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A review paper on development and adoption of small farm mechanization for hilly area

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Abstract
Farm Mechanization has significantly transformed agricultural practices in plains, but its impact remains minimal in hilly regions. In hilly areas, where farmlands are often small and terraced, manual labour and bullock power are prevalent. However, the bullocks here are smaller and less powerful compared to those in plains. The machines designed for plains are unsuitable for the hills due to the unique topography and smaller land sizes. The farmers are still using traditional methods. Considering these points, efforts was made to develop lightweight, simple and compact equipments Plough, Ridger, seed planter, hoe, sprayer matching for the hilly existing farming situations.

Keywords: Farm mechanization, bullock, hilly area, implements

1. Introduction
Farm mechanization contributes positively to agricultural productivity, primarily by ensuring timely field operations and maintaining the quality of work. Energy and timeliness are essential aspects for enhancing productivity and economic viability in agriculture. Advancements in farm equipment technology have reduced the need for both labour and time. Improved hand tools and equipment have the potential to minimize energy consumption and time spent on hill crop production. Hence, the development of enhanced small-scale tools aims to save time and energy while reducing the physical strain on farmers. In the hilly region primary sources of agriculture power are draft animals and human labor. Due to the terrain's undulations and the farmers' low financial standing, the majority of agricultural tasks are carried out by hand using conventional hand tools and equipment. These tools have a low output capacity and a high degree of drudgery in their use. Crop cultivation in the area is done labor-intensively. Excessive labor demand negatively impacts the timeliness of each activity, which lowers agricultural output. A farm's level of mechanization is seen to be a good measure of its overall quality.

In addition to maintaining efficiency and resolving the labor shortage issue during the busiest cropping season, farm mechanization helps minimize human labor. In addition to promoting timeliness in operations and enhancing crop quality, it is a significant way to increase agricultural productivity through the effective use of biological and chemical inputs. Despite the quick speed of technological innovation and modernization, there are still significant mechanization gaps in the area. Because to the state's uneven terrain and small land division, Maharashtra has limited mechanization. With timely operations and precise input application, farm mechanization enhanced productivity. However, not all farmers may use improved agricultural machinery and tools at the same time or at the same rate since they may not have enough knowledge or awareness of them.

2. Status and Strategies
Agricultural mechanization technology is to be considered a vital component of agriculture, as it significantly enhances agricultural output in developing nations. A wide range of tools, implements, machinery, equipment, power, and other mechanical inputs are used; this is referred to as "farm mechanization." The production, productivity, and profitability of agricultural farms, as well as the labor productivity and standard of living of those who work in the field, are all directly and significantly impacted by the proper use of mechanical inputs.

The substantial relationship between farm mechanization and agricultural productivity is supported by research. States that have more access to agricultural energy are more productive than others.

The Status, Challenges, and Strategies for Farm Mechanization in India have been studied by C. R. Mehata. The agricultural sector in India is not growing as quickly as industry and services, which is leading to an increasing economic disparity between rural and urban areas. In emerging nations, increasing agricultural productivity and output is largely dependent on agricultural mechanization. Small and marginal land holdings (less than 2.0 ha) make up 85% of land holdings in India, where the average farm size is 1.16 ha. Farm machinery ownership by individuals is not supported by "economies of scale" when small and non-contiguous farms are mechanized. The development in the rise of mechanically powered agricultural equipment over traditional human and animal power operated equipment analyzes the state of farm mechanization in India. Over the previous 60 years, a clear relationship between productivity and agricultural power availability was observed. By 2020, India's farm production and accessible power are predicted to be 2.3 t/ha and 2.2 kW/ha, respectively. In many regions of the nation, the highly dispersed and fragmented land holdings must be combined in order to profit from agricultural mechanization. A financial aid or obtaining subsidy could be given for acquiring of agricultural machinery and equipment, either as custom hire or private ownership.

3. Farm Mechanization

The development of farm mechanization in hilly regions is a major step toward improving agricultural practices and productivity in difficult terrains. Farm mechanization is the process of doing agricultural work with the help of different tools and equipment in order to reduce labor costs and increase efficiency. Mechanization will be very beneficial in hilly areas where labor-intensive traditional farming practices are used. Farm machinery makes work like seeding, harvesting and plowing tasks easier and faster to complete. This increases output, improves time management, protects soil, and raises standards of safety. Farmers in hilly regions can accomplish sustainable agricultural practices and streamline their operations by implementing suitable agricultural machinery.

Jagvir Dixit worked on the mechanization of maize to increase output and profitability in hill agriculture, A significant part of farm mechanization's contribution to increased agricultural productivity and production is attributed to its timely, high-quality, and precise input application. Even while farm machinery use in Indian agriculture has increased, it is still incredibly insufficiently utilized in hill region agriculture. To close the current mechanization gap for the state of Jammu and Kashmir's mountainous regions, the Division of Agricultural Engineering, SKUAST-K, Srinagar, designed, created, and evaluated a variety of appropriate enhanced tools, implements, and machines. Results for the benefit of farmers and users are supplied along with a package of enhanced agricultural equipment and a machine for mechanizing corn.

Sukhbir Singh conducted research on farm mechanization in Uttarakhand's the hills. The state, which is located in India's North Western Himalayas, comes with naturally existing micro-agroclimatic zones that are ideal for growing a variety of agri-horticultural crops that have massive growth potential. 91% of operational holdings are classified as small and marginal (less than 2 hectares). Despite a number of obstacles, there is a lot of potential to achieve growth in the productivity of labor and land in the hills with proper mechanization.

According to the Sukhbir Singh, the following recommendations for farm mechanization

1. Introducing and developing better power sources and related equipment in accordance with the topography of the area.
2. A development of better equipment drawn by animals to increase the use of animals in various hill operations.
3. The use of gender-friendly technologies to advance the state's socioeconomic development.
4. The establishment of small-scale machine manufacturing facilities in nearby marketplaces.

Aditi Raina studied on the Extent and Impact of Farm Mechanisation in Hilly State of Himachal Pradesh. Farm mechanization has been identified as one of the critical inputs for increasing the productivity of land by ensuring timeliness of agricultural operations, increased labour work output per unit time by reducing efforts, drudgery and improved quality of farm operations. The study was conducted in Kangra district of Himachal Pradesh. Primary data were collected from 80 farmers. The net savings in case of land preparation operations through mechanization were estimated at Rs. 4454, 2330 and 658/ha, in case of wheat, maize and paddy respectively. Similarly, through the mechanization of sowing operation, the net gain was highest in wheat followed by maize and paddy i.e. Rs. 3910, 2347 and 2551/ha and 2551/ha. Through the adoption of various farm mechanization practices on sample farms, they were able to save 56 to 67 man days of human labour and 23 to 35 bullock days/ha in major crops. The total added expenses on account Per hectare net savings through mechanization was to the tune of Rs. 8531, 15152 and 5685/ha in case of maize paddy and wheat, respectively.

S. Singh conducted research on the state and potential of farm mechanization in Uttarakhand, an Indian state in the western Himalayas. In terms of mechanical power and effective tools, the state's level of agriculture mechanization is quite low. Some of the primary causes of the low level of mechanization in the state's hilly regions include the undulating topography, small and irregularly sized fields, a lack of skilled labor, inadequate facilities for repair and maintenance, the low purchasing power of farmers, and the absence of improved farm equipment and implements. Strengthening the agricultural engineering wing in Uttarakhand's hills is necessary to address the issues with farm mechanization and would require the immediate attention of the state government and other financial agencies.

Compared to other states, the highlands of Uttarakhand state use comparatively little modern agricultural equipment. Hill farmers continue to work with the ancient equipment and implements. They use more energy- and time-consuming conventional methods for seedbed preparation, planting, intercultural and harvesting, and even threshing/shelling. The table makes it quite evident that the fields are being prepared for sowing using the native ploughs. Broadcasting is typically used for agricultural sowing, which not only uses extra labor but also has an impact on the crop stand, leading to a low yield.

4. Farm Power, Tools and Implements: The improved hand tools and equipment aim to accomplish the following goals:

1. Cut down on tedious work and improve input utilization effectiveness.
2. Timeliness in operations and reduced turn around times for future crops.
3. Improve the man-machine system's productivity and practice energy conservation.
4. Enhance both the level of the work and the produce.

Improved machinery and hand tools have been introduced by K. P. Singh and C. B. Khoragade to mechanize farming in the hilly regions of the Indian Himalayas. Topography, technology infrastructure, financing, and policy concerns are the main obstacles in the Indian Himalayas. For timely field activities, farm machinery and power are vital components of agriculture. For several agricultural operations to save time and energy, hill agriculture must be mechanized appropriately. Designing better farm equipment and tools helped lessen the hard work that women farmers did on the land and increased the efficiency of both human and animal energy.

It is necessary to provide inclusive small tools and equipment for intercultural, threshing, tillage, planting, harvesting, and harvesting in order to meet the needs of marginal farmers.

Srigiri D. (2016) [7] developed a manually operated single-row multicrop planter. The most important step in crop production is planting. It is crucial to sow at various depths and times as this will impact the crop's output. A late-season seeding will result in a about 35% reduction in yield. Mechanization is not feasible in India due to farmers' small land holdings. The amount of area that can be planted is limited by the manual method of seed planting, which has poor seed placement, inefficient spacing, and causes severe back pain for the farmer. The fundamental specifications for small-scale cropping machinery are that they should be easy to use on various farms, have simple design and technology, and be appropriate for small farm operations.

Sanjay Kumar Nirala studied the performance of a bullock drawn multi crop inclined plate planter. CLAE Bhopal developed a three-row bullock used multi-crop inclined plate planter for sowing various crops. The seed and fertilizer rate were calibrated in the laboratory of C.A.E. RAU Pusa Samastipur. The maize crop seed rate was determined to be 20.60 kg/ha, and fertilizer rates ranged from 9.3 kg/ha to 124.3 kg/ha. The wheel skid was within acceptable limits, measuring 4.53%. Field efficiency was 51.1% and field capacity was 0.23 ha/hr. The plant population was found to be between 10- 12 plants per square meter. Sowing per acre was 3.5 times less expensive than the traditional way.

Dinesh Kumar (2014) [9] conducted the performance evaluation of a manually operated single row cotton planter. The cotton planter performed a field evaluation in which the planter's speed was 1.62 km/h, the actual operating time was 4.53 minutes to cover an area of 0.01 ha with an actual field capacity of 0.132 ha/hr, and the field efficiency was 79.52%. When compared to traditional hand dibbling, planter causes 1.236% greater damage to cotton seed. The average time required by a manually operated cotton planter was 7.57 hr/ha, whereas hand sowing was approximately 11.12 hr/ha. In a manual cotton planter, the average seed rate was 3.031 kg/ha. The cost of manually planting cotton is roughly 209 Rs/ha, however this machine costs 168 Rest/ha.

Singh S. and D.C Sahoo worked on the development and performance evaluation of a manual/bullock-operated multicrop planter for the hilly region. Sowing of agricultural crops in hills is often done manually by broadcasting seeds, which not only consumes more seed but also causes uneven distribution of seed at incorrect depth and moisture, poor germination, sickly plants, and ultimately reduced yield. To address these issues, a single row manual/bullock multicrop planter for hilly small fields was designed and constructed for line sowing of wheat, maize, soybean, lentil, pea, mustard, millet, and other crops. The machine contains a nylon-made cell type seed metering mechanism with four various sizes of cells on a roller, as well as a fluted roller for fertilizer metering.

The basic design considerations in the development of the multicrop planter were (singh s. and D.C. Sahoo)

1. It should be operated manually by two or three people or a pair of bullocks.
2. It should be lightweight enough to be readily transferred from one terrace to another by a single person.
3. The machine should be affordable, that is, within the purchasing power of small and marginal farmers.
4. It should be able to seed the principal crops of the hills, such as wheat, maize, soybeans, millet, pea, lentils, paddy, and so on.
5. It should be able to work in ploughed and unploughed conditions (No-till), meter seed and fertilizer at the needed seed rate.
6. It must be simple to operate and maintain.
7. It should be simple to manufacture by local manufacturers.

S.P. Singh and D.K. Vatsa designed and developed powered one-way plough. By constructing the power transmission system, a powered one-way plough was created. The power transmission unit was designed based on the number of discs, the space between two consecutive discs, the tractor's forward speed, and the operational depth. The plough was driven at forward speeds of 2.77, 4.31, 5.14, and 6.88 km/h, with PDV/GS ratios of 2.62, 1.90, 1.77, and 1.42, respectively.

P.A. Munde and S.N.Solanki designed and developed bullock operated twin ferti hoe in department of farm machinery and Power, College of Agricultural Engineering and Technology, VNMKV Parbhani. The machine designed is a two-row blade weeder with a fertilizer drilling attachment. The Twin Ferti hoe, which is used to remove weeds from crops and apply fertilizer, is made up of the following components or systems. Frame, fertilizer box, fertilizer metering system, shovel tines, beam, and hitch. The depth attained for the weeder field test was 55-68 mm, with a weeding efficacy of 80-83%. The advantages of the created Twin Ferti Hoe over the traditional method identified are labor savings, fertilizer placement according to recommendations, increased fertilizer usage efficiency, and lower operating costs than the previous approach.

The agricultural multipurpose solar powered sprayer was designed by S. Raju. A semi-automatic solar powered agricultural sprayer was built in this project to replace the conventional agricultural sprayer. The main goal of this project is to convert a traditional agricultural sprayer into a semi-automatic one by adding an electric motor and a wheel assembly. The labor skills required are determined by the intricacy of the equipment and machinery used. To address these issues, one of the better variants of the petrol engine pesticide sprayer pump is the introduction of a solar-powered pesticide sprayer pump. It is widely utilized in agriculture and for a variety of other uses. This has more advantages than a petrol engine sprayer pump. The motor is powered by solar energy. As a result, it is a cleaner pump than a petrol engine sprayer pump. 1737.79 Rs/ha.

Manish Kumar studied the performance of a developed animal-drawn single row maize ridger. The field capacity (0.059 ha/h), field efficiency (74.74%) with less plant damage (2.92%) and highest weeding efficiency (46.18%), and ridge dimensions (43.75cm, 12.75cm, 16cm). The designed maize ridger had an average draft of roughly 69.81kg-f and a power demand of 0.491 hp. The average speed of the ridging process was 1.74 km/h. Maize ridger performance versus Ridger plough, Tendua plough, and MB plough. The improved maize ridger has the highest effective field capacity (0.0548 ha/h), followed by Tendua plough (0.0395 ha/h), ridger plough (0.0360 ha/h), and MB plough (0.0158 ha/h).The ridger plough handled the most soil (492.38 cm3), followed by the developed maize ridger (452.31 cm3), the MB plough (305.38 cm3), and the Tendua plough (148.36 cm3). The developed maize ridger had the lowest total cost of operation (1737.79 Rs/ha), followed by Tendua plough (2652.82 Rs/ha), Ridger plough (3000.00 Rs/ha), and MB plough (6440.00 Rs/ha).

Animal Drawn Maize Ridger was developed and tested for performance. After rice and wheat, maize is the third most significant cereal in the world, and it is vital to the Indian economy. Ridging of maize crop 30 DAS is a very significant activity, and maize ridging is traditionally done manually, which requires more labor than other operations, resulting in greater cultivation costs and more hardship. The crop, machine, and operating parameters were discovered and chosen, and the animal drawn maize ridger was constructed and tested in the field. Top, bottom, and ridge height (9.14cm, 16.72cm, 43.5cm) were optimized, resulting in a total volume of soil cover of 425.37cm3 when plant height and row to row spacing were considered. The ridger average draft during the ridging operation was 69.81 kg-f. The maize ridger has a field capacity of 0.06ha/h and a field efficiency of 74.46 percent. The cost of running a maize ridger for ridging maize was discovered.

5. Conclusion

Hill agriculture mechanization is still an innovative concept that is gaining the attention of many academics in this subject. These machines should be designed so that they can be physically lifted and carried up or down a slope by one or two people. It must be able to work on narrow terraces where larger machinery cannot reach and perform the operation. Hill agriculture mechanization is essential for improving the efficiency of numerous processes. The efficiency of human and animal energy has been enhanced by developing better farm tools and machines, which may help in decreasing the drudgery of farmers. Farm mechanization will be crucial in making hill agriculture competitive and successful. In comparison to traditional equipment, hill farmers may find it more beneficial to use updated tools because they can lessen the amount of labor-intensive work involved.

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