Content list available at http://epubs.icar.org.in, www.kiran.nic.in; ISSN: 0970-6429

Indian Journal of Hill Farming

June 2018, Volume 31, Issue 1, Page 98-105

Status and Potential of Farm Mechanization in North Western Himalayan State Uttarakhand of India

S. Singh[1*] . R. Kr. Singh[2]

[1]Division of Agril. Engg, ICAR-I.I.S.R., Lucknow- 226002, Uttar Pradesh

[2]KVK, ICAR-IISR, Lucknow -226002, UP

ARTICLE INFO

Article history:
Received 30 June 2017
Revision Received 6 December 2017
Accepted 21 January 2018

Key words:
Mechanization, North Western, Hills, Uttarakhand, Potential

ABSTRACT

Uttarakhand is a small hill state situated in North Western Himalayas of India blessed with naturally occurring micro agro-climatic regions suitable for cultivation of a wide range of agri-horticultural crops with a great potential for development. Net sown area of the state is only about 13% of its total reported area. The level of farm mechanization in the state is very poor with respect to mechanical power, efficient implements, water management, renewable energy and post harvest technology sectors. The undulating topography, small and irregular sized fields, lack of skilled manpower, poor facilities of repair & maintenance, poor purchasing power of farmers and non-availability of improved farm implements and machine are some of the main reason for low level of mechanization in the hilly region of the state. Immediate attention of the state government and other funding agencies is required to strengthen the agricultural engineering wing in hills of Uttarakhand to handle the farm mechanization problems. Despite various constraints, there is a vast scope for increasing productivity of land and farmer's economy through creation of small water resources for irrigation, land development, use of efficient gender friendly farm power and implements, rain water harvest, disseminating renewable energy gadgets and introducing small scale agro based industries employing post harvest engineering principles.

1. Introduction

Uttarakhand is situated in North Western Himalayas of India and lies between $28^0$43'N to 31^0 27' N latitude and $77^0$34' E to 81^0 02' E longitude. The total geographical area of the state is 53,48,300 hectare, of which approximately 86% area (46,03,500 ha) is under hills and remaining 14% (7,44,800 ha) is plain area with the elevation ranging from 210 to 7817 m above mean sea level. Forests covers close to two-thirds of the area and only 13% per cent of the area is used for agriculture (Table 1 & Figure 1). Many hill districts are earthquake prone, falling into seismic zones IV and V. The state is also divided into four agro-climatic zones *viz*. the tropical zone ends at an altitude of 1000 m, the sub-tropical zones ranges from 1000 to 1500 m, the cool temperate zone ranges from 1500 to 2400 m, and the sub-alpine and alpine zones start at 2500 m. The state falls under the agro-climatic zone-I *i.e.* Western Himalayan Region. Climatically the state is situated in the Temperate Zone. However, the climate varies from sultry hot in the foot hills to arctic cold in snow capped peaks with subtropical climates in the river valleys. Physiographically, the region is divided into following four sub agro-climatic zones *i.e.* The outer Himalayas Zone or Shivalik hills which is located at 500 to 1250 m above mean sea level, the lesser Himalayas Zone located at 1250 to 2750 m above mean sea level, the Great Himalayas Zone located at 2750 to 4500 m above mean sea level and the Trans Himalayas Zone located at 4500 m above mean sea level.

*Corresponding author: ersukhbir75@gmail.com

Table 1. Pattern of land utilization in Uttarakhand

Classification of area	Uttarakhand,'000 ha	All India, '000ha
Total Reported Area	5673	305611
Forest Area	3485	70042
Culturable Waste Land	309	12857
Fallow Land	114	26237
Barren & Unculturable Land	224	42954
Land under Non-agricultural Uses	217	-
Permanent Pasture & Other Grazing Land	198	10149
Land under Misc., Tree Crops and Groves not included in net area sown	383	3351
Net area sown	741	140022
Total cropped area	1166	192197
Area sown more than once	425	52175

Source: Uttarakhand at a Glance (2012-13), Directorate of Economics & Statistics, Govt. of U.K., Dehradun

Despite small geographical area, the state is blessed with diverse agro-climatic conditions, topography and natural resources for cultivation of a wide range of agro-horticultural crops. The weather conditions also vary greatly with the topography and elevation. The temperature ranges from minimum -4.0 ^{0}C in Mukteshwar to maximum 37.9 ºC in Dehradun. The average annual rainfall is 1,843 mm mostly received between mid of June and end of September. The distribution pattern of rainfall varies greatly with time and space over the year and generally it is erratic in nature, which creates water stress conditions at various stages of crop growth. These climatic and other edaphically conditions have given rise to different agricultural practices and crop sequences in this geographical area. The geography of Uttarakhand is so much varied that it has been geographically divided into two parts. There are 16,793 census villages and 95 development blocks. Broadly the region constitutes of 13 districts falling in two major administrative unit *viz.* Garhwal (northwest portion) and Kumaon (southeast portion). Garhwal Division consists of 7 districts, *i.e.* Dehradun, Haridwar, Uttarkashi, Tehri, Pauri, Rudra Prayag and Chamoli while remaining 6 districts *viz.,* Pithoragarh, Bageshwar, Almora, Nainital, Champawat and Udham Singh Nagar fall in Kumaon division (Figure 2.).

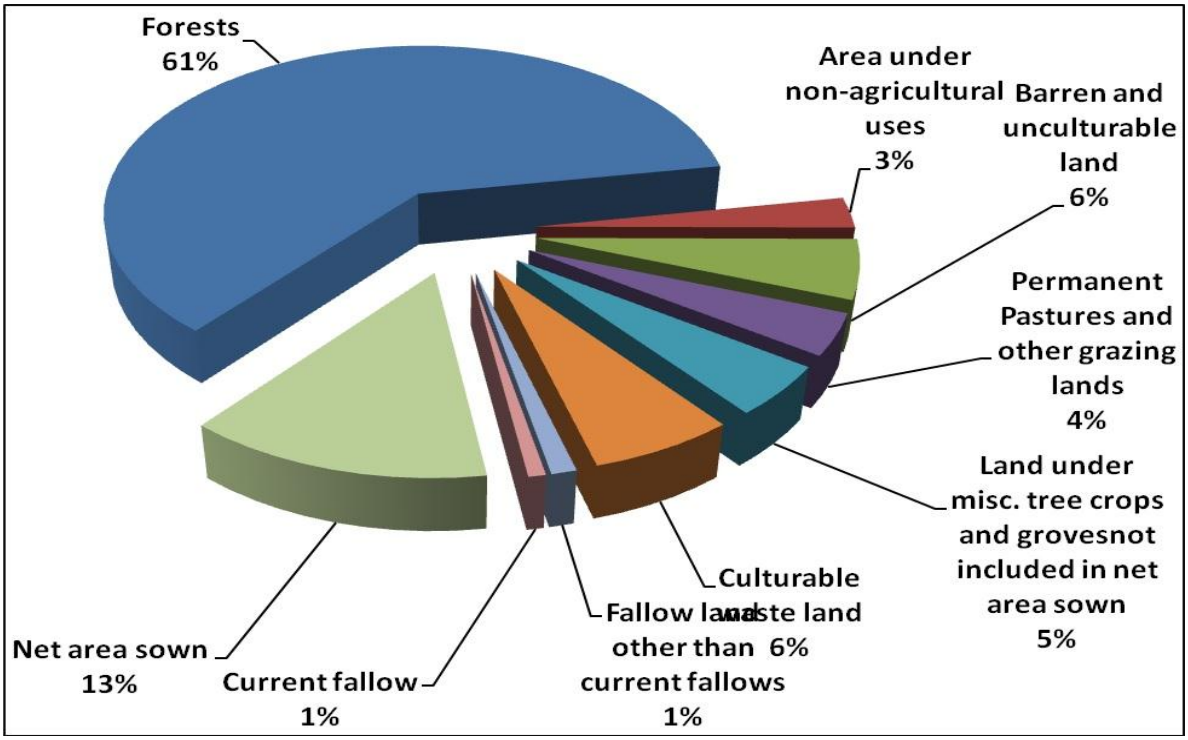

Figure 1. Pattern of land utilization in Uttarakhand

The average land holding in Uttarakhand is 0.89 ha, while the national average for individual holding size is 1.15 ha. Within the state, the average land holding in hilly areas of state is about 0.80 ha. The fragmentation of land holding is expected to be greater, especially under small and marginal farmers' categories in the state. The majority of the farmers in the state are marginal having less than one hectare land holding. There is an abundance of water in the state received through precipitation (snowfall and rainfall) but the major portion goes waste and is utilized in the lower states. Only a small fraction of available water is utilized in the state and farmers are deprived of irrigation water for as well as domestic use. Only 45.34% of the net area sown is irrigated by different sources and the remaining area is rain fed. The major source of irrigation in hills is through *naulas* and tanks/ponds. Similarly, the natural energy sources like sunshine, wind, vegetation, water flow and other biological wastes which are abundantly available in the state are not being harnessed properly, resulting in very low per capita energy availability, deforestation and poor health. The post harvest losses, poor marketing and traditional farming systems also restrict farmers from using improved inputs. The main crops are wheat, paddy, maize, manduwa and sanwa in food grains; urad, gram, pea, masoor & rajma in pulses and mustard, soybean, groundnut in oil seeds. Cropping pattern also varies with the variations in the climatic conditions and cropping seasons. The influence of the monsoon on the cropping pattern is very dominant; with the result of the total cropped area about 70 to 75 per cent is under '*Kharif*' or rainy season crops. The animate power (animal+ human) is the main farm power source for carrying out different farming operations in mainly hilly region of the state. Out of total working population of the state, about 51.21% population are cultivators and agricultural workers (Table 2). High waste of perishable food and fruit products occur every year due to limited agro-processing industries and difficult transport and

Table 2. Population of agricultural workers in Uttarakhand

Category	Population, lakh	
	Uttarakhand	All India
Total population	100.86	12105.7
Total working population	38.72	4817.4
Total main workers	28.70	3624.4
Total marginal workers	10.01	1192.9
Cultivators (Main+ Marginal)	15.80	1186.9
Male cultivators	7.35	827.0
Female cultivators	8.45	359.9
Agricultural Labourers (Main+ Marginal)	4.03	1443.3
Male Agril. Labourers	2.86	827.4
Female Agril. Labourers	1.16	615.9

marketing system in the state. Timeliness and efficient energy utilization in various farm operations along with other inputs are key factors in improving agricultural productivity. Mechanization enables the farmers to change their cropping pattern and to shift towards more profitable crops as they can efficiently use their inputs and enjoy various advantages of flexibility available with respect to cropping season, resources and marketing. A delay of 15 to 20 days can drastically reduce the crop yield, especially in this state, where weather conditions limit the cropping season. In the era of modernization, farm mechanization has now become the necessity. Repeated ploughing over a long period with the traditional plough/tine cultivator have resulted in the formation of hard compact layers beneath the root zone, which restrict the infiltration of water into the soil and its movement. In the long run, this causes soil erosion as the upper layer of the soil during heavy rainfall. With the use of modern farm equipment, the input use efficiency can be greatly improved and crop cultivation may be converted into more profitable venture.

Figure 2. Map showing Uttarakhand State & its districts

There is a great scope of farm mechanization in the state of Uttarakhand, but small and scattered holdings, high vertical interval between terraces (Figure 3) limit the use of large machinery. However, many agro-horticultural and cash crops like dry fruits, apple and vegetables can encourage the development and utilization of small, handy power equipment in the region. Development and adoption of appropriate engineering based technology in farm power implements, land development and irrigation systems, renewable energy and post harvest sectors will certainly benefit the farming community. This paper describes the present status of farm mechanization, its potential and limitations in the state with special emphasis to hilly region of Uttarakhand.

Present Level of Farm Mechanization

Farm Power, Tools and Implements

The use of improved farm tools and implements is very limited in the hills of the state as compared to other states of India. The traditional tools and implements are still in use with hill farmers **(**Figure 4). They carry out seedbed preparation, sowing, intercultural and harvesting and even threshing/shelling operations by traditional methods, which are more energy and time consuming. The present status of farm implements/machines under use in Uttarakhand is shown in Table 3. It can be clearly understood from the table that the indigenous (wooden) ploughs are being used in the preparation of fields and sowing. Broadcasting is normally adopted for sowing of various crops, which not only consumes more man-power but also affects the crop stand, resulting in poor yield.

Table 3. Number of farm equipment and machines in Uttarakhand

Name of machine/equipment	Number
Wooden plough*	897691
Iron plough*	2500
Tractor/Power tiller	144
Power operated machines	330
Zero till drill	60
Sprinkler sets	43
Water lifting pumps	50
Energised Pump Sets/ Tube Wells	24005
Hand pump	36980

*Estimated & Source: Directorate of Agriculture (2005-06) & Directorate of Economics and Statistics (2012-13), Uttarakhand

The clod breaking is a severe problem in some of the regions particularly in paddy harvested fields, which is usually carried out by women and children with the wooden hammer. This again consumes more energy for non-productive cause. *Kutla* (local name) and *khurpi* are used by majority of the farmers in the state for executing weeding and intercultural operations. For threshing of wheat, paddy, mandua *etc*. traditional practice *i.e.* beating with sticks, pounding under feet or bullock treading are being used by the majority of the farmers (Figure 5). However, in tarai region of the state, mechanical power source and equipment are adopted by some of the medium and large farmers. They also use tractor for different agricultural operations in their fields as well as on custom hiring basis to other farms. A few farmers of the hilly region utilize power tillers for field preparation. Harvesting of crops and fodder is being done by plain sickles because of their lower cost and local availability. However, plucking of fruits and vegetables is still executed manually.

Land Use and Water Management Practices

The state is the birth place of four major river systems like Ganga, Yamuna, Ramganga and Sharda and has a number of perennial streams. Besides its 1,843 mm average rainfall, only 48.11% cropped area is brought under irrigation, while the state has exorbitant potential water for irrigation. The most common method of irrigation is through open gravity channels. The state receives abundant quantity of water through precipitation in the form of rainfall and snowfall, which is many times greater than the water requirement of the state. But a major portion of water flows down to other states. A lot of fertile soil is also carried away by runoff water flowing through the rivers. Despite plenty of water resources in the state, irrigation and domestic water availability is very meagre due to undulating topography, poor management of water resources and un-exploitation of ground water. The land is quite fragile and dissected into hills and valleys through numerous streams/gullies. The land slopes are quite high and soil depth is very low at some places. Conveyance of irrigation water through undulating topography to patchy agricultural fields is a complex problem in the hilly region. Small sized and scattered fields in small land holding category and absence of path between two fields restrict the use of tractors, power tillers and improved machine operated implements. The whole state is under severe soil erosion due to high slopes, deforestation, road construction and traditional cultivation practices. The terraced lands are not properly developed for safe water disposal and irrigation. About 88% area is experiencing soil erosion more than 10 t/ ha/year and 35% area is suffering very severe soil erosion (>40 t/ha/year).

Table 4. Status of renewable energy sources in the state

Sources	Number
SPV street light	6123
Solar home light	58830
Solar village electrification systems	19678
Solar lantern	66964
Dish type solar cooker	2801
Family size biogas plant	2151
Improved watermill (gharat)	1531

Source: Official website of Uttarakhand renewable energy development agency, Department of renewable energy, Govt. of Uttarakhand

Post Harvest Technology

Very high post harvest losses occur in terms of quality and quantity of crops, perishable fruits and vegetables due to lack of sole market, efficient transportation and processing and packaging facilities. Hence, many promising high value crops/vegetables/fruits are not being grown on a commercial scale. Small scale agro industries for value addition and canning are also scanty. The farmers have their own traditional ways of storing and processing the farm produce for their daily consumption. Generally, harvested crops are kept in a heap for long duration to facilitate threshing. Food grains are stored in *Byan* (local name).

Renewable Energy

In spite of providing electricity to almost all the villages by the state government for lighting; fuel wood is also being utilized by the villagers in case of the inadequate supply of electricity and severe cold conditions, particularly in hilly region that resulting in deforestation and degradation of land. Study carried out by Vishwambhar and Song (2012) revealed that fuel wood consumption varies from 13 kg/day/households in the lower elevation (1150 m) to 28 kg/day/household in the higher elevation (1900 m). As a result of special emphasis by the government through several schemes, some of the farmers in the state have adopted renewable energy sources for meeting their domestic energy requirements (Table 4). About 2,151 family bio-gas plants of different sizes have been installed in the state. The solar lantern, solar cooker, domestic and streetlight are also in use. More farmers are coming forward for their adoption due to subsidy offered by the government. Few farmers in hilly regions are using improved water mills for flour and rice milling.

Mechanization Potential

Farm Power, Tools and Implements

There is a need to develop gender friendly small tools and implements for tillage, sowing, intercultural, harvesting and threshing operations, so that the requirement of about 71 % marginal farmers could be met. In tarai, foot hills and valley region, some farmers have tractors/power tillers to execute tillage operations in their own fields as well as on custom hiring basis. In case of high vertical interval between terraces, light weight power tillers (80-100 kg weight) with suitable matching equipment can be a good source of power for doing various agricultural operations & can be lifted with the help of 2-3 men from one terrace to another terrace (Singh and Vatsa 2007). There is a great scope of power tillers (250-400 kg weight) in valley area of hills even using it on custom hiring for income generation. Declining trend has been observed in the use of animal power as their rearing and maintenance for taking only 25 to 30 days field work per year is not as beneficial as maintaining a milk cow. However, it is not possible to fully replace animal power with mechanical power. To maintain an eco-friendly system, there is a need to enhance the use of animal power by development of suitable and efficient matching equipment. The present level of land productivity and area under cultivation can only be increased satisfactorily by adopting efficient farm power and machines. There is a tremendous scope of improved mechanization technology for entrepreneurship development through custom hiring.

Land and Water Management

Bringing additional area under cultivation is the need of the day to feed the increasing population of the state. This can be achieved through reclamation measures and conversion of fallow land with the help of deep tillage, leveling and bunding. Of course, considering the alarming rate of soil erosion from cultivated fields and, in order to maintain eco-friendship, conversion of forest land or well-vegetated pasture land is not advisable. Conversion of non-agricultural or wasteland also opens up scope for increasing cultivable area in the state. These opportunities can only be realized with the help of farm mechanization and efficient land use practices. Adoption of small irrigation schemes and exploitation of rain water may be possible solution of the problem. Practically, about 60-70% of cropped area may be possibly brought under irrigation by virtue of excess rain water harvesting and management techniques. In hilly areas, the possible ways to bring more cropped area under irrigation include rain water harvesting in tanks and its recycling, lifting water from perennial streams and conveying it through pipelines to the nearby fields, diverting perennial flow at a

higher point of the stream and conveying the water through gravity channels to the fields and collection of small subsurface seepage water in tanks and using it for irrigation. However, lift irrigation system is not economically viable in some of the cases, where more pipe length and lift energy per unit area irrigated is required due to deep and distant water source. Further, it is possible to save water through minimization of water losses during conveyance, which can be utilized to expand about 10% of the present irrigated area. Sprinkler and micro-irrigation systems can also be exploited wherever possible, particularly in high value horticultural crops. Soil and water engineering research is prerequisite for adoption of other improved farm inputs in the development of rain-fed watersheds. Inter-disciplinary approaches of agricultural engineers with soil scientist and agronomist in this sector are likely to increase 100 to 150% biomass production in the rain-fed area of the state.

Post Harvest and Agro-Processing

There is tremendous scope of small scale agro processing centers in hills. According to an estimate, about 10 % grain losses in the case of cereals, pulses and oilseeds and up to about 30 % in case of fruits and vegetables occur at the country level every year due to lack of storage and post harvest processing facilities. Therefore, raising agricultural and horticultural production always necessitates improved post harvest processing facilities to reduce post harvest losses, so that the improvement in production can be realized and in turn increase the net return to the growers. Due to lack of nearby markets, storage facilities, very few agro-processing industries and difficult transportation pose constraints to the farmers to get more remunerative prices for their produce. Losses of perishable items are comparatively greater in the state. Plastic storage structures and vacuum storage of foods including controlled atmospheric packaging have vast potential in the state especially for fruit growers. Farmers are deprived of growing various high valued and off-season vegetables due to lack of post harvest technology for value addition and preservation. Similarly, establishing small scale agro processing centers and food industries would also be helpful for the state, which could enhance the farmer's income as well as state's revenue.

Renewable Energy

The State has vast potential for biogas generation as the state has 3.45 million cattle and buffaloes. If 60 % of the cattle @ 6 kg dung/cattle/day is utilized for this purpose, about 2,48,688 family size biogas plants of size 2 cu. meters could be run in the state. Consequently, the biogas generated will serve the needs of more than 1,492,128 persons. This energy production will also save more than 870.40 mt of fuel wood/day and also provide a huge amount of biogas digested manure per day. Thus, biogas itself will be a milestone in self-reliance on energy and save the forest. Development of appropriate designs of biogas plant to suit the hilly conditions and minimization of low temperature problem are of more concern to the agricultural engineers.

Low ambient temperature in the state gives rise to the energy requirement, which is usually met by coal/electricity /firewood or a combination. The state has about 275 days of sunshine. If only 10% of solar radiation (1 kW/m^2 surface) is harnessed in the state at 15% conversion efficiency, 0.01 % surface area of total geographical area has the potential to generate 8.02×10^2 MW energy, which will be sufficient for domestic energy requirement of the farmers in the state. This endless source of energy can be effectively adopted for heating, cooking, lighting, refrigeration, drying of grain and farm produce. The state also has a huge quantity of biomass by-products, which can be utilized for electricity generation by the use of gasifier. Pine forests produces about 20.58 lakhs tones dry biomass (pine needle) annually in the state.

The other source of energy in the state is water flow. The major rivers and their perennial tributaries can effectively be utilized for domestic energy requirements through water mills and small-scale hydroelectric units. At present, traditional water mills are prevailing in the state and needs improvement in design. The constructive efforts are required for harnessing of renewable energy in the state.

Skilled Man-Power

Although state have an agricultural engineering college but to meet the above mentioned challenges and for efficient harnessing of available potential in agriculture, horticulture, power and marketing sectors and to cater the future needs of farm mechanization in hill agriculture of the state, there is need to strengthen state line departments by appointment of agricultural engineers at block level. In addition, to develop skilled manpower, there is need to impart training in farm power, farm machinery, land use and development, irrigation and drainage, water shed management, renewable energy and post harvest technology sectors to the development/extension workers, farmers and entrepreneurs.

Figure 3. Farming scene of Uttarakhand showing terrace size and intervals

Figure 4. Traditional tools used by the hill farmers

Figure 5. Conventional practice used for threshing of crops

Conclusion and Suggestions

The agricultural mechanization in hills of Uttarakhand State is in its very early stage and needs immediate attention of the government and other funding agencies. Some suggestions for enhancing the pace of farm mechanization in the state are given below:

- There is a need to establish National Centre on *Hill Farm Mechanization* for north western and eastern Himalayan states of India.
- Introduction of improved power source and matching equipment as per micro agro-climatic and topographic situation of the region.
- Introduction of gender friendly technology for socio-economic development in the state.
- Development of water harvesting tanks/small ponds for collecting surface/subsurface runoff on community basis for irrigation.
- Introduction of small agro service centres for easy accessibility of inputs including spare parts and repair & maintenance facilities.
- Establishment and encouragement of small-scale machinery manufacturing units at local markets.
- There is need to strengthen the research and development activities in post harvest and agro processing sectors.
- Government should provide necessary facilities and subsidies for establishing small-scale agro-processing centers.
- Extension network should be strong to create awareness among the farmers for improved technologies through Front Line Demonstrations, Kisan mela, Field days, Radio/TV talk *etc.*

References

Anonymous (2011). Directorate of Economics & Statistics, Ministry of Agriculture, Govt. of India.

Anonymous (2014). Agriculture census (2010-11), Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India.

Anonymous (2013). Uttarakhand at a glance (2012-13), Directorate of Economics and Statistics, Govt. of Uttarakhand, Dehradun.

Anonymous (2011). 8th Livestock Census, Department of Animal Husbandry, Dairying & Fisheries, MOA, GOI.

Anonymous (2014). Official website of Uttarakhand renewable energy development agency, Department of renewable energy, Govt. of Uttarakhand.

Singh SP, Verma HN (2001). Scope of farm mechanization in Shivalik hills of India. Agricultural Mechanization in Asia, Africa and Latin America (AMA), Japan. 32(1): 59-64

Singh Sukhbir, Vatsa DK (2007). Development and evaluation of a light weight power tiller operated seed drill for hilly region. Agricultural Mechanization in Asia, Africa and Latin America. 38(3): 45-47

Vishwambhar SP, Song C (2012). Estimation of forest biomass flow in the Montane mainland of the Uttarakhand Himalaya. Int J Forest, Soil and Erosion 2(1): 1-7