

Drought mitigation

practices for hilly regions

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Hilly regions are spread over 54 million ha providing home to nearly 34 million people and support about 50 million animals distributed in several states. Climate change and variability manifested by way of rising temperatures, changing rainfall pattern, prolonged dry spells and drought like situations and aggravating land degradation are impacting the hill ecosystems. Hill ecosystems are fragile, home to several flora and fauna and vulnerable to climate change. Prolonged dry-spells interspersed with intense rainfall are being witnessed, resulting in a drought like situation. Drought mitigating options such as water harvesting, in situ moisture conservation measures, drought tolerant crops and varieties, horticulture systems, perennial fodder production systems can mitigate drought and stabilize production and livelihoods.

Keywords: Drought, Drought tolerant crops, Hill regions, Water harvesting

HILL farming constitutes 16% of the total area of the Himalayas. About 69% of the Himalayan landscape consists of rangelands, pastures, wastelands and the forests. About 15% is under permanent snow cover and rocky mountain and serves as a perennial source of clean water to the hills and plains. Agriculture is the primary sector of the economy, contributing 45% to the total regional income of the inhabitants. Majority of the farming households in the Himalayan states have land holdings of less than 0.5 ha there are small landholders with farms of 0.5–1.0 ha. While the average land holding in Himachal Pradesh is about 1.2 ha, it is even smaller, which is about 1.01 ha in Uttarakhand. In the north-eastern Indian Himalayas, shifting cultivation or jhum accounts for 85% of the cultivated area and supports over 1.6 million people, largely tribal communities. Hilly regions comprise of cattle (47.5%), goats (15.8%), buffaloes (12.3%) and sheep (10.4%). For a large number of small and marginal farmers of the hilly region, shrinking land holdings, erosion from sloping farmlands, and decline in soil fertility, climate change and variability are the serious concerns, impacting hill agroecosystems.

Drought like situations in hilly regions

Climate change is evident in hilly regions and projections show that by the end of the century, much of India will see temperature increases of 3–4°C with the hilly northwest Himalayan region be experiencing

warming by more than 5°C. Particularly, the northeast region of India is characterized by diverse climate regimes which are highly dependent on the southwest monsoon. Over 60% of the cropped area are rainfed, which are highly vulnerable to climate variability/change. The northern part of the northeast shows a reduction in precipitation varying from 3% in the northwestern portion to about 12% in the northeastern portion. The number of drought weeks during monsoon months show an increasing trend in Arunachal Pradesh, parts of Assam, Meghalaya, Mizoram, Tripura and Manipur, to the tune of about 25% increase in future. Many parts of the Brahmaputra basin show a tendency of extreme soil moisture stress during the monsoon months, which is likely to lead to moderate to extreme drought condition. Manipur, registered highest rainfall deficit (-52%) in 2011 and 87% (163 mm as against 1262.7 mm) in 2016, highest rainfall deficit among the northeastern states. In Cherrapunji, the annual mean rainfall for the period 1973–2019 showed decreasing trend of about 0.42 mm per decade (average precipitation is 11,861 mm). The projected decline of rainfall is about -10% during winter (*rabi*) season and increase (20%) during the rest of the year in the latter half of this century. A series of drought events may contribute to loss of production and productivity of major crops such as rice, maize, soybean, mustard and others. Climate change likely reduces maize yield by 50% in northeast India. By 2030, the irrigated maize may have yield loss

between 15–50% and rainfed maize by about 35%. In Manipur, during 1975–2007, 24.24% of drought weeks were experienced during the transplanting stage and the panicle initiation stage of rice. About 21.21% and 18.18% of drought weeks coincide with active tillering stage and the milking stage of rice, respectively. The major causes identified for the drought are late onset of monsoon and reduced rainfall intensity. The delayed onset of monsoon led to delayed servings of rice, poor growth of maize, reduced recharge of aquifers, reduced agricultural production and increased crop damage especially in mid-hill regions of India.

Drought mitigation measures

Rain-water harvesting: The importance of rainwater harvesting has increased in recent years due to the increased rainfall variability and depletion of groundwater levels. Rainwater harvesting in jalkunds, water harvesting tanks, sand bag check dams, rockfill dams and wells with recharging structures enables to collect excess runoff during high intensity rains, facilitates groundwater recharge, and thus provides opportunity to farmers to give supplemental irrigation to crops during prolonged dry spells and also opportunities for cropping intensification.

Jalkund: A simple and low-cost rainwater harvesting structure called Jalkund has been developed for storing rainwater in upper terrace conditions of the hilly regions of the country. During the rainy season water can be utilized to provide protective irrigation to the crops for successful cultivation which otherwise would be lost as runoff. The benefits from jalkund can be maximized by growing high value crops, animal husbandry activities etc through providing critical irrigation during dry spells. In Jaintia hills district, receiving a rainfall of 3728 mm, jalkunds were constructed under National Innovations in Climate Resilient Agriculture (NICRA) program which enabled farmers to diversify and contributed to cropping intensification by growing high value vegetables such as cabbage, cauliflower, broccoli cultivation and vegetable seedlings production with low cost polyhouses during the winter (*rabi*) season by irrigating during dry spells with micro-irrigation



Harvested water from Jalkund is used for cultivating vegetables at Jaintia Hills, Meghalaya

systems (sprinkler and drip). Supplemental irrigation with drip enhanced the yields of tomato and cabbage to 28,500 and 12,500 kg/ha respectively. Jalkund contributed to yield improvement of various crops such as rice and vegetables in Lunglei and Ukhrul and Umiam districts to the extent of 60–300%. Micro-irrigation to *rabi* crops during dry spells made vegetable production is a profitable venture in East Sikkim. Supplemental irrigation through drip enhanced the yields of tomato in NICRA village of East Sikkim up to 35% over the farmers' practice.

Sand bag check dam: A sand bag check dam across the seasonal rivulet augments the water storage significantly in the stream and lifting of this water for irrigation provides opportunity for double and triple cropping. It stores the water behind the sand bag check dams, which leads to deep percolation of water and improves the groundwater level in surrounding areas and reduces the moisture stress situations by providing supplemental irrigations to crops and increases the cropping intensity of the area. In Nandurbar district, Maharashtra, this technology helped to harvest runoff during the season and supplemental irrigation to rainy (*kharif*) crops and also for chickpea during *rabi* resulting in yield improvement up to 45% more compared to no supplemental irrigation.



Harvested water through sand bag check dam at Nandurbar, Maharashtra

Rockfill dam: Rockfill dam, a kind of embankment or so called earth rock dams, is a water retaining barrier composed of fill of loose rock by compaction, impervious membrane made of masonry, concrete, asphaltic concrete, steel sheet piles, timber employed as the waterproof placed on the upstream slope and transition layer. The harvested water is used for providing the lifesaving irrigation to crops to mitigate the drought stress. In a Dhansiripar village of the Dimapur district, the Nagaland rockfill dam was constructed covering a cultivated area of 180 ha which increased cropping intensity by 34%. The effective use of water during the moisture stress periods has increased yield of rice up to 6 q/ha.

Small water harvesting tanks: Drought and moisture stress are major constraints in the districts of Hamirpur and Kullu of Himachal Pradesh. To mitigate the

drought, water storage tanks of 50–80 m³ capacity were constructed in NICRA adopted villages of Hamirpur and Kullu districts. During dry spells, supplemental irrigation from the harvested water in the water tanks was given to high value vegetable crops resulting in higher yield in tomato up to 336 q/ha and net return up to ₹2,76,500/ha compared to farmer's practice of growing maize with net income of ₹24,000/ha.

In situ moisture conservation measures

Contour trenching and bunding: It is an important practice for reducing the impact of drought in hilly regions (suitable in areas where slope is >10%). Deep continuous contour trenching and bunding is built along the contours and across the slope of fields to prevent loss of fertile top soil and conserve moisture. Bunds and trenches help to conserve more moisture *in-situ* by storing water for longer days. The stored water in trenches and behind the bund percolate into the land resulting in improvement in groundwater level. Continuous contour trenching and bunding in soybean, cotton and sorghum crops increased yield by 19%, 23% and 11% respectively, as compared to local practice.

Mulching: Moisture conservation through mulching in high value vegetable crops helped to overcome drought-like situations by reducing the evaporation losses. It provides opportunity for second crop under residual moisture during the post rainy season. This enabled less weed growth, pest infestation and less water application, thereby increasing the crop yield. In NICRA village, Kyrדם, Ri-bhoi district, straw mulching in turmeric, ginger, cabbage resulted in yield increase up to 38%.



Contour trenching and bunding at Mon, Nagaland

Conservation furrow: Conservation furrows are one of the most important drought management practices for 500–1000 mm rainfall regions. Adoption of conservation furrow at a specified interval improves the soil moisture availability at the root zone. The technology was adopted in soybean in Umarani village of Nandurbar district resulting in yield improvement up to 38% compared to without conservation furrows.

Raised bed planting: The impact of drought can be minimized by forming raised bed and furrows across the



Mulching in Cabbage at Ri-Bhoi, Meghalaya

slope. Particularly during *rabi* season, the hilly regions receive low rainfall. Forming furrows with raised beds can reduce the moisture stress by harvesting the rain water in the furrows and planting is then done on these raised beds. The technology also reduces the soil loss by conserving the runoff water and mitigates the drought. Raised bed planting of cabbage, cauliflower, pea and broccoli obtained higher yield up to 52%.

System of Rice Intensification (SRI): SRI can be an alternative in areas which are prone to late onset of monsoon and have limited availability of water. The method is highly suitable for water limiting areas of hilly regions. SRI cultivation has increased the yields significantly with the variety Shahsarang in Ri-Bhoi district of Meghalaya.

Short duration varieties: Cultivating short duration varieties can escape the drought and increase the yields. To minimize the impact of drought, several short duration cultivars were introduced for hilly regions. Short-duration rice variety Vivek Dhan 82 (95–110 days) was adopted in Ri-Bhoi district of Meghalaya which achieved higher yield up to 54%. Introduction of maize short duration variety GM 6 (75–80 days) suitable for late sowing in Umarani village, Nandurbar district gave higher yield up to 18%.

Drought tolerant varieties: Drought tolerant varieties of rice, viz. Inghlongkiri, Gitesh, RCM 12, Bhalum III;



Raised bed planting of pea at Dibrugarh, Assam



Dragon fruit cultivation at Lunglei, Mizoram

maize, viz. Bajaura Makka, VL Maize 31 and linseed cv. Shekar were tolerant to the moisture stress conditions and gave higher yields up to 77%. In Sipni village of Tirap district, high-yielding drought tolerant summer rice cv. Dehangi (115 days), resistant to blast and moderately resistant to stem-borer, case-worm and leaf-folder and tolerant to dry spells obtained higher yield up to 22%. Drought tolerant varieties of various crops are given in Table 1.

Dryland horticulture: Northeast region has wide range of both soil and climate that suits for dragon fruit cultivation particularly during *rabi* season. To enhance the resilience of farmers, dragon fruit was introduced in Hnahthial village, Lunglei district. The cost of cultivation was ₹78,000/acre and net returns obtained was ₹1,64,000/acre.

Zero till Pea in Rice fallows: Farmers in hilly regions

leave field fallows after harvest of rice due to terminal drought impacting the crops at harvesting stage. Short duration pea varieties, viz. Prakash and Arkel were introduced in rice fallows of Kyrדם village of Ri-Bhoi district of Meghalaya. Zero-till sowing of pea along with mulching of rice residue achieved higher yield up to 25% with net income of ₹76,000/ha. Short duration pea with zero-till sowing enhanced the cropping intensity from 113–200%.

Intercropping systems: Intercropping is an adaptation strategy to water scarcity and drought for low-input systems. Upland rice can be intercropped with soybean, french bean, groundnut/blackgram/greengram in 4:2 row ratio for enhancing the total system productivity per unit land area. Maize + groundnut (2:2) and maize + soybean (2:2) intercropping produced higher maize equivalent yield up to 43% compared to sole maize.

Perennial fodder cultivation: Frequent droughts in the undulating regions impact availability of green



Maize + Soybean (2:2) intercropping at Lunglei, Mizoram

Table 1. Drought tolerant/escaping short-duration varieties suitable for hilly regions of India

State	District	Crop	Variety	Yield improvement (%)
Arunachal Pradesh	Tirap	Rice	Dehangi	22
Assam	Karbi Anglong	Rice	Inglongkiri	60
	Dibrugarh	Garden pea	Vatika 10	14
	Sonitpur	Linseed	Shekhar	34
Meghalaya	Ri-Bhoi	Rice	RCM 10	18
	West Garo hills	Rice	Bhalum III	77
Nagaland	Dimapur	Rice	Gitesh, RCM 12, CAU R1	10
	Mokokchung	Mustard	TS 38, TS 67	68
	Mon	Maize	HQPM 1, RCM 76	12
		Soybean	JS 335	11
Tripura	Dhalai	Pea	Arka Priya	32
Himachal Pradesh	Kullu	Maize	Early Composite, Girija, Bajaura Makka, KH 517	11-35
Uttarakhand	Uttarkasi	Blackgram	Pant Urd 35	15
		Maize	VL Maize 31	25
		Lentil	VLM 126, VLM 514	32
		Wheat	HS 507, VL 907, UP 2572	30
	Tehri Garhwal	Pigeonpea	VL Arhar 1	43
Maharashtra	Nandurbar	Chickpea	Digvijay	30
	Nandurbar	Sorghum	CSV 27	20

fodder which in turn impact productivity of animals. Shortage of the green fodder during summer and *rabi* season is a constraint for rearing traditional bull calves as the growth of calves is sub-optimal and also taking longer time for getting optimum size as bullocks. Perennial green fodder crops such as lucerne varieties RL 88, Anand 2 were introduced in Nandurbar district to enhance green fodder production during lean period. Lucerne is a leguminous forage crop which can tolerate drought situations. Yield obtained was 720 q/ha and farmers are getting additional income of ₹11,000–15,000 by selling healthy bullocks useful for draught purpose in hilly regions.

SUMMARY

Drought is a recurring phenomenon severely impacting rainfed crops and animals. To enhance resilience of agriculture in hilly regions, drought

mitigating options are to be introduced for stabilizing food production and nutritional security. Practices such as rainwater conservation and its efficient utilization during water scarcity for protective irrigation, soil erosion control, *in situ* conservation practices, soil health management, enhancing the cropping intensity by high value crops, drought tolerant crops and varieties, short-duration varieties, dryland horticulture and perennial fodder cultivation can be effective options for enhancing the adaptive capacity of farmers to drought. Appropriate policies which can scale the proven technologies can alleviate the impacts of prolonged dry-spells and drought like situations and enable vulnerable communities to cope with the climate change.

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