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Spring shed development by employing traditional practices for spring revival and reducing women drudgery in Kumaun Himalayan Region

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ABSTRACT

The Himalayan ecosystem is one of the most important and threatened life support systems on the earth. Ruthless exploitation of vegetal cover from steep hill slopes of Uttarakhand hills is adversely affecting the various natural resources. About 36% of springs have dried resulting into severe crisis of water for drinking as well as irrigation during the past 20 years. It is a dangerous sign that aquifers are depleting in a state where majority of the population in hills dependents on springs for drinking water. Women drudgery is high and bulk of their time is spent in collecting fodder, fuel-wood and water for which walking 4-6 Km/ day is common resulting in neglect of children and personal health. The present study was conducted at two villages (1646 -1715 m elevation) to evaluate the effect of various activities directed towards using a mix of traditional and scientific know how in reviving /improving the water discharge of springs, reducing women drudgery by planting fodder grasses in areas close to villages. The milk production increased by 0.8 to 1.2 liter/ cattle/household. Establishment of micro-reservoirs at each spring shed increased the discharge of water during lean period.

Key words: *Spring shed, Drudgery, Himalaya, Reservoirs, Natural resources*

Introduction

The Himalayan ecosystem is one of the most important and threatened life support systems on the earth. Uttarakhand state of Himalaya region lies between latitudes 28° 43′-31° 27′ N and 77° 34′- 81° 02′ E longitudes. It is located centrally and enjoys the transition between the humid east and sub-humid to semi arid Western Himalaya. The total population of Uttarakhand is 8.5 million of which little over 5 million people live in the mountainous part of the state Singh *et al*. (2009).

The poor village communities of the hilly region predominantly maintain a subsistence living. The relationship between man and forests is quite intimate. However, with increasing population and decreasing forest resources this relationship is leading to forest degradation and is becoming unsustainable. The village communities depend upon the surrounding forests for fodder and fuel-wood and relentlessly extract these resources. The land holding size is generally 0.8 ha, the majority of the farmers in the state are marginal having less than one ha land holding (Singh and Singh, 2018) and agriculture in the hills in its present form is non sustainable as its viability is highly dependent on the surrounding forests. In Uttarakhand the present shortage of feed and fodder is estimated to be 65%. The low quality ani-

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mal (milk less than 1 liter/day) is maintained on low quality fodder of oak species. Women drudgery is high and bulk of their time is spent in collecting fodder, fuel-wood and water for which walking 4-6 Km/day is common resulting in neglect of children and personal health (Singh *et al.,* 2009). The oak forests are degraded due to over exploitation by the local communities who are dependent on oak leaves for fodder, wood for fuel and timber for farm implements. Ruthless exploitation of vegetal cover from steep hill slopes of Uttarakhand hills is adversely affecting the various natural resources (Tewari and Tewari, 2021).

Water, which is the most vital natural resource for life on earth and the scarcest commodity in the 21st century, is also being polluted by various anthropogenic activities. The ancestors of Himalayan communities followed some basic principles to keep water pure and pollution-free (Tambe, 2011). Springs are the main source of water for millions of people in the Himalayas. Both rural and urban communities depend on springs for their drinking, domestic and agricultural water needs. Most water supply schemes that have been laid in the areas have their origins in a spring (Gupta and Kulkarni, 2018). Spring discharge is declining due to groundwater pumping under increased demand, changing land use patterns, ecological degradation and changing climate (Tambe, 2011). About 36% of springs have dried, heads of perennial streams have dried and water discharge in springs and streams has decreased considerably resulting in severe crisis of water for drinking as well as irrigation during the past 20 years. It is a dangerous sign that aquifers are depleting in a state where majority of the population in hills is dependents on springs for drinking water. These effects are being observed in nearly all mountainous regions of India (Tiwari *et al*., 2011). VPs of Uttarakhand are the unique example of people's institution that has been in existence since 1930, for managing their natural resources and efficient environmental governance. Symbiotic relations between forests and local communities have been demonstrably effective. Thus, to take the advantage of collective strengths of communities and VPs there is need to perform a coordinated role. Van Panchayat (VP) can play a crucial role in planning and executing participatory programmes for the protection, promotion and management of natural resources. They help in meeting the resource needs of the local communities and avoiding deforestation at the same time and also have control over the forests. The comprehensive studies are still lacking to support these observations conclusively. Spring depletion in the mountains must be viewed through the lens of depleting stocks of groundwater leading to a serious impact on the lives and livelihoods of communities who dwell there. The management of springs must focus on land use, land cover (forest cover) surface water systems and climatic factors. The present study was planned to evaluate the effect of various activities directed towards using a mix of traditional and scientific know how in reviving /improving the water discharge of springs, reducing women drudgery by planting fodder grasses in areas close to villages.

The main objectives were:

- Revival/Increase water discharge in the perennial and seasonal springs.
- To reduce women drudgery by providing easy access to fodder and water.
- Raising plantation of commercially important species.

Study area

The present study was carried out in the Van Panchayat forest of two villages (Kaltani and Thaat) at Lamgara Developmental Block of Almora District (Uttarakhand) (Table 1).

Methodology

Baseline survey

Two villages, Kaltani and Thaat were selected. A sample of 130 households was selected randomly from these villages through proportional allocation method. The data on different aspects of agricultural development, livestock rearing and natural resource management specially water and land, were collected through personal interview and semi-structured questionnaire method during March to May 2018.

Vegetational analysis

For vegetational analysis of the forests of each village the number and size of the quadrates were determined by the running mean method Bargali (2013). Ten plots of 10 x 10 m at each altitude were randomly established. Trees and saplings were analyzed in 10 x 10 m and seedlings in 10, 1x1 m area within each plot Curtis and McIntosh (1950);

Table 1. Details of the study sites

Name of village	Coordinates	Elevation	Forest type	Annual rainfall	Temperature	Vegetation type
Kaltani	29°32.98'-29°34.32' N latitudes and 79°41.44'-79°43.2' E longitude	1715 m	Van Panchayat	274.5 to 463.2 mm.	Mean maximum temperature varied from 17.31 °C (December) to 27.87 °C (June), while the mean minimum temperature varied from 2.18 °C (January) to 14.87°C (June).	Himalayan moist temperate oak forest and subtropical pine forest
Thaat	29°32.98'-29°34.32' N latitudes and 79°41.44'-79°43.2' E longitude	1646 m	Van Panchayat	274.5 to 463.2 mm.	Mean maximum temperature varied from 17.31 °C (December) to 27.87 °C (June), while the mean minimum temperature varied from 2.18 °C (January) to 14.87 °C (June).	Himalayan moist temperate oak forest and subtropical pine forest

Source of climatic data Rawat (2012)

Phillips (1959). Circumference at breast height (cbh at 1.37 cm from the ground) of all trees was measured in each plot. Tree mean basal area of a species ($C^2/4\pi$ where, C= sum of cbh value of all individuals of a tree species within each plot and $\pi = 3.14$) was multiplied by its density value to calculate total basal area of a tree species. Important Value Index (IVI) was calculated following Phillips (1959) as:

IVI = Relative frequency + relative density + relative dominance

Fodder

The work on selection of fodder grasses were carried out for plantation through community involvement. Transect walk and PRA was been followed for identification and selection of suitable fodder grasses. At appropriate time the root stock of selected fodder grass (*Pennisetum purpureum and Festuca arundinaceae*) were planted following Tewari *et al*. (2004). The plantation of fodder grass (30,000 root stocks of one species of grass) was raised in 1 ha area with community assistance on village wasteland/ Field margins/near the water bodies (Table 2).

Establishment of micro-reservoirs

Across both the village 19 spring sheds were selected. Per village 30 to 50 micro reservoirs (slope 30°) in each spring shed at spacing 6 m popularly known as Khanti/khals of 1.8 x 0.45 x 0.45 cubic meter were dug with water accumulation capacity approximately 546.75 cubic liter water in 30 days of heavy rains for in situ moisture conservation as well

Table 2. Name, uses and nutritional value of selected fodder grass

Name of species	Uses	Nutritional value
Pennisetum purpureum, (Napier grass)	Fodder, soil binder and retain moisture	It contains 30.9% carbohydrate, 27% protein, 14.8% lipid, 18.2% ash and 9.1% fiber (dry weight).
Festuca arundinaceae (Dolni grass)	Fodder, retain moisture, soil binder	It contains 22.1% Crude Protein, 0.51% Calcium and 0.37% Phosphorus.

Source of Nutritional value of fodder (Sawasde *et al*. (2014); Hannaway *et al*. (1999)

as recharging of natural springs within forest and nearby areas of villages (Table 3 and 4).

A site lay out plan with technical assistance was carried out for digging micro reservoirs so as to take maximum advantage of water runoff during the rains. The downhill sides of the reservoirs were planted with selected fodder grass (approximately 15000 root stocks) for moisture retention to increase water discharge in springs. The spring flow measurements were manually recorded by measuring the time taken for a specific amount of water coming out of the spring during summer month (lean period). The measurement was based on Timed Volume Methodologies by using Container and Stopwatch Tubman (2013).

Where flow (*Q*) can be captured into a container of known volume (*V*), one of the most straightforward methodologies for determining discharge is to time (*t*) the filling of the container and calculate flow using the discharge equation:

$$Q=V/t$$

This method is commonly employed at discharge pipes or other places where flow can be captured into a container. It is simple and accurate at lower discharge rates. It can be accurate at higher discharge rates as well depending on the geometry of the discharge pipe.

Seedling raising

For raising and supply of quality planting material two species *Bauhinia variegata* and *Cinnamomum tamala* were raised in nurseries managed by local communities. 1000 seedlings of *Bauhinia variegata* and 1000 seedlings of *Cinnamomum tamala* were raised in the nursery in polythene bags.

Results

Baseline survey

The total population of Kaltani village is 185 and the household are 43 and the population of Thaat is 950 with 145 households. In both villages 2-4 livestock are maintained / household. Across both the villages collection of fuel and fodder from Van panchayat forest (VPs) is about 30 to 40%, Reserve forest 20 to 25%, civil forest 10 to 20% and Agriculture land about 30 to 35% due to high demand. For collection of fuel, fodder and water women travel 2-4 Km/day during winter, summer season. The collection of water by locals is between 25 and 30 liter

Table 3. Number of micro-reservoirs established and coordinates of each selected spring shed in Kaltani village

Name of springs	Number of micro- reservoirs	Coordinates of springs
Eaidi spring	50	N 29°32.198´E 079°43.982´
Eaidi nauli spring	35	N 29°32.206´E 079°43.983´
Shyalgarh	42	N 29°32.156´E 079°44.046´
Nauli gaunsala spring	50	N 29°32.222´E 079°44.135´
Nauva gair spring	45	N 29°32.646´E 079°43.904´
Jali bagad spring	30	N 29°32.652´E 079°43.960´
Nauva kameli spring	30	N 29°32.620´E 079°43.838´
Shyai ijar spring	50	N 29°32.620´E 079°43.838´

Table 4. Number of micro-reservoirs established and coordinates of each selected spring shed in Thaat village

Name of springs	Number of micro- reservoirs	Coordinates of springs
Katyura spring	50	N 29°32.595´E 079°44.763´
Kuthiger spring	50	N 29°32.492´E 079°44.642´
Bhatoda I	40	N 29°32.372´E 079°44.645´
Bhatoda II	45	N 29°32.450´E 079°44.684´
Bakhali spring	45	N 29°32.422´E 079°44.547´
Gajaar spring	30	N 29°32.374´E 079°44.507´
Thulgada I spring	40	N 29°32.551´E 079°44.533´
Thulgada II spring	50	N 29°32.551´E 079°44.533´
Supani	35	N 29°32.558´E 079°44.545´
Shelkhola I spring	42	N 29°32.345´E 079°44.721´
Shelkhola II spring	50	N 29°32.294´E 079°44.791´

per day from the natural resources. During summers the problem of green fodder and water aggravates. During survey various springs of selected areas had dried up and the water status of that area was very poor (Table 5).

Vegetational analysis

In the VP forest of Kaltani village total tree density was 280 tree/ha. The maximum tree density was 100 tree/ha for *P. roxburghii*. The maximum sapling density was 110 for *P. roxburghii*. Seedling density was found maximum 120 individuals / ha for *Q. leucotrichophora*. Total basal area of tree was maximum 4.3 m^2/ha and IVI maximum 105.21 for *P. roxburghii*. The forest showed good regeneration of *Q. leucotrichophora.* The maximum sapling and tree density was of *P. roxburghii* followed by *Q. leucotrichophora* (Table 6).

In the VP forest of Thaat village total tree density was 300 tree/ha. The maximum tree density 80 tree / ha for *P. roxburghii* and *Rhododendron arboreum*. The maximum sapling density was 70 for *P. roxburghii*. Seedling density was found maximum 60 individuals / ha for *Q. leucotrichophora*. Total basal area maximum 3.76 m^2 /ha and IVI maximum 93.67 for *P. roxburghii*. The forest showed good regeneration of *Q. leucotrichophora* but no conversion of seedling into sapling were found. The maximum sapling and tree density of *P. roxburghii* shows the forest was dominated by *Pinus roxburghii* (Table 7).

Fodder

35- 40 households per village were actively involved in the production of fodder grasses. However only 20-25 families /village took benefit of activity. As a result of fodder availability near the village the daily

Table 5. Baseline survey of two selected villages

Name of Village	Kaltani	Thaat
Population	185 people	950 people
Household	43	145
Animals	2-3 livestock/household	2-3 livestock/household
Total Area	500 ha	500 ha
Non Irrigated land	50 ha	45 ha
Uncultivated or barren land	300 ha	400 ha
Agriculture land	80 ha	65 ha
Collection of fuel and fodder	VPs - 30-35% Reserve forest – 15-25% Civil forest – 20% Agriculture land- 30%	VPs - 30-40% Reserve forest – 20-25% Civil forest – 10% Agriculture land- 35%
Collection of drinking water per day by naturals resources	30 liter / household	25-30 liter / household
Income /month	8000-12000 /household	7000-12000 /household

Table 6. Vegetational parameters of Kaltani Village

Name of species	Size class	Density (Tree/ha)	Frequency %	Abundance	A/F	TBA (m^2/ha)	IVI
Quercus leucotrichophora	Tree	60	40	1.5	0.03	1.01	51.33
	Sapling	40	40	1	0.02	0.147	61.22
	Seedling	120	90	1.3	0.01	0.047	153.3
Pinus roxburghii	Tree	100	80	1.2	0.01	4.3	105.21
	Sapling	110	60	1.8	0.03	0.443	98.93
	Seedling	30	30	1	0.03	0.011	60.04
Myrica esculenta	Tree	60	50	1.2	0.01	2.6	84.83
	Sapling	70	40	1.7	0.04	0.235	69.54
	Seedling	10	10	1	0.1	0.006	49.04
Rhododendron arboreum	Tree	60	50	1.2	0.02	1.1	58.26
	Sapling	70	40	1.7	0.04	0.24	69.99
	Seedling	20	10	2	0.2	0.006	37.23

visits to the forest area for fodder collection by the women during the lean months was reduced by 50%. The milk production increased by 0.8 to 1.2 liter/ cattle/household (Table 8).

Effect on springs after the establishment of micro-reservoirs

Perennial springs

In the year 2018 during pre project activity (April – June) in all the perennial springs data was collected on the water discharge rate of the springs which was 1 liters or less than 1 liters per 30 minutes. During July 2018 micro-reservoirs were dug in each spring shed in both the selected village. The water discharge from springs of that area was observed in the year 2019, 2020 and 2021 in the summer season (lean period). The discharge of water from the springs gradually increased. The discharge of water increased to 4 – 5 liters per 30 minutes (Fig. 1 and 2).

Seasonal springs

In the year 2018 during pre project activity (April – June) in all the seasonal springs it was observed that there was no water discharge. During July 2018 micro-reservoirs were dug in each spring shed in both the selected village (Table 3 and 4). The water discharge from springs of that spring shed was observed in the year 2019, 2020 and 2021 in the summer season (lean period). Across both the villages 3 springs showed signs of revival and water discharge was 1 or $1^{1/2}$ liters in 60 minutes. However in other springs there was no water discharge (Fig. 1 and 2).

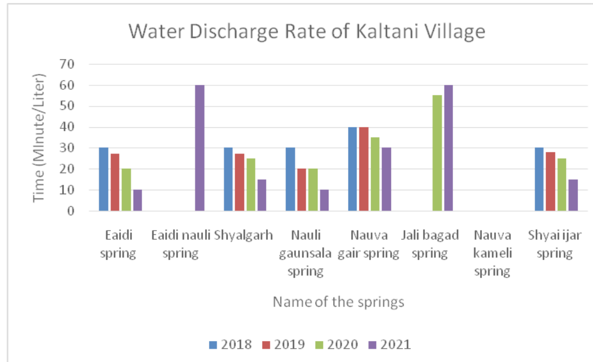

Fig. 1. Analysis of water discharge from springs after the implementation of project activity in Kaltani village.

Seedling survival

Seedlings of *Bauhinia variegata* had grown to 40 cm – 50 cm in height and seedlings of *Cinnamomum tamala* 60 cm in height in two years. They were planted out

Table 7. Vegetational parameters of Thaat village

Name of species	Size class	Density (Tree/ha)	Frequency %	Abundance	A/F	TBA (m^2/ha)	IVI
Quercus leucotrichophora	Tree	70	50	1.4	0.02	1.43	62.84
	Sapling	50	40	1.2	0.03	0.133	88.86
	Seedling	60	60	1	0.01	0.011	90.41
Pinus roxburghii	Tree	80	60	1.3	0.02	3.76	93.67
	Sapling	70	40	1.7	0.04	0.21	93.97
	Seedling	50	50	1	0.02	0.012	84.88
Myrica esculenta	Tree	70	60	1.1	0.01	1.88	72.85
	Sapling	40	30	1.3	0.04	0.07	56.71
	Seedling	40	30	1.3	0.04	0.008	65.85
Rhododendron arboreum	Tree	80	60	1.4	0.02	1.62	70.35
	Sapling	30	30	1	0.03	0.057	58.76
	Seedling	40	40	1	0.02	1.54	58.56

Table 8. Assessment of impact of perennial fodder grass production, harvesting and its consumption by livestock in selected villages

Name of Fodder grass	Production (t/ha)	Harvesting time	No. of cattle / household	Fodder eat by/cattle/day (Kg)	No. of Families reaping benefit of fodder	Increase milk production per liter /Cattle/ household
Pennisetum purpureum	4.0	60 days	2-3	7-10	15	0.8-1.2
Festuca arundinaceae	3.3	63 days				

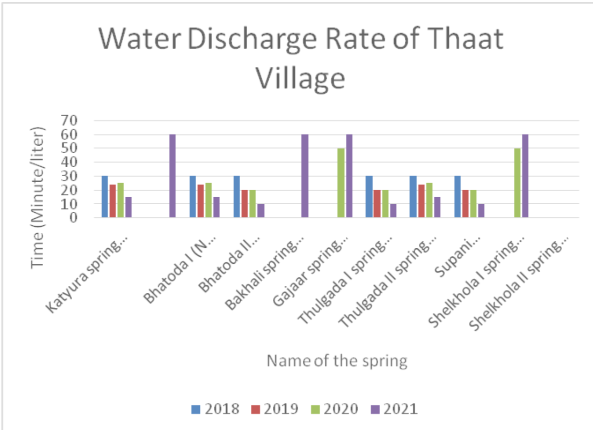

Fig. 2. Analysis of water discharge from springs after the implementation of project activity in Thaat village.

during rainy season on wasteland, field margins and near microreservoirs. The survival rate of *Bauhinia variegata* was 80% (800 seedlings survived) and *Cinnamomum tamala* survival rate was 50% (500 seedlings survived) in field areas.

Discussion

Natural resources like forests, water play an important role in the rural livelihood. Village level institutions called Van Panchayat (VP) can play a crucial role in planning and executing participatory programmes for the protection, promotion and management of natural resources and help in meeting the resource needs of the local communities and avoiding deforestation at the same time and also have control over the forests Lead India (2002). During the recent past, rural resource development practices have changed in response to population increase and the resultant increased demand on natural resources as well as increasing socio-economic and political marginalization. Depletion of natural resources is one of the greatest challenges before human societies globally Tambe (2011).

The presence of a sufficient population of seedlings, saplings and young trees, indicates a successful regeneration of forest species. In the present study the selected forests showed high seedling density of *Q. leucotrichophora* and high sapling density of *P. roxburghii*. In VP forests good management practices such as protection of forest from fire, illicit felling and preventing damage to trees due to lopping along with grazing and watching the forest on rotational basis may be the cause for better regeneration.

The survival rate of *Bauhinia variegata* and *Cinnamomum tamala* was 80% and 50%. The growth of these species is still very less but will provide good benefit during coming years to communities.

In the present study the production of *P. purpureum* was 4.0 t / ha. Similarly Tewari *et al.* (2004) reported among the six fodder grass species *P. purpureum* showed high production in various VPs of Uttarakhand. The demand of green fodder can be fulfill to some extent by planting quality fodder grasses on individual community land, degraded lands and in Van Panchayat forest land. As the demand of green fodder is maximum between winter and dry summer months the fodder grasses can cover the bare lands and also yield green fodder during lean season which reduces the women drudgery (Tewari *et al.* (2004).

The villages people in hills are highly depend upon aquifers, springs etc. for drinking water and irrigation purposes. Spring shed development approach to recharge groundwater to revive mountain springs holds lot of promise for the Himalayan region. For augmenting ground water recharge the people of hilly region take recourse to construction of recharge pits in the mid slopes of the hills. These are called chal or khal in local parlance and are generally ditches dug out in the middle slopes of the hill at places with relatively low gradient where rain water from the upper slopes naturally runs down. Settlement of clay layer at the bottom ensures these pits to retain water for appreciable duration after the rains. Besides augmenting recharge of ground water these cater to the needs of the house hold grazing animals Rautela (2015). In the present study the assessment of water flow from springs indicated that after digging of micro-reservoirs and planting downhill sides of the reservoirs with fodder grass for moisture retention water discharge increased in all 11 perennial springs during summer period (3 – 4) liters per 30 minutes compared to liters / 30 minutes before the earthern ponds were dug and grasses planted. However there was no significant increase in water discharge in 7 seasonal springs. Negi and Joshi (2002) reported high discharge of spring during the lean period, from 1055 liter / day to 2153 liter / day in five years after spring treated with engineering and vegetative measures in Dugar Gad watershed in Garhwal region. Infiltration of rainwater into the spring recharge zone increased through vegetative measures, which augmented discharge in down slope springs Negi and Joshi (2002).

Tambe *et al.* (2011) reported that the lean period spring discharge increasing substantially from 4.4 to 14.4 liters per minute through rainwater harvesting technique in West Sikkim. However, no change in the discharge rate of water and no water discharge in some springs even after digging the micro-reservoirs and planting the grasses could be attributed to the fact that these springs had their spring shed at a different location that the slope above the spring.

Conclusion

The study concluded that the depleting springs and women drudgery is a serious problem in the selected areas, establishing micro-reservoirs at spring shed can be useful in reviving the springs which can positively overcome the water problem of the area. The production of fodder grass reduces women drudgery and dependency on forests. The production of high quality fodder grass can maintain good quality animals that would be more income generating coupled with reducing the disturbance on the natural forests that can promote regeneration.

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Conflict of interest

No conflict of interest

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