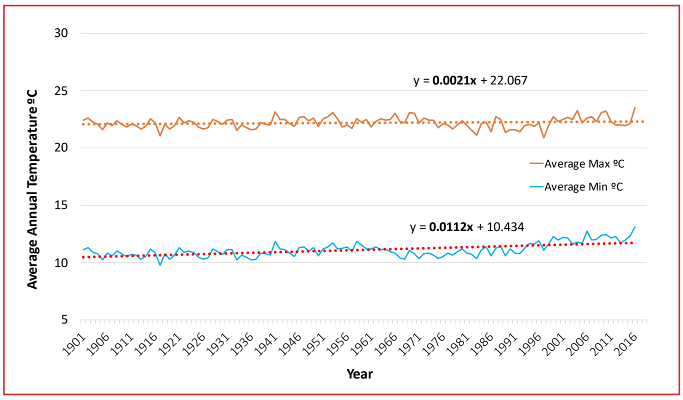

Figure 3. Variation in average annual maximum and minimum temperature °C in Pithoragarh (1901-2016)[9].

BOX 2: Onsite implications of forest degradation: Chir pine, fire risk and forest protection

Surface Temperature in Pithoragarh Forests

Left to Right: Pine Needles in Degraded Pine Forest: 73.5°C, Grass under Oak Canopy: 20.6°C, Grass in Mixed Pine/Oak Forest: 34.9°C, Oak Canopy: 30.3°C. Date: July 27, 2019. Time: 13:30. High daytime soil surface temperatures (73.5°C) bake the topsoil, making it difficult for vegetation to establish in degraded pine forests. Water infiltration is impeded and groundwater stores decline. Location: Gorang Valley, Pithoragarh. (Photos: H.P. Liniger)

Chir Pine Forest regularly affected by fire

A 40–50% decline in biomass and 80% decline in net primary productivity is estimated in chronically disturbed forests[10] (Photo: J Bandy).

with sun exposure (Box 2). Such dramatic daytime temperatures not only impose harsh conditions on the soil, but also contribute to increased air temperatures in forests, thereby influencing local and regional warming[11]. Notably, the frequency and intensity of wildfire has increased in Uttarakhand, burning an estimated 4,500 hectares of classified forest area in 2018 alone[5]. These severe surface cover and temperature changes affect the water balance in forests, resulting in soil compaction, decreased infiltration, increased runoff and reduced recharge of groundwater stores that feed into springs.

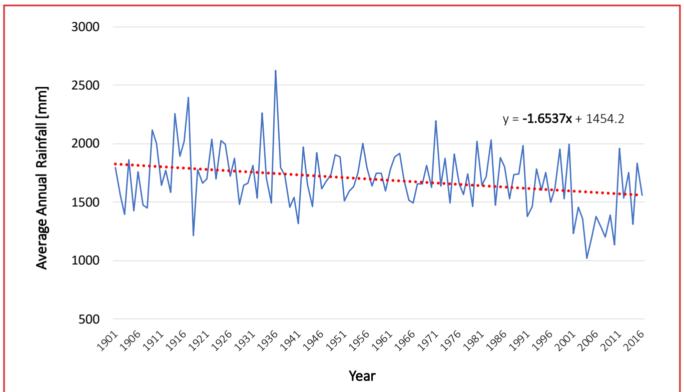

Figure 4. Pattern of average annual rainfall for Pithoragarh (1901-2016) [9].

Assessing the different land management options for spring rejuvenation

Sustainable community forest management combined with springshed protection is an effective approach for significantly improving the spring flows, maintaining forest resources and preventing further land degradation[17]. In the rural village of Nakina in the Gorang valley, the community Forest Council (*Van Panchayat*) is reviving their local springs through a protective forest-springshed approach that includes: 1) regulated forest resource extraction, 2) natural assisted regeneration with planting of broadleaved species, 3) maintaining an oak and fodder nursery, 4) protecting the forest perimeter with stone wall and firebreak, and (5) recharge ponds, trenches, and check dams within the mapped Vaishnavi Springshed (Figure 5).

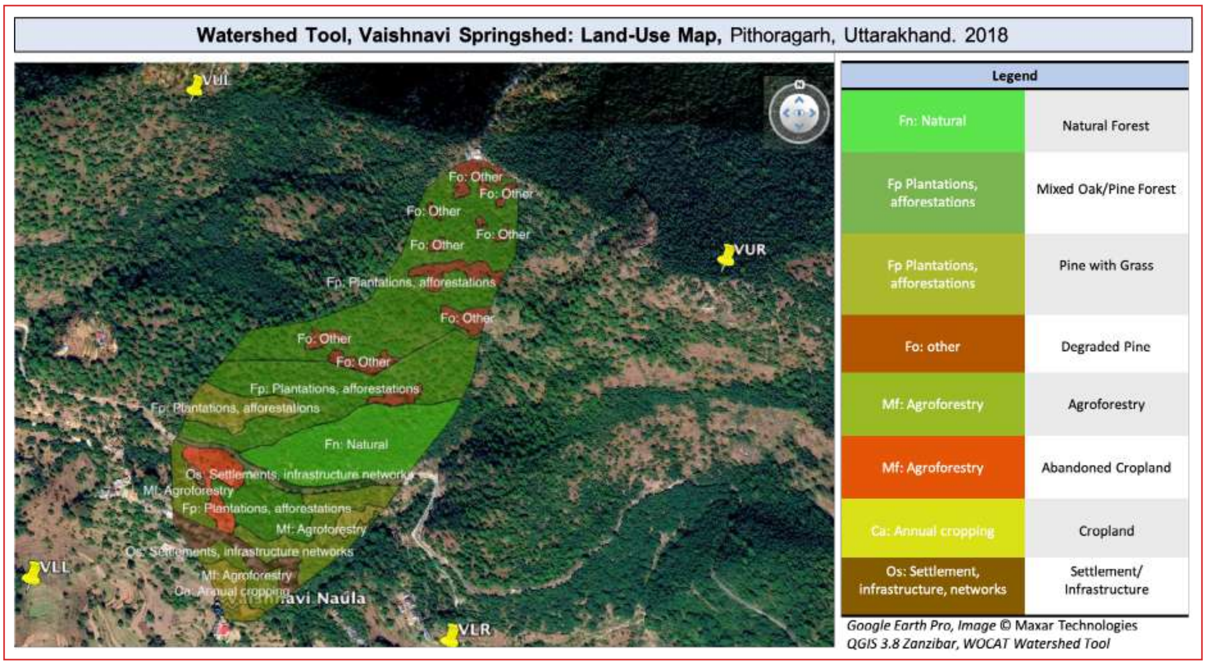

Figure 5. Vaishnavi Springshed: WOCAT Watershed tool application and mapping of the different land uses within the catchment area of 15 hectares.

Villagers estimated a 30% increase in spring discharge during the dry season[12]. Out of the total 44 households in Nakina, an estimated time saved (collecting water, fodder and fuelwood) was 1.5-3 hours per household per day. These results are consistent with a study by Joshi et al., 2017[16]. Improved water provisioning saved each household an estimated $30.9 – $318 USD per year (7-21% of annual income)[13]. Approximately $3,500 USD was spent per springshed (15 hectares), with returns apparent after 3 years of initial implementation[12,14].

Offsite impacts of land use change

Increased surface runoff, flood disaster risk, and the loss of groundwater recharge that feeds springs are principal offsite impacts in Uttarakhand. Because 85% of annual rainfall in the state occurs during the monsoon (June-September)[10], high and intensive rainfall events are concentrated within a short period of time. Rainwater must effectively infiltrate into the soil and recharge groundwater levels. Therefore, a water balance was calculated to understand the affects of land management on surface water (Figure 7).

Water Balance: Runoff and Spring Recharge

The resulting water balance and percent runoff of rainfall for each land use type (Figure 8a) reveals that the majority of the rainfall is lost to runoff from settlement/infrastructure (55%) and degraded pine forests (44%). Although settlement/Infrastructure gives the highest runoff, springsheds are usually situated in the forest above human settlements.

Runoff in a degraded pine forest (44%) is much higher than that of a broadleaf forest (1%) and mixed oak/pine forest (5%). Cropland, abandoned cropland and agroforestry reduce runoff between 256-324 mm, thus saving 25 to 33% of the monsoon rainfall for groundwater recharge.

Figure 8b indicates that a broadleaf forest and an afforested mixed oak/pine forest can provide an annual average spring flow of at least 7 litres per minute, while a degraded pine forest gives only 1.76 litres per minute.

Although the water balance approach assumes total groundwater flow into a spring, the model illustrates how spring flows are

Figure 6. A recharge pond serves as a water harvesting technology, collecting runoff water from a nearby pine forest. It serves as a point of infiltration and groundwater recharge for their local spring. (Photo: HP Liniger)

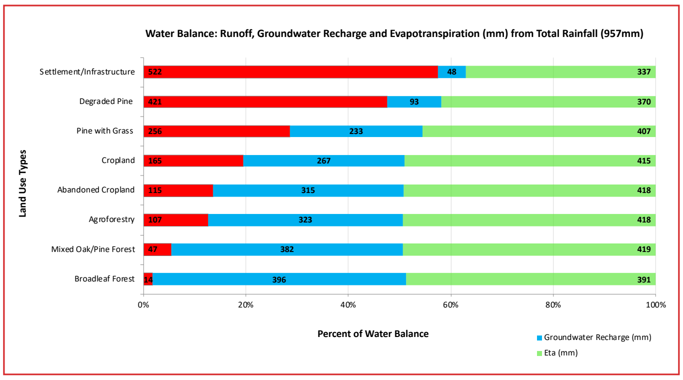

Figure 7. Water Balance: Rainwater divided into runoff, groundwater recharge and evapotranspiration in mm for different land use types. The calculation assumes a total rainfall of 957 mm (between May and September 2018) using daily local rainfall records. (Source: Bandy and Liniger 2020)[15].

BOX 3: Summary of Spring Recharge Potential and Impacts of SLM Practices

Spring Recharge Potential in Degraded Pine Forest.
Contribution to spring discharge is 1.76 litres per hectare/minute from 1 hectare of degraded pine forests (exposed to reoccurring forest fires) over 365 days using 2018 daily rainfall (957 mm from May to September) in Pithoragarh, Uttarakhand. (Photo: HP Liniger).

Spring Recharge Potential in Natural Broadleaf Forest.
Contribution to spring discharge is 7.5 litres per hectare/minute from 1 ha of natural broadleaf forest over 365 days using 2018 daily rainfall (957 mm from May to September) in Pithoragarh, Uttarakhand. (Photo: HP Liniger).

Nakina *Van Panchayat* member collects enough fodder for her livestock and benefits from a decreased workload.
Forest health improves and land degradation decreases with community forest management. SLM interventions involve: establishing a protective fire wall, firebreak, enriching the forest with broadleaf trees, fodder grasses, as well as constructing check dams, recharge ponds and trenches within springsheds. (Photo: J. Bandy)

Springshed management increases spring flows in the dry season.
Improved water provisioning reduces drudgery of water collectors (mainly women and children), saving each household up to 20% of their annual income. Commitment to overall resource management is enhanced, as springs preserve the cultural bond between people and nature. (Photo: HP Liniger).

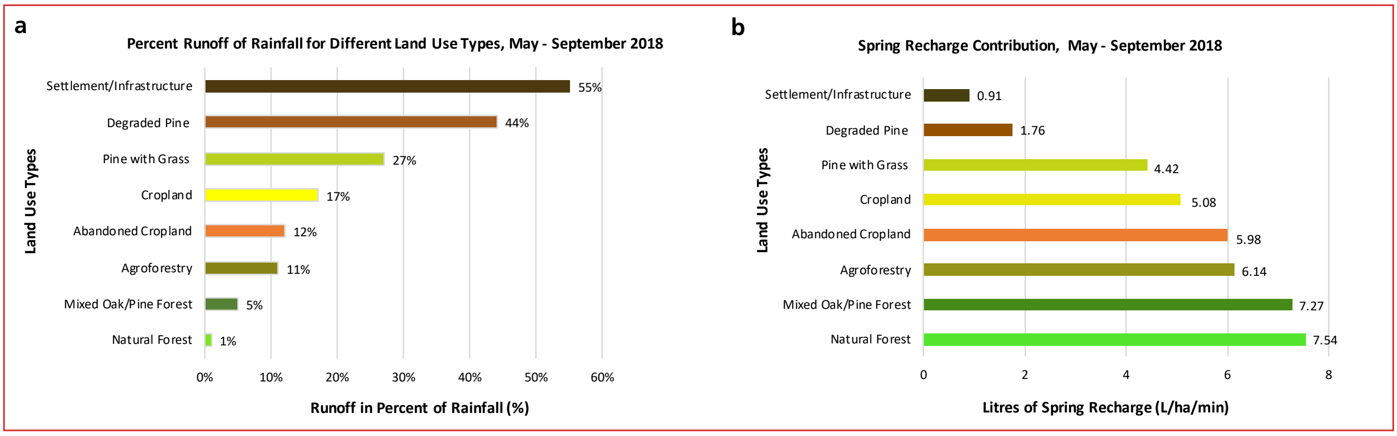

Figure 8a) Percent runoff of rainfall for different land use types. The calculation assumed total of 957 mm from daily local rainfall records (between May and September 2018); 8b) Spring Recharge Contribution (Liters/ha/minute) are compared for different land use types[15].

rooted in land use changes. Degradation of broadleaved forests and the spread of pine-dominant forests are threatening natural resources and spring water.

Cropland and agroforestry can improve spring water flows and reduce runoff, and sustainably managed systems will increase food, fuel and fodder availability. Abandoned cropland can enhance spring water recharge due to perennial vegetation cover on terraces. Using WOCAT Questionnaires[12], SLM impacts were summarized in Box 3.

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Special Acknowledgements

Villagers of Nakina, Digtoli, Bhurmuni in the Gorang Valley, Pithoragarh

Dr. Ranbeer Rawal, Dr. Gcs Negi, GBPNIHESD (G.B. Pant National Institute of Himalayan Environment and Sustainable Development)

Neetu Tyagi and Raj Narayan, State Climate Change Centre, Dehradun for support in providing climate data.

Kapil Bisht (G.B. Pant Senior Project Fellow), and Deepak Chaulagain (MSc. Tribhuvan University), for field support and translation.

Dr. Rajan Kotru, ICIMOD (International Centre for Integrated Mountain Development) and the Kailash Sacred Landscape Conservation and Development Initiative (KSLCDI) for project support and partner collaboration.

SDC (Swiss Agency for Development and Cooperation) for-project financial support.

Further information

Link to all results from 'on- and offsite benefits of SLM':

- Other On-offsite policy briefs
- Our Synthesis report
- Link to video: India
- WOCAT SLM technology database: Examples from India

1 – 18 The list of references is available in the online version of this policy brief: www.wocat.net

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WOCAT SLM Policy Briefs summarise key findings about aspects of sustainable land management. Topics include on- and offsite benefits, disaster risk reduction, biodiversity, climate change adaptation/ mitigation, ecosystem services - and many more. The briefs are based on up-to-date research and implementation experience by specialists and land users. The briefs and other WOCAT resources are available at: www.wocat.net

Implications for practice, policy and research

Acknowledge the impacts of land use and land use change

In Uttarakhand, the major causes of the drying-up of springs are forest degradation, striking changes in land use, and climate change. Over-exploitation of forest resources and encroachment of pine forests provoke forest fires and leave the soil impermeable, inhibiting groundwater recharge and disrupting spring flow regimes. The impacts of these changes affects downstream areas, increasing risks of floods during the monsoon, followed by sedimentation and disruption of river flows during the dry season. The paradigm of 'too much' (floods) followed by 'too little' (drought) is apparent, and mitigation through land management is critical.

Develop an integrated methodology for spring monitoring and revival across the Himalayas

There is a need to establish collaborative initiatives (with land-users, research institutions, NGO's, local government and international agencies) to identify gender-responsive interventions and support grassroots innovation in local communities for spring recharge. Long-term monitoring of local rainfall, spring discharges and river flows is crucial for understanding seasonal variations, capacity of groundwater storage and validation of recharge efforts. The Uttarakhand case study illustrates how community protection and enrichment of broadleaf forests integrated with geo-hydrology based springshed management can maintain or increase spring flow to communities in the dry season, as well increase fuel and fodder availability.

Agriculture-based schemes for water conservation and resource management

There is a need to monitor land use change, identify on- and off-site impacts, and increase efforts to promote SLM practices, such as agroforestry and natural broadleaf regeneration in the Himalayan region. Mainstreaming good land management practices will increase the capacity to implement spring revival programs that simultaneously sustain rural livelihoods. For a future in mountain agriculture, the local people require support and engagement with multidisciplinary experts (agriculturalists, land practitioners, hydrogeologists, etc.), governmental agencies, and NGOs in order to envisage land management options that secure water resources. Improving market access and encouraging the production of traditional crops, local medicinal and aromatic plants, and other niche mountain products holds great potential for sustainable development and biodiversity preservation. Furthermore, enhancing eco-tourism should be explored to create novel opportunities for the next generation in the Himalayan region.

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This issue
Series editor: Hanspeter Liniger
Editor: Hanspeter Liniger
Language editor: Will Critchley, Jaclyn Bandy
Design: Simone Kummer
Printed by Varicolor AG, Bern
MIX Papier FSC® C020328

ISSN 2296-8687

Citation: Liniger HP, Bandy J, Bhuchar S, Joshi R. 2020: *Spring Revival through Sustainable Land Management (SLM) in the Himalayan foothills: Uttarakhand, North India.* WOCAT SLM Policy Brief, No. 1. Bern, Switzerland: CDE.

Keywords: Sustainable land management, spring recharge, forest management, disaster risk reduction, India

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