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Review Article

Historical Evolution of Farm Machinery in Bangladesh: A Review

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ABSTRACT

Bangladesh has undergone one of the most significant agricultural transformations in South Asia, driven by the rapid evolution of farm machinery since the mid- 20th century. From a purely manual and animal-driven farming system to a modernized agricultural landscape characterized by power tillers, tractors, combine harvesters, mechanical irrigation, and emerging digital tools. Farm mechanization has reshaped production practices, rural labour dynamics, and food security. This historical review synthesizes existing research, national policies, sectoral reports, and development project documents to examine the chronological evolution of farm machinery in Bangladesh. The study identifies four key phases: pre-mechanization (before 1960), early mechanization (1960-1990), rapid mechanization (1990-2010), and advanced mechanization with modern and digital integration (2010-present). It explores the technological drivers, socio-economic influences, and institutional roles behind this transformation. The review highlights significant gains in productivity, expansion of irrigated area, labour savings, and growth of rural machinery service market. Despite these achievements, challenges remain in land fragmentation, import dependency, sustainability of diesel-based machinery, and shortage of skilled operators. The paper concludes by suggesting directions for future research and policy, focusing on sustainable, energy-efficient, and small-farm-friendly mechanization to support climate resilient agricultural development in Bangladesh.

Keywords: Farm machinery, Farm mechanization, Irrigation mechanization, Traditional machine, Automatic machine

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1. Introduction

Agriculture has long served as a cornerstone of Bangladesh's economy and rural livelihoods. Historically dependent on manual labour and draft animals, the country's farming system has evolved substantially during the past six decades. Agricultural mechanization, or the introduction and use of mechanical power and modern equipment into the agricultural production system, has played a significant role in this evolution. The population of Bangladesh is increasing at the rate in 1.2% per year [1]. On the other hand, the agricultural land in this country is shrinking at the rate of 0.4% per year [2] due to urbanization, industrialization, infrastructure expansion and environmental effects. According to the Bangladesh Bureau of Statistics (BBS) survey data reported in June 2025, Bangladesh lost about 9.0 million of its farmlands over the eight years 2015-2023 [3]. Rice production in Bangladesh at the time of independence was approximately 12 million tons, but later it increased to 39 million tons in 2024 [4]. One factor responsible for the increase in Boro rice production during the dry season was the introduction of irrigation mechanization. However, a major turning point occurred in the 1990s, when a policy change encouraged the private sector to introduce farm machinery. Similarly, the simultaneous policy of

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subsidized chemical fertilizers and agricultural machinery further accelerated the cultivation of high-yielding crop varieties [5].

Agricultural mechanization is the acceleration of agricultural work with agricultural machinery at every level of farm operations. The number of agricultural labourers in the country is decreasing day by day. The number of educated unemployed is also increasing due to the country's rising education rate. Currently, the rate of agricultural workers in the country is 36.6% (27 million), and it is in a decreasing trend [6]. Many youths are migrating abroad for higher income. Local workers are shifting towards light-labour industries, transportation and service sectors. As a result, worker availability decreases during the peak seasons of sowing/planting and harvesting crops, and labour wages increase abnormally [7]. In such a situation, agricultural production is forced to adopt mechanization to increase output. Agricultural mechanization is the process of integrating modern machinery and equipment into agriculture, thereby increasing productivity and reducing farmers' risk of labour shortages and natural disasters. Mechanization in agriculture is essential for agricultural production due to labour shortage, timely operations, and efficient use of agricultural inputs [6]. Agricultural mechanization increases productivity by about 15%, increases crop production by 20%, reduces labour by 30%, reduces time by 30%, reduces seeds by 20%, and reduces fertilizers by 20% [8].

Agricultural land in Bangladesh is fragmented and uneven, and there are no roads for transporting large agricultural machinery to the field. Therefore, small and lightweight machinery is used in agriculture. Almost 100% of engines, power tillers, tractors, rice transplanters, reapers, and combine harvesters used in the country are imported. About 85% of other agricultural machinery (such as threshers, seed drills, bed planters, irrigation pumps, sprayers, etc.) and spare parts are produced locally [6]. A study shows that between 2008 and 2019, the share of mechanized agricultural land increased significantly. Both small and medium land ownership and rental use are spreading; small farmers are also able to buy machinery [9]. The rapid population growth, urban migration, scarcity of agricultural labour, and the need to produce more food from limited arable land have driven Bangladesh to adopt a wide range of farm machinery. The process has been influenced by technological innovations, government policies, donor-supported programs, private-sector initiatives, and global market trends [10].

Since ancient times, farmers have used various indigenous agricultural machines and tools for crop production. Later on, different manual operated and engine operated farm machinery have introduced simultaneously in the country. Therefore, it is necessary to search for and document the historical evolution of agricultural machinery in Bangladesh. This paper provides a critical, chronological review of the evolution of farm machinery in Bangladesh.

2. Materials and Methods

This review employs a narrative synthesis approach based on:

- Research articles indexed in Scopus, Web of Science, AGRIS, and Google Scholar, etc.
- Reports and web-based information of BBS (Bangladesh Burau of Statistics), BARC (Bangladesh Agricultural Research Council), BARI (Bangladesh Agricultural Research Institute), BRRI (Bangladesh Rice Research Institute), BADC (Bangladesh Agricultural Development Corporation), BAU (Bangladesh Agricultural University), DAE (Department of Agricultural Extension) and MoA (Ministry of Agriculture), etc.
- FAO (Food and Agriculture Organization), IFRI (International Food Policy Research Institute), World Bank, National Agriculture Policy, National Agricultural Mechanization Policy, Agricultural Mechanization Action Plan, etc.
- Project documents and web-based information of CIMMYT (International Maize and Wheat Improvement Centre), IRRI (International Rice Research Institute), iDE (International Development Enterprises), etc.
- Data were categorized chronologically to identify phases of mechanization, adoption trends, key machinery types, and socio-economic drivers. Findings were then synthesized into different sections.

3. Results and Discussion

3.1 Phase I: Pre-Mechanization Era (Before 1960)

The Department of Agriculture was established in Bengal in 1880 as a subordinate part of the Department of Land Records, following a recommendation from the Famine Commission under the Government of the then Bengal Presidency during the period of British India. The Department of Agriculture in Bengal was formally established in 1905 and gained separate status under Viceroy Lord Curzon [11]. In addition, to create research facilities, an agricultural research laboratory was established in Tejgaon, Dhaka, named 'Agricultural Research Laboratory' in 1905, which was the foundation for agricultural research, extension and education. In 1908, Dhaka

Farm (Bengal Government Research Farm) was established on 161.20 hectares of land. The establishment of Dhaka Farm was a significant one in the field of agriculture [12, 13]. In 1928, the country's first agricultural engineering workshop was established inside the then Dhaka Farm in the present Sher-e-Bangla Nagar. John Peterson was then the head of workshop in charge of this workshop. Almost all branches of the engineering workshop were functional in this workshop. The work of this workshop was to repair tractors, power pumps, threshers, sugarcane crushers and other agricultural machinery of Dhaka Farm and to manufacture spare parts for them. Bengal Agricultural Institute (BAI) was established in 1938 by Sher-e-Bangla A.K. Fazlul Huq, the then Chief Minister of undivided Bengal. BAI was the first formal agricultural education institute in Bengal [14]. Farm mechanization in the then East Pakistan was initiated through the Mechanized Cultivation and Power Pump Irrigation (MCPP) scheme, introduced by the Department of Agriculture during 1950-51 for use of tractors and small power pumps [6, 15]. The WAPDA (Water and Power Development Authority) began construction of the largest Ganges-Kobadak (GK) irrigation project in the 1954-55 fiscal year and opened it for surface water irrigation in the 1962-63 fiscal year [16]. This was a milestone for surface-water irrigation systems in Bangladesh (The then East Pakistan).

During this period, human labour and draft animals were used to operate farm equipment and tools in agricultural activities. Only a few numbers of mechanized agricultural equipment were used on the government farm. Then, labour engagement in agriculture was about 80% [17]. Field implements were animal-drawn wooden ploughs, yokes, ladders, sickles, Khurpi, Bida, spades, carts (Bullock-, buffalo, and horse-drawn), etc. In this period, crops were cultivated mainly under rainfed conditions. Limited-scale supplementary manual irrigation was applied using swing baskets, Doon, pitchers, etc. Postharvest method and equipment were beating of crops, animal treading, *Dheki*, *Ghani*, *Dhama, Kantha*, *Jata*, mortar and pestle, *Kula*, *Motka, Gola, Dole, Auri*, etc. [17]. Two pictorial views of traditional ploughing and irrigation are shown in Figure 1.

(a) Bullock drawn country plough (b) Don for surface water irrigation

Figure 1. Traditional agricultural machines for tillage and irrigation

3.2 Phase II: Early Mechanization (1960-1990)

High-yielding varieties (HYV) of rice and chemical fertilizers, along with surface water irrigation, were introduced during the 60s, marking the 'Green Revolution' in Bangladesh (The then East Pakistan). The Water Development Board has constructed several large irrigation projects, including the Dhaka-Narayanganj-Dhaka (DND) and Buri-Tista projects, and the Thakurgaon Deep tubewell project, since its establishment in 1959 [16]. Bangladesh Agricultural Development Corporation was established in 1962, and agricultural mechanization in Bangladesh thereby led to the establishment of BADC with deep tubewells (DTWs) and large-size low-lift pumps (LLPs) for irrigation [18]. Irrigation system development and a cooperative model were associated with government promotion of tractors since the 1960s. However, small landholdings, coupled with further land fragmentation, impeded the widespread adoption of tractors [19]. A tractor and a power tiller were brought in through government schemes for land reclamation. Tractors and power tillers were used on some government farms and commercial farms, such as tea gardens. The government distributed 2,238 power pumps, 200 tractors, and 13,828 sprayers and dusters under a government scheme [16]. BADC started tilling farmers' land with tractor on a hire basis during the 70s. Due to high machine prices, the unavailability of spare parts, and fragmented land, this program was not successful [16]. Then, quality agricultural machines were imported from original manufacturing countries like Japan, the UK, and the USA, and prices were high, beyond the purchasing capacity of farmers [20]. After independence, irrigation policy in Bangladesh increasingly focused on the use of STWs and less

energy requiring LLPs for irrigation [21]. BADC played a significant role in irrigation mechanization in Bangladesh. BADC invested and rented DTWs, LLPs, and STWs to farmers' organizations in 1972 [22].

During 60s, a rice pedal thresher was introduced in Bangladesh by 'Comilla Cooperative Karkhana' similar to the Japanese model [21]. Later on, BARI developed a wheat pedal thresher during 80s. These locally made pedal threshers became popular among farmers due to their low cost and ease of operation. Within a short time, many thresher manufacturers emerged in the country, including Bogura, Cumilla, Sylhet, Jashore, Kishoresganj, and Kushtia, and made the thresher available in almost every corner of the country [21]. Before 1988, the import of low-quality agricultural equipment was restricted. The National Standardized Committee' was responsible for controlling the quality of imported machinery including agricultural equipment and only a list of standard machines required for agricultural operations could be imported [7]. During the 70s and 80s, the most common types of tractors (4-wheel tractors) were Massey Ferguson, International, Ford, and Belarus; pump sets were Kirloskar, Ruston, and Deutz; and power tillers (2-wheel tractors) were Yanmar and Kubota [20].

A part of the history of agricultural mechanization relates to the spread of self-owned manual pump irrigation. Among the manual pumps, treadle pump gained most popularity due to low cost and easy operation. This pump could be installed using bamboo pipe and a strainer and operated by family labour, including women. Treadle pump spread in remote Charland, where groundwater was near the land surface (≤ 6.0 meters). International Development Enterprise (iDE), Rangpur Dinajpur Rural Service (RDRS) and other organizations played a significant role in popularizing locally made treadle pumps. Using these pumps, small and marginal farmers were able to successfully produce crops such as vegetables, wheat, and spices. But due to small flow rates of the pumps, only a few decimals of rice land could be irrigated [23]. However, the pumps gave the farmers the outright realization about the importance of water for crop production. Subsequently, small diesel-engine-powered STWs had emerged in the country as minor irrigation systems [20, 24]. Pictorial views are given in Figure 2 of mechanical tilling and manual pump irrigation.

(a) Land preparation by power tiller (b) Groundwater irrigation by treadle pump

Figure 2. Semi-mechanical agricultural machinery for tillage and irrigation

3.3 Phase III: Rapid Mechanization (1990–2010)

On November 29, 1988, a cyclone impacted Bangladesh, taking a major toll on human lives and reducing the draught oxen and buffalo population used for land preparation, with the deficiency estimated at approximately 5.8 million animals [25]. To minimize the shortage of animal draft power, the government suspended the National Standardized Committee and eliminated most major import tariffs in 1989 to encourage affordable farm machinery (made in China and India), which was thought to be of comparatively lower quality [23, 26]. These actions resulted in a drastic increase in imports of small diesel engines, power tillers, and their spare parts. The number of STWs increased from 93,000 in 1982 to 260,000 in 1990 [27]. STWs and LLPs became the backbone of Boro rice expansion and thus mechanized irrigation contributed directly to food self-sufficiency. Due to liberalization of import and competitive markets, the prices fell sharply, leading to mass diffusion of power tillers. Power tillers became the most widely used versatile farm machine for land preparation, threshing, water pumping, and rural transportation. Since then, various tractor brands, such as Tafe, Sonalika, Mahindra, Eicher, etc., are available in the market. Two Chinese brands of power tillers such as Dongfeng and Sifang are widely using in Bangladesh [20]. In the meantime, BARI developed multi-crop power thresher and maize sheller, and BRRI developed a power thresher, which gained mass popularity and is now locally produced and used by the farmers.

During this period, farm mechanization mainly spread among farmers through custom-hiring service models, especially for irrigation, tilling, and threshing [7]. In the early 2000s, the Department of Farm Power and Machinery (FPM) of BAU provided technical and financial support to private manufacturing workshops to upscale their activities through REFPI (Research and Extension in Farm Power Issues) project [28]. BRRI conducted a GoB funded project named PAMP (Popularizing Agricultural Machinery Project) for the research and extension of rice based machinery and technology during 2002-06. During the project period, farmers purchased more than 5000 BRRI machines and operated them on a custom-hire basis for farmers [29]. Pilot demonstrations of irrigation equipment and farm machinery, and capacity building of village mechanics and farmers, have been carried out by DAE through ASSP (Agricultural Support Service Project) and other projects since 1997 [30].

During this period, manufacturing and repair workshops, along with local mechanics had emerged in the country. Many expert mechanics were exoduses through 'golden handshake' of BADC under the privatization programme in the early 90s [20]. Many of the retired mechanics joined private manufacturing, repair, and training organizations such as MAWTS (Mirpur Agricultural Workshop and Training School). Therefore, local manufacturing and repair of quickly growing agricultural machinery did not pose major challenges. The impact of these actions, in combination with other measures, appeared to be dramatic, increasing Bangladesh's cropping intensity, especially multiple-crop and Boro rice production [5]. This phase marked a turning point, establishing a privately driven mechanization. The following photographs show the mechanical land preparation and irrigation (Figure 3).

(a) Land preparation by tractor (b) Groundwater irrigation by STW

Figure 3. Mechanical agricultural machines for tillage and irrigation

3.4 Phase IV: Modern Mechanization and Digital Integration (2010-Present)

This is the rapid mechanization phase. Government and donor funded many projects executed in this phase to enhance rapid mechanization. BARI, BRRI, and DAE jointly executed the project named FMTD (Farm Machinery and Technology Development) to disseminate BARI and BRRI-developed farm machinery to farmers through extensive field demonstrations and training. During the project period, BARI developed 3364 farm machines, and BRRI developed 5375 farm machines were distributed to the farmers at a 60% subsidized price. DAE's role was mainly demonstration and extension supports [29]. The Government of Bangladesh had been implementing a development assistance program (25% subsidy) through DAE to enhance at agricultural mechanization since 2009 [31]. In Phase I of the GoB project 'Enhancement of Crop Production through Farm Mechanization' (2009-2012), a total of 38338 farm machines were distributed to farmers at 25% development assistance (subsidy). The distributed machines were 1294 tractors, 34691 power tillers, 1821 power threshers, 500 foot-pump sprayers, 8 seeders and 2 rice transplanters [30]. In Phase II (2013-2018), the subsidy level was raised to 50%-70% (50% in plain land and 70% in Haor and coastal areas) with a clear focus on rice transplanter, PTOS seeder, reaper, mini combine harvester and power threshers. In Phase II, DAE distributed 30,513 machines on subsidy, including 13,182 power tillers, 7,869 power threshers, 4,785 reapers, 1,388 mini combine harvesters, 1,964 PTOS seeders, 1100 foot-pump sprayers and 225 rice transplanters. During Covid period (2019-20), DAE distributed (50-70% subsidy) about 1,249 combine harvesters, 499 reapers and 13 rice transplanters to address labour shortages and ensure timely harvesting of crops in Haor and coastal belts [30]. For the period 2020-2025, DAE launched a GoB project titled 'Mechanization of Agriculture through Integrated Management', aiming to distribute 53,100 units of 12 types of agricultural machines to farmers at subsidized prices (50-70%) across the country. Under this project, up to December 2023, 35623 machines were distributed among the farmers. These machines were 8911 paddy and wheat combined harvesters, 67 maize combine harvesters, 2000 reapers, 519 reaper-binders, 379 rice transplanters, 12060 seeders/bed-planters, 9063 power threshers, 1309 maize shellers, 33 grain dryers, 164 power

sprayers, 41 power weeders, 1077 numbers of potato harvesters [30]. Unfortunately, the machine distribution activity was halted by a government decision before the project's completion due to uneven and expedited allocation [31].

BARI developed 57 different agricultural machines, of which about 20 are used in farmers' fields. BRRI developed 48 machines for rice among them 15 are popular to the farmers. BSRI (Bangladesh Sugar Crop Research Institute) developed 12 machines for sugar crops, of which seven are promising. Besides these, BINA, BJRI, BAU, and HSTU developed several agricultural machines suitable for farmers and commercial uses. Mechanization also advanced in fisheries and livestock, but local machines were not developed by research institutes or universities, except for the BRRI chopper machine, BARI chopper machine, BARI Cream separator, BARI mini-RAS, etc. Some manufacturers are fabricating and marketing machines like small feed mills, feed mixers, aerators, milking machines, etc. [32]. Research on precision farm machinery (IoT, AI, UAV, GIS, robotics, etc.) is advancing across different research institutes and universities [33]. Some technologies have already evolved from research, such as agricultural drones, remote-controlled power tillers, automatic irrigation, automatic seed storage control, and automatic fruit graders at BARI [34]. The uses of these machines are still limited to research fields and have not been diffused to the farmers' level. The BRRI semi-automatic seed sower machine has started to be produced commercially [35]. In the future precision farm machinery will replace the mechanical machines to cope with the 4AR (Fourth Agricultural Revolution).

3.5 Labour Dynamics in Agriculture

The distribution of labours in different sectors of Bangladesh and labor wage over time is shown in Figure 4. At the beginning of this period (before 2010), there was a labour crisis in agriculture. So, the wages of laborers increased sharply. High wages made it difficult for farmers to make agriculture profitable. During this time, industry expanded rapidly in Bangladesh. As a result, there was a huge demand for laborers in industries, including the garment industry. In addition, many agricultural workers migrated to Malaysia, Singapore, the Middle East, and many European countries in search of higher income. A report shows that labor migration from Bangladesh increased by 11.54% in 2025 compared to 2024 [36]. Agricultural works are hard and labor-intensive and workplace is in mud, rain, open sun, dust, dirt, etc. So, many semi skill and skill agricultural labors shifted to industrial factories, service centres or abroad. As a result, there was a labor crisis in agriculture. The graph shows that over time, the share of labours in the agricultural and industrial sectors is gradually decreasing, while the share of labours in the service sector is gradually increasing. This is because agricultural works are seasonal and dependent on natural disasters. Income in agriculture is uncertain due to floods, droughts, and cyclones. The use of modern agricultural machinery (tractors, power tillers, harvesters) makes it possible to produce more works with fewer workers. As a result, the demand for labor in agriculture is decreasing. On the other hand, modern industries require skilled and technology-based workers. Unskilled workers are moving to the service sector because physical labor is less in the service sector, work is relatively safe, and salaries are higher than in agriculture and many industrial sectors. Moreover, the educated population prefers office-based or technology-based work over agriculture or industry. Therefore, the participation of workers in the agricultural and industrial sectors is gradually decreasing, while the participation of workers in the service sector is gradually increasing [37].

3.6 Mechanization Transformation

Transformation of agricultural mechanisation began in 1960 with power-pump irrigation and tillage equipment and has continued to date. Agricultural mechanisation, especially irrigation mechanisation, ran parallel to the Green Revolution. Figure 5 shows the patterns of power use in agriculture, along with labour decline, since 1960. Negative but good correlation ($r = -0.90$) is found between farm power use and labour displacement from agriculture. In 1960 labour engagement in agriculture was 92% and it decreased continuously to 36.6% in 2025. In this long period, farm power use in agriculture increased from 0.24 to 3.61 kW/ha. Although motorized irrigation mechanization began in the 60s, other mechanization started slowly with manual machines. During the 70s, mechanization began for tillage, threshing, reaping, etc. Irrigation expansion and mechanization facilities have increased significantly. At the time of independence, only 10-12% of the country's total arable land was under irrigation. Currently, it has increased to more than 75% [38]. Minor irrigation has transformed agriculture into three seasons along with crop diversification. Some commercial farms have started growing high-value crops in controlled environments, such as greenhouses. Farmers are growing some high-value crops like tomatoes under polysheds during summer and rainy seasons. The present status of agricultural mechanization is shown in Figure 6. Land preparation, irrigation, threshing, and milling are mechanized at over 95%. Now, one-fifth of rice and wheat

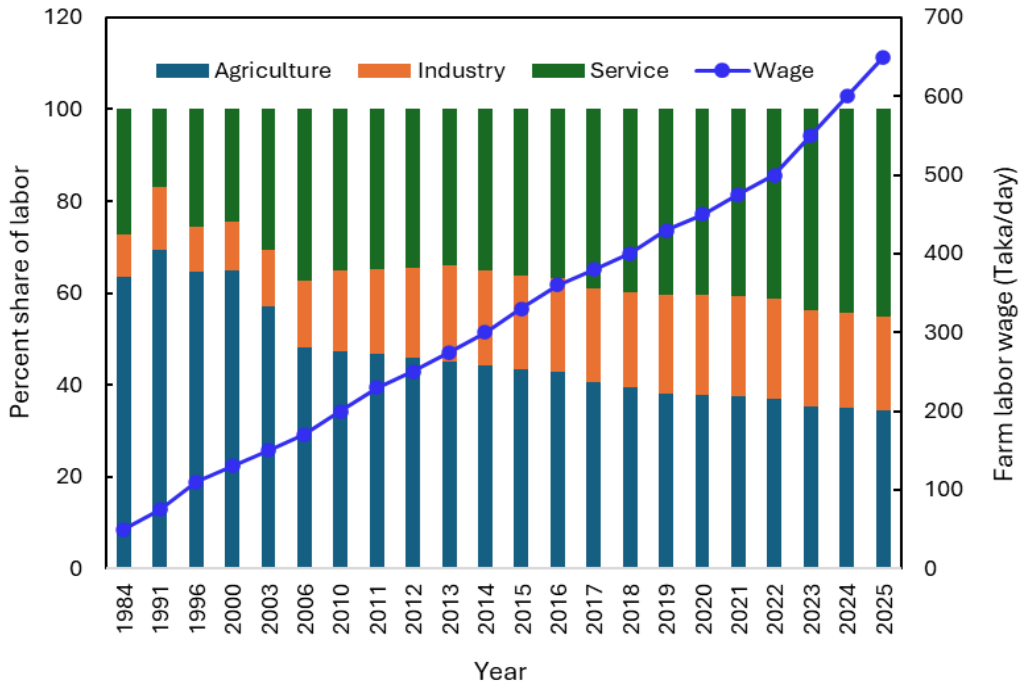

Figure 4. Variations of share of labour in different sectors and labor wage in Bangladesh with time

are harvested by combine harvesters and reapers due to the distribution of these machines under the DAE subsidy program. Other mechanized operations are below 10% due to awareness, technical, and economic factors such as knowledge gaps, the use of herbicides, and low fertilizer prices [6].

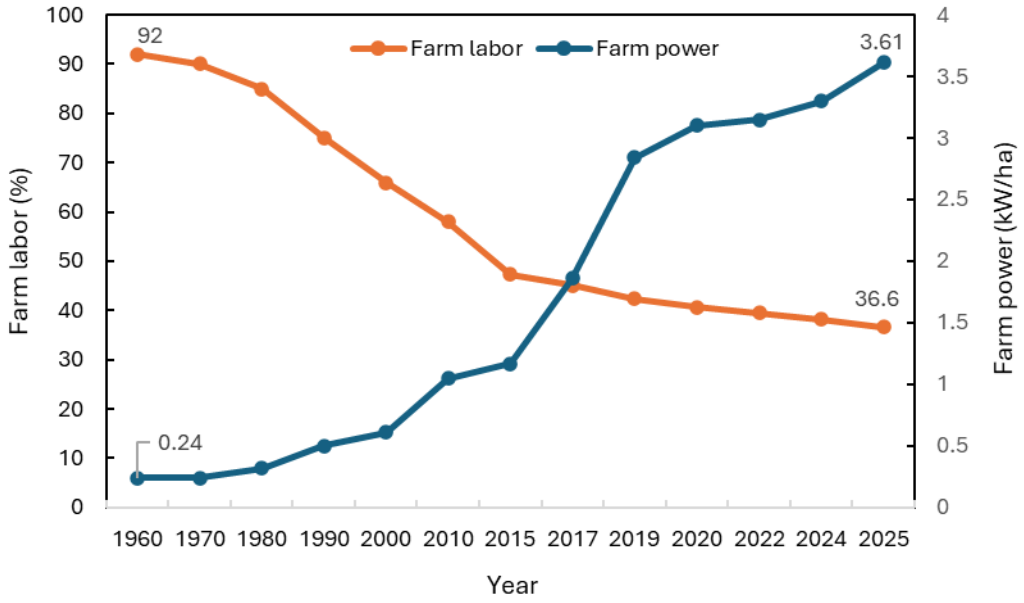

Figure 5. Farm labour vs mechanical power use in agriculture over time

Data base of some commonly used agricultural machinery in Bangladesh since 1977 is given in Table 1. It is observed from the table that the number of most machines increased over time, except for the fertilizer applicator. It was invented by BARI, BRRI and BAU for application of mainly USG (urea super granule) when the price of urea was Taka 42. To save urea fertilizer through a government initiative, the number of USG applicators increased sharply. When the government reduced the price of urea fertilizer to Taka 16, the use of this machine decreased to almost zero [37]. The number of manual weeders increased up to 2017, then decreased gradually due to the use of herbicides as an easier method of controlling weeds [40].

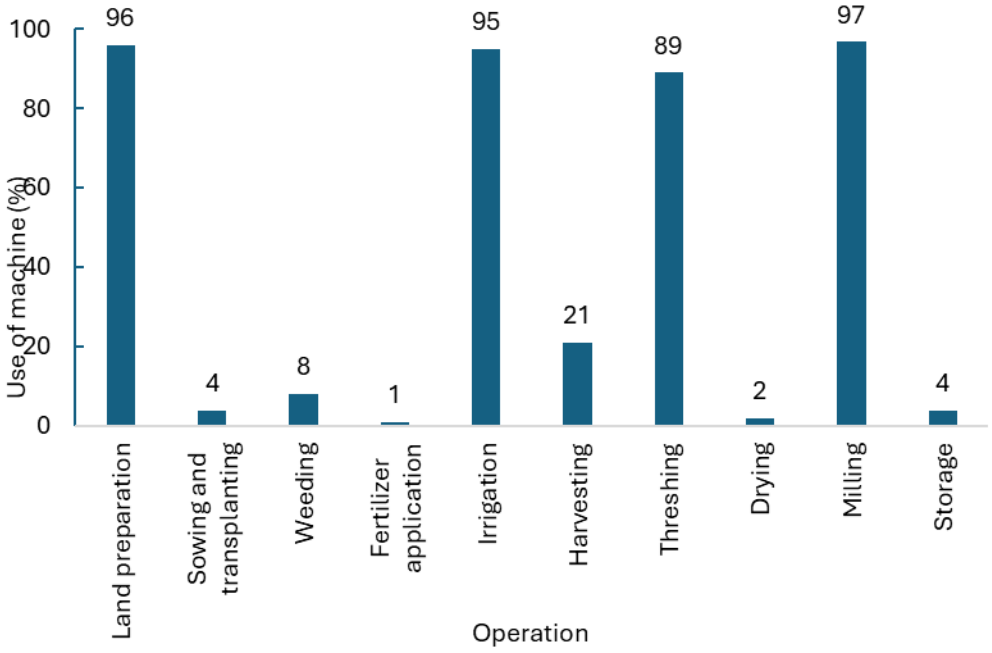

Figure 6. Present status of machine uses in different agricultural operation

Table 1. Time series data of commonly used agricultural machinery in Bangladesh

Farm Machines	**1977**	**1984**	**1989**	**1996**	**2006**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Power tiller	200	500	5000	100000	300000	343000	366700	400030	42027	436000	456000
Tractor	300	400	1000	2000	12500	14890	17905	21938	26369	33500	35000
Deep tubewells	4461	15519	22448	24506	28289	31,302	32174	32,912	34045	35322	36034
Shallow tubewell	3045	67103	223588	325360	1182525	1304973	1374548	1425136	1436813	1523609	1563791
Low lift pumps	28361	43651	57200	41816	119135	138630	142,792	150613	161216	170569	171041
Solar pump					33	37	45	53	62	70	100
Seeder					451	481	620	890	1220	1650	2000
Rice transplanter								25	32	45	65
Manual weeder	500	1500	5000	50000	150000	200000	220000	225000	230000	240000	243000
Fertilizer applicator								450	7587	8900	8500
Knapsack and foot pump sprayer	500	10000	55000	550000	800000	1000000	1100000	1150000	1250000	1300000	1345000
Open drum thresher	150	500	3000	10000	130000	140000	144000	147000	148000	149500	152000
Closed drum thresher		100	1000	5000	45000	55000	63000	70000	85000	105000	135000
Maize sheller			100	850	2000	3500	5000	8500	12000	14500	15000
Combine harvester						20	30	60	100	130	200
Reaper						40	50	56	60	72	80
Winnower						200	500	950	1200	1500	2000
Sugarcane crusher			300	700	1500	5000	1500	23500	25700	28000	32000

Continuation of Table 1.....

Machine	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Power tiller	478000	498000	610000	700000	720000	727000	736000	740000	750000	755000	770000	775000
Tractor	37300	41500	35000	45000	48000	51000	55000	57000	60000	65000	69000	70000
Deep tubewells	36034	36979	37175	37538	37634	37007	36955	33896	33968	34040	35054	35000
Shallow tubewells	1563791	1417008	1398960	1355852	1357532	1398706	1409689	1469980	1477454	1479266	1579711	1580000
Low lift pumps	171041	173179	176478	181469	187134	199914	204391	205212	206548	350542	350913	360000
Solar pump	300	320	500	800	1500	2200	3500	4600	5500	4523	6500	6700
Seeder	2850	3800	4200	5000	5500	6400	7500	8500	10000	12062	20812	22100
Rice transplanter	100	260	300	400	550	700	840	880	912	1040	1120	1200
Manual weeder	245000	250000	250000	250000	240000	235000	230000	225000	223000	222000	200000	190000
Fertilizer applicator	16000	16000	18800	18800	16000	12000						
Knapsack and foot	1400000	1425000	1440000	1450000	1465000	1470000	1480000	1500000	1520000	1540000	1550000	1570000

pump sprayer												
Open drum thresher	155000	159000	165000	172000	177000	186000	200000	208000	212000	215000	220000	225000
Closed drum thresher	146000	155000	165000	175000	190000	205000	210000	214000	218000	220000	228058	230000
Maize sheller	18100	22600	26500	32000	37600	40500	42000	46700	48500	49000	49695	52500
Combine harvester	320	966	1388	2677	3645	5507	6250	8979	9500	9667	11500	11600
Reaper	150	300	500	850	1050	1275	1550	8000	10000	12500	15000	15200
Winnower	2250	2400	2600	2750	2900	3100	3200	3350	3500	3750	4000	4500
Sugarcane crusher	35600	37000	38500	40300	42000	44600	46400	48900	50000	51800	53400	55000

Source: [10, 30, 31, 41, 42, 43, 44, 45]. Numbers of some machines of unavailable years are estimated from the data trend.

In Bangladesh, the share of renewable energy is 5.38% (1689.79 MW), and the contribution of solar energy to this share is 82.70% (1396.62 MW). So, solar irrigation pump (SIP) may be an important renewable and clean energy source for irrigation. There are about 3,523 SIPs installed by various government organizations, totalling 60.696 MW_p of generating solar power [46]. Infrastructure Development Company Limited (IDCOL) has fixed a more ambitious target to install 50,000 SIPs by 2027 [47]. The Asian Development Bank (ADB) prepared a road map for installing up to 45,000 SIP systems with pump ratings ranging from 4 kW to 25 kW, adding 1000 MWp of solar capacity to the country by 2031. The project would be executed in two phases: during 2023-2026, 18,000 SIPs would be installed, and the remaining 27,000 SIPs would be installed during 2027 to 2031. These SIP systems would displace the consumption of 300,000 tons of diesel fuel annually, avoiding 900,000 tons of carbon dioxide equivalent ($MtCO_2e$) emissions every year. The target number of SIP systems aims to replace diesel pumps irrigating up to 400,000 hectares of land and serving more than 1.3 million farmers. The proposed breakdown by SIP system type is 15,000 solar low-lift pumps for irrigation with surface water, 2,000 solar deep tube wells, and 28,000 shallow tube wells for groundwater irrigation [48].

The Cereal Systems Initiative for South Asia - Mechanization and Irrigation (CSISA-MI), a five-year project (July 2013-September 2018) led by CIMMYT in partnership with iDE, developed the capacity of 3474 service providers with 3757 machines (Axial Flow Pump 1017, PTOS 1851, and reapers 889) [49]. Cereal Systems Initiative for South Asia-Mechanization and Extension Activity (CSISA-MEA) in modernizing Bangladesh's agriculture through capacity building of light engineering agricultural workshops during 2019-2024. CSISA-MEA supported the agriculture-based light engineering industry through workforce training, private sector engagement, digital innovation, eco-friendly practices, research, finance access, and market linkages in Cox's Bazar, Jashore, Faridpur, Chuadanga, Kushtia and Bogura with the collaboration of BARI, BRRI, DAE and BITAC (Bangladesh Industrial Technical Assistance Centre) [50]. Department of Farm Power and Machinery of BAU executed a project titled 'Appropriate Scale Mechanization Innovation Hub (ASMIH)-Bangladesh' during 2016-23 in the southern region of Bangladesh. The suitability of different agricultural machines was tested in farmers' fields, along with capacity building for different stakeholders. This department also conducted another research project titled 'Postharvest Loss Reduction Innovation Lab (PHLIL)-Bangladesh'. The BAU-STR dryer was developed, and nine PhD students were graduated through these projects. Four advanced laboratories (Drying, storage, biogas, and engineering shop) had been developed in this department for research and student and practitioner capacity building [33].

The expansion of mechanization is the outcome of the combined efforts of various stakeholders involved in the process, including the government, research institute, extension agent, development partner, manufacturer, trader, dealer, NGO, and farmer. Development partners such as CIMMYT, IRRI, ACIAR, iDE, KOICA, JICA, and NGOs are also involved in disseminating farm machinery and technology by providing training and logistical support to end users. Some agricultural machinery manufacturers and light engineering workshops have already included CNC (Computer Numerical Control) and sophisticated workshop machinery in their production lines [51]. Therefore, the evolution of agricultural mechanization in Bangladesh had transformed step by step from manual, labor-intensive agriculture to motorized, and then to an emerging era of semi-automatic and automatic mechanization, found feasible and sustainable in the long run [52]. Long run feasibility should take into account autonomous machines, considering labour scarcity and increasing wage rates.

4. Conclusions

The evolution of farm machinery in Bangladesh represents a transformative journey from manual, labour-intensive agriculture to an emerging era of smart and sustainable mechanization. Over the past six decades, mechanization has enabled increased agricultural productivity, improved food security, reduced drudgery, and transformed rural labour markets. A combination of private-sector dynamism, supportive policies, affordable technologies, and demographic pressures facilitated this transformation. Moving forward, Bangladesh must prioritize smallholder-oriented, environmentally sustainable, and technologically advanced mechanization pathways. Local manufacturing, digital agriculture, renewable energy integration, and enhanced technical training will be central to ensuring a resilient and efficient agricultural sector capable of meeting future food and livelihood demands. The information gathered in the paper will help researchers, planners, manufacturers, and interested parties understand the facts and facets of the evolution of farm mechanization in Bangladesh and consider extrapolating ideas toward a modern, sustainable mechanization in the country.

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