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An overview of agricultural mechanization in Nepal

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Abstract

Increased migration of the youth from Nepal has created a demand for mechanization in Nepalese agriculture. The systematic agricultural mechanization can lead towards the sustainable agricultural commercialization for a prosperous Nepal. This paper analyzes the efforts, status, and policies related to agricultural mechanization and recommends policy reforms to align with the new constitution of the Federal Republic of Nepal, institutional capacity building, business development, favoring local production of agricultural machinery, promotion of custom hiring in business model, capacity development, promotion of women-friendly technologies, equitable agricultural mechanization program, and an integrated effort for sustainable agricultural mechanization through a public-private partnership model.

Keywords: Agricultural mechanization; Policy; Spread; Commercialization capacity development

1. Background

Agriculture is the backbone of the Nepalese economy due to its contribution to National Gross Domestic Product (GDP) by one-quarter and to employment by two-thirds [5]. Nepalese agriculture is dominated by smallholders' subsistence agriculture. Due to the open border with India, the migration of youth in the lean agricultural season in search of a job is a common phenomenon in the hills and mountains of Karnali and Far Western provinces. The migration of youth to foreign countries other than India sharply increased during the last two decades. The rural unemployment and unattractive traditional subsistence agriculture practice of Nepal along with the globalization and development of information and communication technology (ICT) are recognized as the major factor behind the increased foreign migration. It is reported that the Department of Foreign Employment (DOFE) has issued over 4 million labor approvals to Nepalese workers in the last decade since 2008/09 for foreign employment [6]. The majority of these workers are male youth from rural areas resulting in the labor shortage in peak agricultural season and increased work burden on women farmers [13]. The lack of agricultural labor and their increased daily wage has resulted in the demand for agricultural mechanization in Nepal. Hence, the migration of youth can be regarded as a major driver for the increasing demand for agricultural mechanization. In addition, due to the expansion of transportation and communication networks in the country and the remittance money flow, small-town market centers have formed throughout the country, creating a conducive environment for commercial agriculture. Moreover, the foreign returnee youths have started investing in commercial agriculture and created a demand for appropriate mechanization technologies. In this context, this paper reviews and analyzes the mechanization efforts, status, policy programs, and future directions.

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2. Efforts on promotion of agricultural mechanization in Nepal

The timeline of institutional efforts related to agricultural mechanization promotion is presented in Table 1. The foundation of agricultural mechanization was laid by the first agricultural engineer of Nepal, Huta Ram Baidhya, who was instrumental in establishing the Agricultural Engineering Unit at Singhadurbar, where he started modern carpentry and metal workshop [7]. On that foundation, the second agricultural engineer, Mr. Siddi Nath Regmi made a strong contribution to agricultural mechanization by establishing Agricultural Implement Research Unit at Ranighat, Birgunj where he started tests and promotion of animal-drawn metal plough and other modern tools and machinery in the Terai region of Nepal. With the support from the Union of Soviet Socialist Republics (USSR), Agricultural Tools Factory (ATF) was established in 1964 and made a significant contribution to the agricultural mechanization of Nepal by the production and supply of modern agricultural tools and machinery, viz., metal animal-drawn mould-board plough, disk harrow, thresher, pump set, tractor-trailer, wheelbarrow, hand hoes, etc. At that time the Agricultural Implement research unit at Ranighat served as a research wing of ATF. Mr. Siddi Nath Regmi also served as the General Manager of ATF for two terms and contributed to agricultural mechanization through the production and supply of modern agricultural tools and machinery to Nepalese farmers. During his tenure as the General Manager, the ATF was running in profit and provided a bonus to their employees and he was also awarded by the Management Association of Nepal (MAN) as the best manager (personal communication of author with Mr. Regmi).

Japan government-supported project "Janakpur Agriculture Development Project (JADP) was started in 1971 and under this project the shallow tube well, deep tube well, power tiller, and threshers were promoted in the Terai region of Nepal. Similarly, after the establishment of the Agriculture Development Bank (ADBN), more fund was made available for agricultural credit (including agricultural mechanization technologies, viz., tractor and

Table 1: Institutional development related to agricultural mechanization in Nepal.

Year	Institutional development
1953	Establishment of Agricultural Engineering Unit at Singhdurwar, Kathmandu
1959	Establishment of Agricultural Implement Research Unit, Ranighat, Birgunj
1964	Establishment of Agricultural Tools Factory (ATF), Birgunj
1968	Establishment of Agricultural Development Bank (ADBN)
1971	Janakpur Agriculture Development Project (JADP), Janakpur
1990	Nepalese Society of Agricultural Engineers (NSAE)
1991	Establishment of Nepal Agricultural Research Council (NARC) and Agricultural Engineering Division (AED) made responsible for Agricultural Mechanization Research
1996	Privatization of Agricultural Tools Factory and its research unit Agricultural Implement Research Centre (AIRC), Ranighat handover to NARC.
2000	Agricultural Engineering Bachelor Program Started at Institute of Engineering Purbanchal Campus, Dharan.
2004	Directorate of Agricultural Engineering (DoAE), Hariharbhawan established in Department of Agriculture (DOA)
2015	National Agricultural Entrepreneurs Association (NAMEA)
2016	Prime Minister Agricultural Modernization Project(PMAMP) started
2018	DoAE combined with Agribusiness Promotion and Market Development Directorate and formed Centre for infrastructure Development and Mechanization Promotion, Hariharbhawan under DOA.
2018	Agricultural Mechanization Promotion Centre at Naktajhij, Dhunsha majorly to implement Agricultural Mechanization program/training implementation including Irrigation development works of than JADP.
2018	Establishment of Agricultural Machinery Testing and Research Centre, Nawalpur under NARC
2020	AED is renamed as National Agricultural Engineering Research Centre (NAERC) under NARC.

power tiller, shallow tube well, deep tube well, etc.) due to several Agricultural Credit Projects funded by Asian Development Bank since 1970. Along with the provision of credit facilities on agricultural mechanization and irrigation technologies, ADBN also played a vital role in the promotion of appropriate rural technologies, viz., rower pumps, treadle pumps, sprinkler irrigation, greenhouse, biogas, mills, micro-hydro plants, etc. through its Appropriate Technology Units (ATUs) established in the different regions of Nepal [1]. In 1990, the Nepalese Society of Agricultural Engineers (NSAE) was established to create a network and professional development of agricultural engineers in Nepal. After its establishment, it has also organized several workshops and exhibitions on agricultural mechanization in Nepal.

The establishment of the Nepal Agricultural Research Council (NARC) in 1991 has provided a clear role of agricultural mechanization research to Agricultural Engineering Division (AED), Khumaltar. After several field testing of imported agricultural machinery, AED started the promotion of power tillers and their attachments, viz., seed drill, reaper, rice transplanter, zero till drill, mini-tiller, laser land leveler, etc. Similarly, to address the need of farmers, AED also developed several prototypes of appropriate agricultural machinery and commercialized them through private workshops, viz., tubular maize sheller, coffee pulper, millet thresher, Jab seeder, dryland weeder, rice husk stove, seed cleaner, improved plough, ginger washer, Urea Molasses Block Press, monkey repeller, etc. In addition, it is also involved in training the youth farmers on the operation and maintenance of modern agricultural mechanization technologies (NAERC, 2020). After the privatization of ATF, its research unit has also come under NARC as Agriculture Implement Research Centre (AIRC), Ranighat. AIRC has made a strong contribution to field testing and the promotion of crop establishment technologies used in rice and wheat cultivation. Similarly, after several field research, it is promoting the mechanization technologies in maize, potato, and sugarcane cultivation in the Terai region of Nepal. To ensure the utilization of quality machinery, Agricultural Machinery Testing and Research Centre (AMTRC) was established as a new center of NARC at Nawalpur Sarlahi in 2018. Recently, AED has been renamed as National Agricultural Engineering Research Centre (NAERC) under NARC [7].

The agricultural engineering bachelor program was established at the Institute of Engineering Purbanchal Campus, Dharan in 2000. Initially, 24 agricultural engineers graduated each year and now it has increased to 48. The extension of agricultural mechanization technologies was formally initiated by the Department of Agriculture only in 2004 after the establishment of the Directorate of Agricultural Engineering (DoAE), Hariharbhawan. DOAE initiated the promotion of agricultural mechanization technologies through demonstration, and training on the agricultural mechanization technologies in collaboration with AED. In addition, it has initiated the subsidy program on agricultural machinery, and started community post-harvest centers, and agricultural machinery custom hiring centers. Organizing the first agricultural mechanization exhibition (AGRIMECH) at Narayanghat by DoAE in collaboration with AED, NARC and Agro Enterprise Centre (AEC), Federation of Nepalese Chambers of Commerce and Industries (FNCCI) in 2014 was a milestone of the agricultural mechanization promotion in Nepal for bringing all the agricultural mechanization related stakeholders in a single platform. Due to the first AGRIMECH, the agricultural machinery-related private sectors (agricultural machinery importers, traders, and producers) organized themselves to establish National Agricultural Entrepreneurs Association (NAMEA) in 2015. Agricultural mechanization promotion policy -2014 and Agricultural development strategy (ADS) -2015 have created a clear roadmap for agricultural mechanization in Nepal. After the promulgation of the constitution of Nepal, agriculture development has become the responsibility of three tiers of government, viz., federal, provincial and local government. The Nepal government took a lead role in agricultural mechanization promotion through Prime Minister Agricultural Modernization Project (PMAMP) and Centre for Agricultural Infrastructure Development and Mechanization Promotion (CAIDMP), Agricultural Mechanization promotion center (AMPC), at the federal government level, agriculture development directorates at 7 provincial government levels and agriculture development sections at 753 local government levels.

CGIAR (The Consortium of International Agricultural Research Centers) centers like International Maize and Wheat Improvement Centre (CIMMYT) and International Rice Research Institute (IRRI) played important roles in the agricultural development of Nepal by strengthening the national research and extension system. However, mechanization-related research and development projects like the Cereal System Initiative in South Asia (CSISA) are implemented by CIMMYT and IRRI with limited collaboration with the national research and extension system. For the sustainability and long-term impact of those research and development projects, the CGIAR centers should support the national research and develop-

ment systems to take lead in launching similar projects.

The private sectors, viz., importers, traders, and service providers played an important role in agricultural mechanization in Nepal. The agricultural machinery traders are involved in the demonstration of modern agricultural machinery and training the operators. Some private sectors like Buddha Air have come forward in the promotion of agricultural mechanization in Sunsari and Morang through custom hiring of agricultural machinery as their social responsibility.

The investment in agricultural mechanization has increased multifold compared to that of 10-15 years before but the human resource (especially the engineers and mechanics) in the government and private sector has not increased. Because of the lack of appropriate human resources, the extension and research system has become weak. Hence the agricultural mechanization-related extension systems at the local, provincial, and even federal governments are focused on the distribution of agricultural machinery instead of the sustainable transfer of agricultural mechanization technologies. In addition, the role and responsibility of 3 tires of governments related to agricultural mechanization should be well defined to avoid duplication. It is also realized that there is a lack of middle-level technicians (mechanics and agricultural machinery operators) in the rural area for the efficient and sustainable utilization of agricultural mechanization technologies. CTEVT should come forward to fill this human resource gap. Similarly, the research and testing should be strengthened to promote research-led efficient technology and management practice related to agricultural mechanization.

3. Agricultural mechanization in Nepal

The timeline for the spread of various crop-related agricultural mechanization technologies in Nepal is presented in Fig. 1.

Metallic Plough: In the early sixties, the source of farm power was mainly animal power, and wooden animal-drawn ploughs were used to plough the land. In the sixties, the metal animal-drawn mould board plough was promoted in Nepal and it is found to be adopted in the Terai region of Nepal. Similarly, the animal-drawn disc harrow was also found to be adopted in the Terai area of Nepal. Most of the hilly areas of Nepal did not adopt the mould board plough because it moves the soil to one side and is not appropriate for ploughing small and irregular terraces and sloppy land.

Tractor: The four-wheel tractor was introduced in the Terai region in the mid-sixties and it was promoted by ADBN after the 1970s by providing credit in Terai. The trend of the cumulative number of tractors registered in Nepal is presented in Fig. 2. In total, 150,000 tractors are registered in Nepal. The figure shows that the rate of import/registration of tractors increased significantly after 2008 indicating an increased level of mechanization. The increased registration of tractors after 2008 may be due to the end of the Maoist insurgency in 2006. Most of those tractors are used for transportation purposes in the hills, mountains, and Terai. It is estimated that about one-third of those tractors are used for agricultural purposes in Terai. Tillage operation in Terai is mostly mechanized by using four-wheel tractors with tillage attachments like cultivators, disc harrows, rotovators, levelers, etc. [11]. Laser leveler was also introduced by NARC and a private custom hiring service provider (Mr. Abhaya Yadav) from Bara district operator is providing laser leveling service for the last 10 years.

Power tiller: The Japanese Kubota Power tiller was introduced in the mid-seventies. It could not expand due to high initial cost and lack of a proper supply chain. In the eighties, the agricultural development bank promoted the two-wheel tractors (Japanese and Korean) imported by the private sector and Chinese ones by National Trading Limited. By the early nineties, it is estimated that there were about 2000 power tillers in Nepal [3]. The two-wheel tractor was getting popular for tillage in Bhaktapur, Nala, Panchkhal valley, and the Terai region of Nepal. After the end of insurgency in 2006, there was a jump in the sale of two-wheel tractors from 500 to 1200 units per year in 2009. The sale of two-wheel tractors peaked in 2015 (7000 units per year) and stabilized at 2000-3000 units in recent years (Fig. 3). The jump in the sale of power tillers was due to the emerging private sector in import and sales of Chinese power tiller in Nepal and the government subsidy after the agricultural mechanization promotion policy 2014.

Mini-tillers: Mini-tillers made in China were introduced in Nepal after 2000. Due to a lack of labor and difficulty to maintain bullocks, farmers in the hills preferred to adopt it for tillage. In 2070/71 BS (2013/14 AD) only 500 mini-tillers were imported whereas last year (2019/20 AD) more than 11500 were imported into Nepal. Increased adoption of mini-tiller may be due to the subsidy provided by local, provincial, and even federal governments. It is estimated that more than 50000 mini-tillers were sold in the hills. But due to a lack of operation and maintenance skills and spare parts in the hilly areas of Nepal, majority of them are not found to be properly utilized (based on the author's field observations and interaction with the farmers of several hill districts). It is also observed that the mini tiller with the same engine model is reported with different horsepower in their specifications. In addition, the operators raised the issues of the vibration of the mini-tiller, resulting in difficulty during its operation, which indicates the need for testing and certification of those minitiller. As most of the minitillers are used mainly for tillage operation only, it indicates the need for multiple uses in different agricultural operations to increase the annual operating hours.

Gravity Ropeway: Even though Nepal has a long history of ropeways in Nepal, the innovations in Bhattedanda, Lalitpur in the transportation of milk to nearby road head in 1990 by using gravity ropeway opened the scope of its utilization in the transportation of agricultural products in the hilly areas of Nepal [14]. Gravity ropeway is replicated in various locations in the hilly areas of Nepal for the transportation of agricultural produce to the market. For example, the Practical Action installed 15 gravity ropeways in Achham, Tanahun, Gorkha, and Kalikot to transport agricultural produces (mainly fresh vegetables) from the hilly areas to nearby highway downhill, which reduced the transportation cost from 50 percent to 70 percent [8].

Crop Establishment Equipment: Various crop establishment equipment was introduced by NARC, viz., 4-wheel tractor attached with zero till drill, precision maize planter, sugarcane planter, potato planter, etc.; two-wheel power tiller drawn with minimum-till-drill and self-propelled rice transplanters. These crop establishment equipment were adopted by the farmers in various districts like Rupandehi, Nawalparahsi, Bara, Parsa, Morang, and Sunsari and their adoption is slowly spreading around. The slow spreading of these crop establishment technologies is due to the lack of proper extension services to demonstrate and convince the farmers and service providers of these crop establishment equipment.

Irrigation Equipment: Centrifugal pumps run by single cylinder diesel engines (India-made) were introduced in the mid-sixties in the Terai region of Nepal. JADP promoted shallow and deep tube wells with Japanese pump sets in Dhanusha and Mahattari in 2071. After the mid-seventies, ADBN provided loans and subsidies on shallow and deep tube well in Terai and it got popular throughout Terai. In the mid-nineties government withdrew subsidies on these shallow tubewell and diesel pumps and the spread of their use became slow. ADBN also introduced low-cost treadle pump and rower pump technology for small farmers in the Terai region. After 2000, the introduction of small horsepower pumps

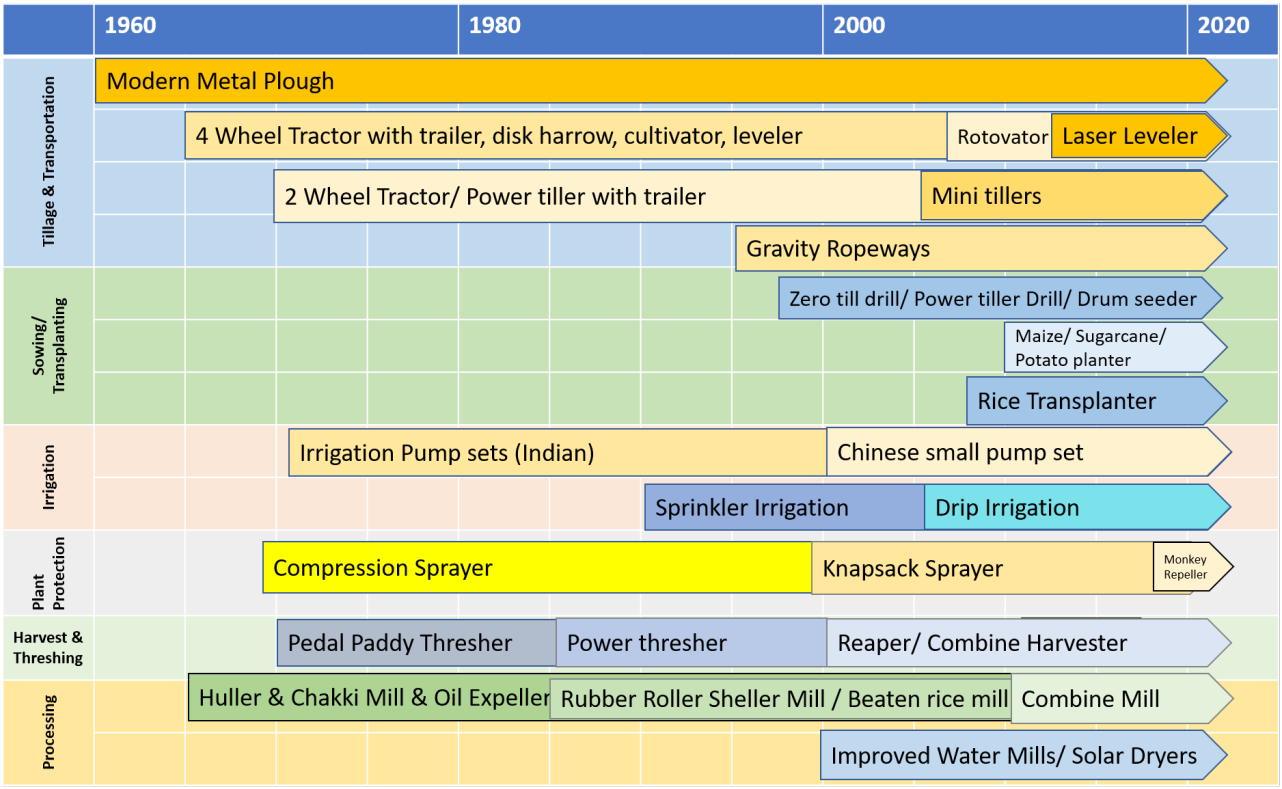

Figure 1: Spread of various crop-related agricultural mechanization technologies in Nepal.

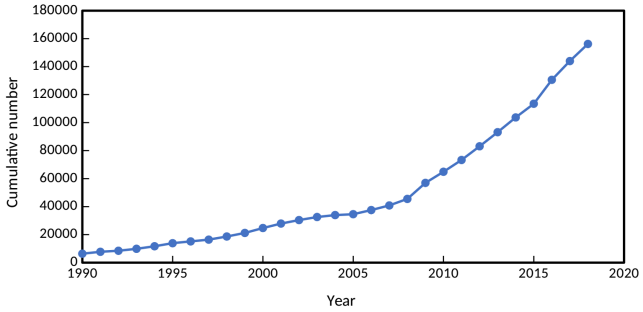

Figure 2: Cumulative number of tractors registered in Nepal (Source: Dept. of Transport Management).

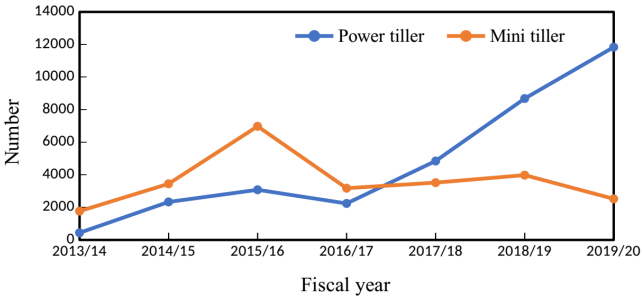

Figure 3: Annual import of power tiller and mini-tiller (Source: Department of Customs).

(run by diesel as well as petrol engines) was liked by the farmers. Due to the provision of government subsidy on solar lift irrigation, it is spreading in both Terai and hill areas in recent years. Even though sprinkler irrigation and drip irrigation was introduced in Nepal in the mid-eighties by ATU, they could not spread till the late nineties. In the late nineties, International Development Enterprise (IDE) introduced a low-cost simple drip irrigation system for small farmers. At present drip and sprinkler technology is also adopted by the farmers cultivating horticultural crops, and high-value vegetables at the commercial scale.

Plant Protection Equipment: The history of insecticide application in Nepal started with the import of pesticides to control Malaria in 1952 [10]. Along with the increased cultivation of vegetables, potatoes, and fruits, plant protection chemical application has also increased. Initially, the brass cylinder compression-type sprayer used to be popular. After 2000, the Chinese knapsack sprayers (9 to 16 liters) were popular among the farmers. Farmers are not found to be aware of the safety protocol for the application of plant protection chemicals. Similarly, the farmers need to be trained on the calibration of sprayers, the use of specific nozzles, and the quality of the sprayers. At present, monkey menace is the major problem of the farmers in the mid-hills for which NAERC developed a monkey-repelling gun, and it is getting popular among the farmers.

Harvesting and Threshing Equipment: The sickle is an important traditional harvesting equipment used throughout the country. The farmers in Terai are also using a serrated sickle to harvest rice and wheat. In the late nineties, the reapers and combine harvesters were introduced in Terai and it is getting popular across Terai. Fig. 4 indicates the growing popularity of combine harvesters in Terai due to the significant reduction in the cost of harvesting and threshing (around 50%) of rice and wheat [12]. Pedal-operated rice thresher was introduced to address the difficulty in manual threshing of modern varieties in the early days and at present, it is commonly used in accessible hilly areas of Nepal.

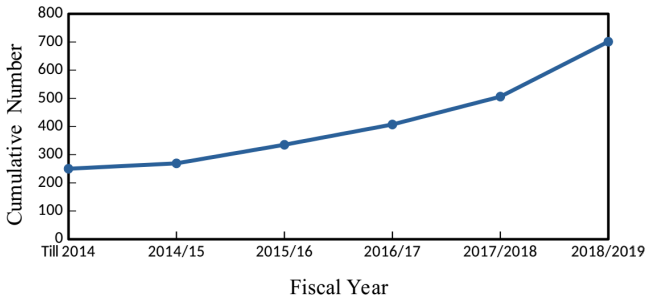

Figure 4: Cumulative number of combine harvesters in Nepal [12].

In Terai, the power wheat thresher brought from India and that developed by ATF were introduced in the late eighties. However, the threshing of rice by animal and tractor treading was common till the mid-nineties in Terai. After 2000, tractor PTO-driven rice and wheat threshers (India-made) became popular in Terai. Hand-cranking winnowing fans are also popular in the Terai region of Nepal. In the mid-nineties, AEDNARC used to promote the tubular corn sheller for the small farmers in the hills. However, small electric Chinese corn sheller is getting popular in the hills. Similarly, AEDNARC developed millet threshers, which are popular in the hills.

Processing Equipment: Traditional water mill (Ghattas) and manual processing devices like foot pounder (dhiki), quern (janto), pounder (okhal), screw oil press (saa), and oil crushing device (kol) are our traditional crop processing technologies. Indian rice huller and grinder (chakki) were the modern crop processing technologies introduced in the mid to late sixties in Nepal. The introduction of the Chinese rubber roller sheller mill enhanced the processing efficiency of rice milling in the early eighties in Nepal. Similarly, the improved water mills for multipurpose applications, viz., hulling, oil expelling, and development of micro hydro plants in the hilly areas, facilitated the establishment of grain processing mills. Except in the remote hilly areas, the crop processing operation is found to be mechanized throughout the country. It is reported that there are more than 27500 small/medium mills, and more than 25 modern rice mills provide crop processing facilities to the farmers [9]. Other processing equipment like coffee pulper and solar tunnel dryers were also developed and promoted by AED, NARC.

Agricultural mechanization technologies for livestock and fisheries: Chaff cutter (large flywheel type, India-made) is a commonly used machine in the Terai region. At present, China-made electric-operated chaff cutter (comparatively safe) is getting popular in the hills as well in Terai. A locally made poultry feathering machine is also popular in Nepal. Milking machines, fish pond aerators, UMB making press, etc. are a few agricultural mechanization technologies related to livestock and fish farming introduced in Nepal. The slow introduction of mechanization technologies related to livestock and fisheries in Nepal may be due to limited research and development in this area.

4. Agricultural mechanization-related policies in Nepal

Before the promulgation of the agricultural mechanization promotion policy 2014, all the policy and plan documents, viz., Agricultural Policy 2004, Agriculture Perspective Plan (APP) 1995-2015, periodic plans (5/3 yearly plans), and annual budget programs were silent on agricultural mechanization. However, the next few policy provisions played a positive role in the promotion of agricultural mechanization in those periods:

- Import tax on farm machinery was reduced to 1% in 1970
- Tractors were exempted from all taxes including wealth tax in 1990
- Tractors used in agriculture and farm machinery exempted from Value Added Tax (VAT) since 1996
- The electricity tariff used for the irrigation pump was subsidized
- Subsidy on import duty of agricultural machinery and cold store used in agri-business in Agribusiness Promotion Policy 2006

The real grass-root level demand for agricultural mechanization increased due to youth labor migration from the rural area. To address this demand, Agricultural Mechanization Promotion Policy was announced in 2014, which has drawn a clear road map for agricultural mechanization in Nepal. This policy addressed the issues of smallholder farmers and gender equality [2]. This policy has the following four major objectives.

- To make the agricultural business sustainable, competitive, and commercial by enhancing productivity through suitable agricultural mechanization for geographical and socioeconomic conditions.
- To enhance the access of farmers/ entrepreneurs to agricultural machinery and equipment through business development of agricultural mechanization service
- To promote women-friendly agricultural machines and equipment
- Institutional development of agricultural mechanization-related institutions for the standardization, regulation, research, monitoring, and promotion of quality agricultural machines and equipment.

In 2015, the new constitution of the Federal Republic of Nepal was promulgated, in which every citizen's right to food sovereignty was established. The new constitution has outlined the concurrent power of 3 tiers of government (federal, provincial and local government) in agriculture development. As the constitution is the supreme law of the nation and the agricultural mechanization promotion policy was implemented before the promulgation of the constitution of Nepal, it is needed to be revised to streamline with the new constitution. Especially, the role of the three tiers of government in agricultural mechanization is to be demarcated.

Similarly, the Agricultural Development Strategy (ADS) 2015 has also considered mechanization as an important input for enhancing agricultural production and productivity [4]. ADS envisaged the increased accessibility of the mechanization options through information dissemination, improve customer access to finance, capacity building of service providers, business development of custom hiring, revise regulation and tax support, pilot voucher, and establishment of agricultural mechanization centers in 3 geographic regions of Nepal. These policies and strategies are to be brought into practice for the mechanization and modernization of the Nepalese agriculture.

Agricultural mechanization depends upon multi-sectoral policies, viz., land policy, industrial policy, commerce policy, labor policy, energy policy, environment policy, rural credit policy, etc. For example, the ceiling in land ownership and lack of scientific land use policy are considered as a barrier to the mechanization and commercialization of Nepalese agriculture. Similarly, high import duty on raw materials along with VAT and low import duty on agricultural machinery along with VAT exemption hindered the growth of the local agricultural machinery industry. Fixing an attractive minimum wage rate for agricultural labor can create a favorable environment for agricultural mechanization. Likewise, other policies such as energy policy, environmental policy, and rural credit policy, also directly affect the agricultural mechanization.

Agricultural mechanization policy is envisaged to be dynamic and multisectoral to cater to the changing needs of the farmers. In this context, directive committee and technical committee are clearly defined in the agri-mechanization promotion policy-2014, to provide a platform to discuss and address policy-level and program-level issues in agricultural mechanization. However, not even a single meeting of these technical and directive committees, which are envisaged by the policy, has been held to date. Hence, the technical committee and directive committee defined by the agricultural mechanization policy-2014 should be activated and they should make appropriate policy and program-level decisions to address the need of the majority of the stakeholders for enhancing the efficiency and profitability of the production system sustainably.

5. Way forward

The future direction of agricultural mechanization is solely dependent upon the future scenario of agriculture in Nepal. Sustainable utilization of location-specific agricultural environments and resources to maximize the benefit to the farmers with minimum damage to the environment should be the future direction of Nepalese agriculture. In this context, our mechanization efforts should maximize the benefit to the farmers by enhancing the efficiency of the agricultural production system with minimum damage to the environment. Our policy and programs should create a favorable environment for the transformation of smallholder subsistence farmers into agricultural entrepreneurs, for which mechanization efforts can play a crucial role. The major interventions required for sustainable agricultural mechanization are listed below.

- There is a need of revisiting the agricultural mechanization promotion policy - 2014 to align with the federal republic constitution of Nepal. The specific role of 3 tiers of government on agricultural mechanization needs to be clarified and the institutional development and linkages for agricultural mechanization in the new context are needed to be defined and explained to reduce the duplication of efforts, and enhance the effectiveness and efficiency of the program/investment. In addition, the committees (Technical and Directive) mentioned in the agricultural mechanization promotion policy should be activated to create a platform for the interaction of mechanization-related stakeholders, and to make the policy dynamic to address the issues raised by the stakeholders. In addition, a land use policy is also to be formulated and implemented for the commercialization of agriculture in Nepal.
- The strengthening of the institutions related to agricultural mechanization (research, extension, education, etc.) is needed to deliver the desired results of investment in agricultural mechanization. Sustainable agricultural mechanization can only be achieved through research-led identification of appropriate mechanization technology/ practice, systematic transfer of technology to specific target farming communities, and human resource development at all levels to address the mechanization functions, regulation, and standardization so that the farmers and the stakeholder obtain quality mechanization technology and services. Moreover, the agricultural mechanization centers, as envisaged by the Agricultural Development Strategy (ADS) in Terai, hill, and mountain, should also be established.
- Strengthening the domestic production of quality agricultural machinery as per the need of the farmers can lead toward sustainable mechanization as well as the industrialization of the country. For this, the policy interventions should promote local innovations and local production of quality agricultural machinery. This will save the billions of money spent on the import of agricultural machinery. In addition, our local farm tools supply system through local blacksmiths should be strengthened by supporting the modernization of those blacksmith shops.
- As most of the farmers are smallholders, it will not be economical to distribute agricultural machinery to all farmers. But the high-quality service of agricultural machinery could be provided to them through custom hiring services. At present, there are thousands of private custom hiring service providers providing agricultural mechanization services to farmers. They should be recognized, and supported in terms of skill development (technical skills and business development skills) and financing (easy access to credit with subsidized interest, etc.) and regulated (defining quality machinery service standards, service charge range, etc.) to provide quality service to the farmers. Hence, the competitive custom hiring service run in a business model with proper regulation can benefit the farmers at a wider scale.
- Public-private partnership (PPP) model in the promotion of agricultural mechanization is needed for sustainable agricultural mechanization, in which the government's role could be policy formulation, research, regulation, and extension, whereas the private sector's role could be production, and business development of agricultural mechanization technologies and services. Similarly, CGIAR centers should contribute to strengthening the national agricultural mechanization research and extension system. In addition, INGOs and NGOs can also contribute to the sustainable agricultural mechanization framework in the prioritized areas.
- For agricultural mechanization, lack of infrastructure (road, irrigation, electricity, etc.) is considered as one of the major hurdles. For example, there is no farm road, and the machinery has to move from one plot to the next, causing conflict among the farmers. Hence, the command area development should be an integral component of irrigation system development and renovation project. Similarly, the local government can also invest in the development of rural infrastructures (viz., farm roads, farm irrigation/ drainage, farm electrification, communication infrastructure, etc.) in the agricultural area to create a conducive environment for commercialization and mechanization in agriculture.
- Due to the increased out-migration of male members of the family, women farmers are taking the additional responsibility of farm work. Hence there is a need for the promotion of women farmer-friendly agricultural mechanization technology to reduce their burden.
- While promoting the mechanization technologies, the supply chain of the spare parts and maintenance service is also to be ensured in the rural area. In addition, there is an utmost demand for middle-level technicians in agricultural mechanization for operation and repair maintenance services in the rural area. The Council for Technical Education and Vocational Training (CTEVT) could take the lead role to fill this gap. Similarly based upon the interaction with the faculties and students of the Purbanchal engineering campus in Dharan, the curriculum and the faculty and facility for a Bachelor in Agricultural Engineering is needed to be strengthened to produce innovative agricultural engineering entrepreneurs rather than government job seekers. In addition, to impart more practical skills to this manpower, there is a need for mandatory internship provision (in professional institutions) for those students before being awarded a degree in agricultural engineering.
- Our agricultural mechanization program should address

the diverse socio-economic and geographic conditions of Nepalese farmers. In this context, our agricultural mechanization programs should be equitable for gender, farmer's size, geographic location and socioeconomic condition, crop commodity, etc., and this will lead to a balanced development.

- To ensure the promotion of quality agricultural machinery in Nepal, the Agricultural Machinery Testing and Research Centre at Nawalpur, Sarlahi should be strengthened for the provision of a clear legal framework, enhanced testing infrastructure, and human resources. Moreover, the Nepalese government should promote only the quality-tested and certified agricultural machinery in Nepal. In addition, after the increase in agricultural mechanization, farm accidents are also increasing. So, environmental safety and end-user/customer safety should also be focused on. To address this, we need to enforce safety regulations, enhance safety measures, and create awareness among the operators, farmers and customers through training, awareness campaign, and production of information education and communication (IEC) materials.

References

[1] Amatya, U B, Nepal, In: M. J. Campbell (Ed.), *New Technology and Rural Development: The Social Impact*, (p. 513), Psychology Press (1990).

[2] Devkota R, Pant L P, Gartaula H N & Patel K, Responsible Agricultural Mechanization Innovation for the Sustainable Development of Nepal' s Hillside Farming System. *Sustainability*, 12 (2020) 374.

[3] FAO, Mechanization for Rural Development: A review of patterns and progress (Kienzle J, Ashburner J E, & Sims B G, Eds.), *FAO*, 20 (2013).

[4] MoAD, Agriculture Development Strategy (ADS), 2014, *Ministry of Agricultural and Livestock Development (MoALD), Singhdurwar, Kathmandu, Nepal,* (2014).

[5] MOF, Economic Survey 2020/21, *Ministry of Finance (MOF), Singhdurwar, Kathmandu, Nepal,* (2020).

[6] MoLESS, Nepal Labour Migration Report 2020, *Ministry of Labour, Employment and Social Services, Singhdurwar, Kathmandu, Nepal*, (2020).

[7] NAERC, Annual Report (2019/20), *National Agricultural Engineering Research Centre (NAERC), Nepal Agricultural Research Council (NARC), Khumaltar, Lalitpur, Nepal*, (2020).

[8] New Spotlight Magazine, *Gravity Ropeway a Way to Hope*, Kathmandu, Nepal, 15(15) (2012).

[9] Regmi N & KC L B, Rice mills, milling processes and current status in Nepal, In: *Rice Science and Technology in Nepal,* Crop Development Directorate and Agronomy Society of Nepal, (2017) 653-660.

[10] Sharma D R, Thapa R B, Manandhar H K, Shrestha S M & Pradhan S B, Use of pesticides in Nepal and impacts on human health and environment, *The Journal of Agriculture and Environment*, 13 (2012) 67–74.

[11] Shrestha S, Status of Agricultural Mechanization in Nepal, *Proceedings of Sustainable Agricultural Mechanization Roundtable: Moving Forward on the Sustainable Intensification of Agriculture 8-9 December 2011, Bangkok Thailand*, 4 (2011) 1–4.

[12] Shrestha S, Shrestha S, Shivakoti S, Pradhan G P, Adhikary S, Bimoli S & Dahal B, Utilization of the combine harvesters for the agricultural mechanization in the Terai, *31st Summer Crop Workshop at Lumle 9-11 March 2021*, (2021).

[13] Tamang S, Paudel K P & Shrestha K K, Feminization of Agriculture and its Implications for Food Security in Rural Nepal, *Journal of Forest and Livelihood*, 12(1) (2014).

[14] Upadhya M, Bhatte Danda Milkway: Making market accessible to marginal farmers, In: Gyawali D, Dixit A & Upadhya M (Eds.), *Ropeways in Nepal,* Nepal Water Conservation Foundation, Kathmandu, Nepal, (2004) 282.