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Farm mechanization in Bangladesh: a Review

Md. Belayet Hossain Meah
Executive Director
Manohar Development Foundation (MDF)

ABSTRACT

Farm mechanization is one of the major cause of change in agricultural sector now a days in Bangladesh. Labor shortage and high labor wage rate compelled the farmers to accept farm mechanization. Power availability in farming sector increased at visible rate due to intervention of government policy in mechanized cultivation.Adoption of mechanized cultivation increased rapidly due to active involvement of public, private, donors and non-government organization. Quality machinery and after sale service are necessary in successful implementation of farm mechanization program. Government intervention plays an important role in promoting farm mechanization. The growth of manufacturing industry increased rapidly due to increase in market size. Small and fragmented lands restrict the farmers to use larger size of farm machinery. Government assistance in farming sector should be continued to procure selected farm machinery at farmer's level, exemption of import tax on some items, disbursement of fund on the machinery research, extension and capacity building. Government should formulate mechanization policy and promotion law on the production, supply and usage of farm machinery.The studyconcludes -there is no doubt that the application of farm power to appropriate tools, implements and machines "farm mechanization" is an essential agricultural input in Bangladesh with the potential to transform the lives and economies of millions of rural families.

Keywords: *Farm mechanization, Labor shortage, Bangladesh*

INTRODUCTION

Agriculture of Bangladesh is characterized by overwhelmingly small holdings due to higher population density and nearly 80 per cent of its population residing in the rural areas coupled with unabated land fragmentation due to the inheritance laws of the country **(Rahman *et. al.*,2011)**.According to preliminary estimate of BBS, in FY2017-18, food grains production stood at around 413.25 lakh metric tons (MT). In the same fiscal year, the total internal procurement of food grains was 16.7 lakh MT against the target of 17.3 lakh MT.

In addition, an amount of Tk.20400 crore was targeted to be disbursed as agricultural credit against that Tk.21393 crore was disbursed till June 2018, which was 104.87 percent of the target**(Anon, 2018d**). Rice based cropping pattern shows dominancy in Bangladesh for the highest demand of rice as staple food and suitable condition for rice production **(Shirazy *et. al.*, 2016)**. In Bangladesh, rice is grown in 80% of the total cropped area **(Kabir *et. al.*, 2016).** Rice (*Oryza sativa* L.) is grown in three distinct seasons- namely boro (Dec-April), aus (April-July) and a man (Aug-Nov).The country produced 36.278 million metric ton of cleaned rice in 28.075 million hectares of land **(Anon, 2018b).**Rice is the staple food of about 150 million people of Bangladesh. It provides nearly 48% of rural employment, about two-third of total calorie supply and about one-half of the total protein intakes of an average person in the country. Rice sector contributes one-half of the agricultural GDP and one-sixth of the national income in Bangladesh **(Anon, 2018c).**The yearly per-capita rice consumption is decreasing from 180 kg in 1977 **(Ahmad and Hassan, 1983)** to 148 kg in 2015. The population will reach 215.4 million in 2050 and the demand of cleaned rice would be 44.6 million ton **(Kabir *et. al.*, 2016).** This decreasing consumption is replaced by wheat, which is the second most important cereal crop, grown in winter season in Bangladesh with an area and production of 0.867 million hectares of land and 1.098 million metric ton respectively **(Anon, 2018b)**. The land area is decreasing at the rate of 80,000 hectare annually due to construction of road, house and industry **(Anon, 2009 BRRI).** The farmers have to grow more food within the limited land

resources to meet the growing demand. The country aims at increasing productivity in order to achieve food for raising demand and establish social security of this growing population (**Anon, 2015a**).

The agricultural labor force followed decreasing trend (48.3 % in 2002-03 and 40.6 % in 2016-17) due to shifting low productivity to high productivity sector **(Anon, 2018a)**. As a result, the availability of agricultural labor force become very scarce and cost of crop cultivation increase with the hike in the wages of labor leading to reduce profits to the farmers. Unavailability of laborers during cultivation period compelled the farmers to delay in harvesting which results in yield loss; sometimes incurred total loss of field crops due to natural disaster. It also hampers the land preparation and sowing operations for the next crop.

To keep economical consistency over the shifting of manpower from agriculture to service and industry, it requires filling up the labor gap in agricultural operations by mechanical interventions **(Islam *et. al.,* 2016a).** There is a substantial contribution of mechanization in agricultural operations that made it possible to release agricultural laborers to get into other high income professions (i.e. business or service).

Total factor productivity growth in the agriculture sector of Bangladesh from 1948 to 2008 was largely due to technological progress **(Rahman & Salim, 2013).**Mechanization reduces the drudgery of farm labor, relaxes peak-seasonlabor constraints, reduces costs of production, and can save crucial resources **(Biggs & Justice, 2015; Rahman *et. al.,* 2011).** Low mechanization levels also can make farming unattractive to the youth and disproportionately affect women farmers (**Baudron *et. al.,* 2015**).

Application of farm mechanization will adversely affect the labour requirement, which will adversely affect the exiting unemployment situation. However, at the same time it is argued that the application of mechanization will boost up the overall productivity and production with the lowest cost of production **(Aurangzeb *et. al.,* 2007).**With the introductionof medium-scale mechanization the nature of using cultivation power has changed significantly and it appeared that the use of farm machineries has increased rapidly.In this review paper, researcher tried to analyze the status of farm mechanization in agriculture in Bangladesh.

PROBLEM STATEMENT

Farm mechanization is the main plank of modern agriculture. Many developed countries revolutionized by using farm mechanization, which resulted in tremendous production and productivity gains. However, the conditions under which it was introduced in those countries differ greatly from Bangladesh context. Two of the most important conditions were the shortage of labour and large sizeof farm. But as the pressure of population on land is increasing steadily, the solution lies in mechanizing agriculture, which would realize the goal of achieving targeted food gains production in Bangladesh.

REVIEW OF LITERATURE

There have been some studies conducted on the impacts of mechanization on overall livelihood of the rural population(**Anon, 1973; Gill, 1984; Miah *et. al.*, 2002**). These studies indicated that the increased use of small scale mechanization and to some extent, mechanization seriously affected the income of small farmers and landless labourers while contributing little to the overall productivity of farming system.

Besides, a number of studies (**Roy and Blase, 1978; Duft 1986; Agarwal, 1981;Aurangzeb *et. al.,*2007**) were conducted outside the country regarding this issue. **Miah *et. al.,* (2002)**studied socio-economic impacts of farm mechanization on the livelihood of rural laborers in Bangladesh. **Khalequzzaman and Karim (2007)** studied agricultural mechanization and its impact on rural environment. **Aurangzeb *et. al.,* (2007)** found with the introduction of small-scale mechanization the nature of using cultivation power has changed significantly and it appeared that the use of power tiller for tillage has increased rapidly. **Wohab (2010)**conducted research on status of Agricultural Mechanization in Bangladesh. **Rahman *et. al.,* (2011)** studied on impact of farm mechanization on labour use for wheat cultivation in northern Bangladesh. **Reza &Khan (2013)** studied on impact of farm mechanization on productivity and profitability of rice farm in Rajshahi district. **Ahmmed, (2014)** studied on present status, prospects and challenges of mechanization in Bangladesh. **Islam (2016)** studied on Mechanized rice transplanting in Bangladesh. **Islam (2016a)** conducted research on investigation on selective mechanization for wet season rice cultivation in Bangladesh. **Mottaleb *et. al.*, (2016)** studied factors associated with small-scale agricultural machinery adoption in Bangladesh: Census

findings. **Islam (2018)** conducted research on status of rice farming mechanization in Bangladesh. **Aryal*et. al.,* (2019)** studied understanding factors associated with agricultural mechanization: a Bangladesh case.

DATA AND DATA SOURCES

The main approach is to assemble relevant information and data of most recentyear from multiple sources. This study collected time series data from nationaldata sources i.e Bangladesh Bureau of Statistics, annual report of Department of AgriculturalExtension, Bangladesh Rice Research Institute, Wheat Research Centre,handbook of Bangladesh Agriculture Research Institute etc.The authors of this study also gathered very valuable informationfrom national, international journals, articles, review papers etc.

AGRICULTURAL FARM MECHANIZATION IN BANGLADESH

Mechanization may be defined as the process of injecting power and machinery between man and materials in a production system **(Khalequzzaman and Karim, 2007).** Agricultural mechanization is an art and scientific application of agricultural machinery, tool and implement for increasing farm production and cropping intensity. The irrigation policy in Bangladesh in the 20th century originally focused on large-scale canal systems and Deep Tube Wells (DTW) **(Biggs& Justice, 2015).**

Agricultural mechanization in Bangladesh there by started with DTW for irrigation **(Pingali, 2007).** Irrigation system development and a cooperative-model were associated with the government promotion of four-wheel tractors (4 wt) since 1960s. However, small land holding coupled with further fragmentation of land impeded the wide-scale adoption of 4 wt **(Hossain*et. al.,*2007).** After independence, irrigation policy in Bangladesh increasingly focused on the use of shallow tube wells (STWs) and less energy requiring Low Lift Pumps (LLPs) for irrigation **(Biggs & Justice, 2015).**Several institutional models were under taken to promote small-scale mechanization. The Bangladesh Agriculture Development Corporation(BADC) started renting STWs to farmer organizations in 1972 as well as investing in DTWs and LLPs **(Hossain, 2009).**Consequently, by mid 70sthe number of LLPs in Bangladesh reached 35,000 units **(Anon, 2012w).**

Since the 1960s locally manufactured mechanical threshers are extensively used as economical options to overcome labor shortages. In1960, a pedal thresher was reproduced in Bangladesh by 'Comilla Cooperative Karkhana' using the Japanese model **(Anon, 2012w).** At present, almost each district in Bangladesh has a local thresher manufacturer. In some districts such as Jessore and Khulna, there are more than 100 thresher manufacturers **(Anon, 2012w).** Before 1988, the import of agricultural equipment was restricted. The 'Standardized Committee of Bangladesh' was responsible for controlling the quality of imported machinery including agricultural equipment and only a list of standardized machines required for agricultural operations could be imported. In 1988, the Ershad Government started liberalizing markets, lowered the tariffs on machine imports, and dissolved the Standardized Committee. This policy change resulted in an import surge of low-cost small engines and engine powered machinery such as power tillers (two-wheel tractors, 2WTs),diesel pumps and other equipment into Bangladesh, primarily from China **(Gisselquist*et. al.,* 2002; Kienzle *et. al.*,2013; Mottaleb *et. al.,* 2016; Pingali, 2007**). After the trade liberalization in 1988, cost of these machines especially power tillers and minor irrigation pumps fell by 50% resulting in increases of 400% in sales of diesel engines and more than 1000% in power tillers compared to sales three years before the liberalization **(Gisselquist *et. al.,* 2002).**

At present, 80% land is prepared by power tiller and 18% by tractor or 2 WTs and/or 4WTs **(Islam, 2018 and Kienzle *et. al.,* 2013).**However, mechanization of other agricultural field operations is still very low in Bangladesh and thus, adoption of other agricultural equipment such as bed makers, seeders, weeders, harvesters and winnowers is not common **(Islam, 2009)**.From the onset mechanization in Bangladesh spurred farm machinery hiring services. In the 1960s, BADC established a rental operation system of LLP at a 75% subsidy scheme to farmers. Due to the prevailing small landholdings, many farmers who own agricultural machines opt for hiring out these machines in addition to operating ton their own land **(Biggs & Justice, 2015; Kienzle *et. al.,* 2013).** This, on the one hand, optimizes the use of machines and on the other hand, increases farmers' access to these machines. Through custom hiring services, even the poor can afford to mechanize farming **(Alam*et. al.,* 2004).** This

has been reported across South Asia and for different implements – including 4 wt drawn zero-till seed drills(**Erenstein & Farooq, 2009**), laser-land leveling (**Aryal *et. al.*, 2015**) and2wt (**Mottaleb *et. al.*, 2017**). Hence the existence of rental markets can facilitate rapid adoption of lumpy technology and make technology accessible to even poor and marginal farmers who otherwise could not invest in or access it. Bangladesh agriculture is now one of the most mechanized agricultural economies in south Asia (**Baudron *et. al.*, 2015; Islam, 2009**).This was facilitated by a focus on small-scale machinery more adapted to its socio-economic context -be it through cheap imports or local production and manufacturing. Table 01 presents the existing scenario of farm machinery available in Bangladesh.

Table1. *Present Status of Farm Machinery in Bangladesh*

Name of machine	Quantity, no.	Source
Diesel engine	25,00,000	Anon. (2016)
Power tiller	7,00,000	Ahmed, 2014; Tiwari*et. al*., 2017
Tractor	60,000	Ahmed, 2014; Kabir, 2014
Seeder	5,000	Wohab, 2012
Rice transplanter	300	Islam, 2016
Weeder	2,50,000	Ahmed, 2014;Tiwari*et. al.,* 2017
Granular urea applicator	800	Ahmed, 2014
Prilled urea applicator	18,000	Anon. (2016)
Sprayer	13,00,000	Ahmed, 2014
Reaper	500	Ahmed, 2014;Tiwari*et. al.,* 2017
Combine harvester	130	Ahmed, 2014; Kabir, 2014
Open drum thresher	1,50,000	Anon. (2016), Alam, M. (2016).
Closed drum thresher	2,20,000	Anon. (2016), Alam, M. (2016).
Winnower	3000	Ahmed, 2014; Tiwari*et. al.,* 2017
Power driven pump	1,67,175	Anon. (2016)
Deep tube well	35,566	Anon. (2016)
Shallow tube well	15,48,711	Anon. (2016)

THE GROWTH OF AGRICULTURAL MECHANIZATION IN BANGLADESH

Bangladesh has the globe's highest per-capita level of rice consumption at 172.6 kg person^{-1}year^{-1}(**Anon, 2015e**). The government of Bangladesh (GoB) has tended to encourage mechanization as an avenue to increase rice production and move towards rice self-sufficiency. To facilitate this process, the GoB voluntarily reduced import restrictions and tariffs on select machineries, while also supplying subsidy to help purchasers offset fixed costs**.** The GoB first introduced irrigation pumps and tractors in the 1960s (**Ahmed, 2001**). Four wheel tractors were initially promoted, which are arguably scale-inappropriate in Bangladesh given the small average farm size at around 0.53 hectares, which is often divided into multiple fields (**Hossain *et. al.*, 2007**), making demand aggregation for tillage services among farmers, and between-field and -farm transport of tractor equipment problematic. The GoB also first introduced centralized irrigation facilities by establishing deep tube wells (DTWs) and supplying low-lift irrigation pumps (LLPs) to farmers on a rental basis from the Bangladesh Agricultural Development Corporation (BADC). The GoB also supplied fuel at 75% subsidized rate to pump owners through BADC until the 1970s (**Hossain, 2009**). By 1978, BADC had rented out and managed a total of 9,000 DTWs and 35,000 LLPs (**Anon, 2012x**).

Irrigation and land preparation management under nearly complete government control however presented large logistical and financial burdens. Eight years after independence, Bangladesh undertook liberalization policies, and as a result, the government gradually opted out of state-led support of mechanization and began the privatization of irrigation, with additional efforts to open markets for land preparation equipment (**Gisselquist *et. al.*, 2002**). BADC initiated sales to liquidate DTWs and LLPs to farmers' cooperatives and also to individual farmers, many of whom became service providers (**Hossain, 2009**). Privatization, however, only gained full momentum when a number of tariff and non-tariff barriers on the import of irrigation and diesel engines and tractors were eliminated, actions that were linked to disaster response management by the Bangladeshi government.

During this period, the GoB's Standardized Committee was responsible for controlling the quality of imported machinery, including

agricultural equipment. They did so by advising the import of high-cost Japanese tractors, pumps, and engines, while discouraging more affordable Chinese made machinery thought to be of comparatively lower quality (**Justice and Biggs, 2013**). The urgency resulting from the cyclone and consequent threat to food insecurity however prompted the GoB to reconsider such policies. In 1988, President Hussain Muhammad Ershad voluntarily eliminated most of the major import tariffs on standardized diesel engines and two-wheeled tractors, in order to facilitate the broader availability of two wheel tractors and the associated 8-16 HP Chinese engines that drove them. In the next step, President Ershad disbanded the Standards Committee, to facilitate the rapid import of comparatively inexpensive diesel engines and two-wheeled tractors from China (**Justice and Biggs, 2013**). Six years later, the import of two wheeled tractors was made completely duty free (**Anon, 2012x**).

These actions resulted in a drastic increase in imports of small diesel engines for mechanized irrigation and land preparation. The number of shallow tube wells (STWs) used for irrigation increased from 93,000 in 1982 to 260,000 in 1990 (**Anon, 2012x**). Currently, more than 550,000 two-wheeled tractors, the vast majority of which are made in China, are used to prepare 80% of Bangladesh's cropland (**Anon, 2012x**; **Ahmmed, 2014**). A total of 1.63 million of STWs, DTWs and LLPs are also used to irrigate (BADC, 2013) nearly 55% of all cropland (**BBS, 2011**). The impact of these actions, in combination with other measures, appears to have had a dramatic impact on increasing Bangladesh's cropping intensity, or the number of crops grown per unit of land per year. This is acknowledged to have been partly attributable to the spread of irrigation (**Hossain 2009**), and indicated that cropping intensity appeared to be stagnating until the late 1980s, and then began to gradually but steadily increase as result of these actions.

Import Scenario of Farm Machinery

Import of agricultural machinery in Bangladesh is still active until today. In 2012-13, the most recent year for which GoB data is available, 112 importers imported 30,771 two-wheeled tractor driven power tillers with an average price of USD 1,135 each. In the same year Bangladesh imported 2000 mechanical seed drills and rice transplanters, the former which can be attached to two-wheeled tractors for direct seeding, and USD 2.54 million worth of spare parts and other agricultural machineries from abroad. Owners of agricultural machinery in Bangladesh also tend to work as service providers by renting or selling mechanized land preparation and irrigation services to other farmers (**Krupnik *et. al.*, 2013**). As a result, even relatively small farm holders are able to access affordable machinery services through custom hiring systems (**Anon, 2012x; Justice and Biggs, 2013**).

- Now, almost 100% power tillers are being imported from China. Two models of power tiller namely Dongfeng and Sifang are widely used in the country. **(Islam, 2018).**
- Very few rice transplanters including walking and ride on types are operated in the country and all the transplanters are imported from Korea and China. **(Islam, 2018).**
- CIMMYT introduced power tiller operated Chinese seeder (2BG-6A) in 1995.
- The use of seeder machine is increasing day by day, Most of the seeder machines are imported from China and very few are manufactured locally. **(Islam, 2018).**
- Irrigation pumps and sprayers (either power or knapsack sprayer) were imported from Korea, China, Brazil, and India. Now, irrigation pumps and sprayers are manufactured locally. **(Islam, 2018).**
- At present, reapers are imported from China, South Korea, Vietnam and India. Very few rice-wheat reapers were manufactured locally and sold to the farmers. The quality of reaper was not up to the mark. The local manufacturer was unable to manufacture good quality cutting blade which was the crucial part of the reaper due to lack of heat treatment facility. **(Islam, 2018).**
- The demand of rice-wheat thresher and maize sheller are met up by the local manufacturer. Combine harvester of different makes and model are imported from India, South Korea and China**(Islam, 2018).**

Farm Machinery Manufacturing Industry

Until the beginning of this century, Rahman Engineering Workshop, Kushtia; Alim Industries Limited, Sylhet; Comilla Cooperative Karkhana, Comilla; MAWTS, Dhaka; Mahboob Engineering, Jamalpur and Uttaran Engineering Workshop, Dinajpur played pioneering rule in manufacturing different kinds of farm machinery

especially hydrotiller, weeder and thresher. There were also small manufacturers available in the country to fabricate threshers and irrigation pumps and sold directly to the farmers. Large manufacturers are establishing the research and development section, setting up marketing and testing facility, creating good environment for worker, installing modern capital machinery to start line production with maintaining quality of the product. **Alam *et. al.*,(2014b)** stated that the growth of farm machinery manufacturing and associated industries were about 70 foundries, 800 agro-machinery manufacturing workshop, 1,500 spare parts manufacturing industries and workshops and about 20,000 repair and maintenance workshops are engaged in agro-machinery subsector of the country. The growth of local farm machinery manufacturing industry is expanding day by day. Knapsack sprayers, irrigation pump, seeder, thresher, corn Sheller, rice milling equipment and spare parts of power tiller and engine are manufactured locally in different parts of the country and satisfy the local demand. Very few manufacturers have research and development section to modify the farm machinery according to the demand of the farmers. Manufacturers do not have the instrument to test the machine in off-load and load condition. Reverse engineering started in Dholaikhal and Nawabpur area in old Dhaka town. Later those factories were shifted to Bogra and Jessore areas. Bogra is the largest manufacturer of farm machinery and spare-parts in Bangladesh. Manufacturer face problems on capital, setting up infrastructure, skilled labor, complexity in bank loan, low quality of raw material and technical know-how of the worker. In the competitive market, many manufacturers produced sub-standard machinery and sold to the farmers at lowest price, which created a negative impact among the farmers **(Islam, 2018).**

Table6. *Existing (Annual) Market Size of Agricultural Machinery*

Agricultural Machineries	Annul market size (million Taka)					Source
	2011	2012	2013	2014	2015	
Power Tillers	4200	4025	3000	4200	4375	Tiwari *et. al.*, 2017). Alam *et. al.*, (2017)
Tractors	5525	4140	3996	4025	4375	
Pump	1400	1600	1050	1225	1120	
Engines	21600	30000	21750	22500	23760	
Thresher	3320	4070	5216	5302	5369	
Corn shellers	107	142	215	268	341	
Sprayers(local)	126	420	428	450	458	
Sprayers imported	30	45	47	56	59	
Spare parts local	20000	20600	20800	21000	21300	
Spare imported	6000	5400	5400	5300	5400	
Sub total	62308	70442	61901	64326	66557	
Repair and maintenance of old machines	8841	10609	12731	15277	18333	
Total market size	71149	81051	74632	79603	89955	

IMPORTANCE OF FARM MECHANIZATION

Transplanting, weeding, harvesting and threshing operations are considered as four major labor intensive operations in rice cultivation in Bangladesh condition. **Table 03** presents the operation wise labor requirement in manual and mechanized rice cultivation. Mechanized cultivation substantially reduces the labor force than manual operation. Traditional method is incapable whereas adoption of mechanization is a way to meet such conditions with a burden of large investment. Emphasis should be given to mechanize these operations in order to reduce the labor requirement in rice cultivation. To increase crop security, faster transplanting and harvesting operation are ways that could only be established by mechanical intervention. Mechanization transform the labor intensive works to power intensive works and reduce the human drudgery. It has been proven that mechanization maximize the production, reduce the cost of cultivation and post harvest loss and made agriculture profitable **(Islam, 2018).**

Table3. *Labor Requirements in Manual and Mechanized Rice Cultivation*

Technology	Labor requirement		Remarks
	Manualman-hr ha^{-1}	Machineman-hr ha^{-1}	
Transplanter	123-150	9-11	Islam *et. al.*,(2016b) (Islam, 2018).
Prilled urea applicator	4	4	(Islam, 2018).Islam *et. al.*,(2015)

USG applicator	4	4	(Islam, 2018).Islam *et. al.*,(2015)
Weeder	86	22	(Islam, 2018).Islam *et. al.*,(2017)
Reaper	80-84	9-10	(Islam, 2018).Alam *et. al.*,(2014a)
Open drum thresher	50-52	20-22	(Islam, 2018).Islam (2006)
Close drum thresher	50-52	14-18	(Islam, 2018).Islam (2006)
Winnower (man¯hr t¯1)	21	5	Ahiduzzaman *et. al.*,(2000) (Islam, 2018).

Table4. *Distribution of Labour Hours Used Per Hectare by Operation in Wheat Field*

Item	Mechanized farm	Traditional farm	Remark
Plouging	32	168	**Rahman *et. al.*, 2011**
Sowing	8	9	
Interculture	146	135	
Irrigation	37	34	
Harvesting	206	224	
Threshing	25	170	
Others	77	95	

FARM POWER AVAILABILITY

Power availability in agricultural operation indicated the intensity of mechanization. Farm power availability was calculated based on the energy input per unit area of cultivable land. Table 2 shows the trend of farm power availability in agriculture over the period of 1960 to 2013. The power availability was very low before 1984. From 1960 to 1984, the rate of increment of farm power was observed 1.2%. The farming sector got momentum to use machinery after liberalization of import policy on power tiller in 1988. After 1995, government emphasized the importance of mechanization and taken different initiatives such as provided fund in research and extension on farm machinery, policy formulation, tax exemption on some important items and encouraged local manufacturing of farm machinery. Hence, power availability in farming sector sharply increased at 8% rate due to intervention of government policy in mechanized cultivation **(Islam, 2018).** The progression on the farm power availability in farming sector continued due to provide government assistance to procure selected farm machinery at farmer's level, exemption of import tax on some items, disbursement of fund on the machinery research, extension and capacity building.

Table2. *Farm Power Availability in Agriculture Sector*

Year	Available power, kW ha-1	Source
1950	0.2	**Islam, 2010 and, Anon, 2015b. (Islam, 2018).**
1960	0.3	
1970	0.5	
1980	0.8	
1990	1.0	
2000	1.2	
2010	1.4	
2015	1.8	

DIRECT BENEFITS OF FARM MECHANIZATION

Mechanization of farming is considered as one of the top ten engineering accomplishments in the 20th century **(Tiwari *et. al.*, 2017b).** Farm mechanization has been well-received world over as one of the important elements of modernizing agriculture. The level and appropriate choice of farm mechanization has direct beneficial effects on land and labour productivity, efficient use of farm inputs, increased farm income and the quality of life of farmers. Farm machines also ensure timeliness of farm operations and increase work output per unit time. Suitability to small farms; simple design and technology; versatility for use in different farm operations; affordability in terms of cost and most importantly, the provision of support services are the basic requirement for the expansion of farm mechanization. One of the feasible options to increase crop production in the region is to follow intensive method of cultivation and this could be achieved only by mechanization. The global threats of food deficit also forecast to produce 40% more grain by 2020, most of which will have to come from yield increases and reduced losses through appropriate mechanization. Farm mechanization has the potential to meet the contemporary

challenges and to increase productivity in a sustainable way.

Table2. *Direct Benefits of Farm Mechanization*

Benefits	Value (%)	Source
Saving in seed	15-20	**Tiwari *et. al.*, (2017a)**
Saving in fertilizer	15-20	
Saving in time	20-30	
Reduction in labour	20-30	
Increase in cropping intensity	5-20	
Increase in productivity	10-15	
Reduction in drudgery of farm workers	10-30	

IMPACT OF MECHANIZATION ON AGRICULTURAL PRODUCTIVITY

Agricultural mechanization plays an increasingly important role in agricultural production in the world. **Zaman (1997)** and **Sarker (1997)** revealed that mechanization had a key role to play in agricultural development. It reduces drudgery, increases the safety and comfort of the working environment; it enhances productivity, cropping intensity and production. During the post-green revolution period, the impact of farm mechanization on agricultural production and productivity has been well recognized in Bangladesh. Now, it has been proven that mechanization creates an employment opportunity in rural areas through diversifying the business especially development of skilled manpower and growth of spare parts shops in the village level. More labors are engaged in manufacturing different types of farm machine. Repair and maintenance workshops have been established in the rural areas. It helps in poverty reduction and better livelihood of the rural poor people. Everybody realizes the urgency of mechanical intervention in crop production to minimize the labor demand and increase the crop productivity. It reduces the burden of labor shortage during peak periods, increase the labor productivity and encourages the off-peak employment of labor in rural non-farm activities especially postharvest activities i.e. drying, bagging, cleaning are basically done by the female farmers **(Islam, 2018).**

From the different studies the following impacts of the mechanization on the agriculture given below.

- That farm mechanization led to increase in inputs on account of higher average cropping intensity and larger area and increased productivity of farm labour. (**Verma and Tripathi, 2015**). **(Islam, 2018).**
- That farm mechanization increased agricultural production and profitability on account of timeliness of operation, better quality of work done and more efficient utilization of inputs. (**Verma and Tripathi, 2015**). **(Islam, 2018).**
- That farm mechanization increases on- farm human labour marginally, whereas the increase in off- farm labour such as industrial production of tractors and ancillaries was much more. (**Verma and Tripathi, 2015**). **(Islam, 2018).**
- That farm mechanization displaced animal power to the extent of 50 to 100% but resulted in lesser time for farm work. (**Verma and Tripathi, 2015**). **(Islam, 2018).**
- The cropping pattern and the changes there in depend on a large number of factors like climate, soil type, rainfall, agricultural technology, availability of irrigation facilities and other inputs, marketing and transport facilities and growth of agro-industries (**Neena, 1998; Gadge, 2003; Rashid *et. al.*, 2005**). **(Islam, 2018).**
- **Anon (1991)** reported that hiring of animal was 20 percent more expensive than PT hiring and also supported that cash flow and benefits were higher in multiple use of PTs. Similar results was reported by **Sarker (1997).**
- Mechanization can increase around 20% productivity of cropping system which is not yet well introduced among farmers for a sustainable agriculture **(Das and Hasnat, 2016).**
- The cropping intensity and production of food crops has recently been increased significantly due to adoption of mechanized tillage, irrigation, and spraying operations **(Sarker, 2000).**
- Farm machinery contributes to increase cropping intensity by reducing turnaround time between two crops. **(Islam, 2018).**

- Mechanization can help to increase the cropping intensity by reducing the turnaround time and faster operation of agricultural activities **(Kabir *et. al.*, 2016)**.

Impact of Farm Mechanization on the Farmers

The effects of the farm mechanization on the farmers are in the form of new seed, fertilizer technology, new cultural techniques of farming, modern farming implements and changes in the timing of operations.

Typically, however, improvements in technology also increase the productivity of capital and alter the technological rates of substitution of capital for manpower, reducing the amount of capital that is necessary to replace a unit of manpower at particular levels of output. Other innovations make it possible to reduce the amount of manpower in relation to land needed to produce specified levels of output (**Verma and Tripathi, 2015**).

Mechanization affects the coat structure of agricultural production by:

- Saving labour (manual and bullock)
- Easing jobs
- Increasing yield
- Saving land
- Facilitating the opening up of new land.
- Conserving natural resources

Factors Behind Adoption of Farm Mechanization

Pull Factors

Labor Shortage

Workers have to labour in puddling paddy fields often under high sun and heavy rainfall. The manual irrigation method for lifting surface water to the field from nearby low-lying lands with accumulated surface water from rainfall was highly labour-intensive and involved drudgery. Therefore, escape from the extreme drudgery in manual agricultural works, farm machineries have been hugely accepted by the farmers as an effective and cheap replacement. **Mandal, (2014). (Anon. 2012)**

Mobility

Farm machineries are easily movable from one to another place. So farmer can earn money through business easily. ***(Anon. 2012)***

Affordability

From day by day price and availability of farm machineries become affordable to farmers. So considering the rate of efficiency, time per work, labour it's easy to take decision to buy machineries by paying cash or installment. ***(Anon. 2012)***

Efficiency

Farm machineries can combat human labour with their efficiency. Machines save time, cost and labour. ***(Anon. 2012)***

Return from Investment is High

Farmer can get his/her investment on farm machineries back within 1 to 2 seasons. ***(Anon. 2012)***

Scarcity of Fodder

Growing scarcity of fodder, maintenance of farm animals for providing draft power became costly. This development promoted Mechanization of tillage operations and reduced dependence on animals for providing draft power. **Wohab (2010).**

Push Factors

'Simple' Machine to be Replicated

Local workshops are mostly equipped with repairing parts for the most farm machines. So farmercan easily attach parts or repair their equipment's. ***(Anon. 2012)***

Research and Development Efforts

Under different GoB and donor projects, special effort was given on the farm machineries. Day by day researchers are trying to develop and upgrade local machineries for better quality. ***(Anon. 2012)***

Countrywide and District Level Promotion

Different farm machinery companies open their outdoor services to countrywide district and Upazila level. So farmer can buy in cash or installment and repair facilities easily. ***(Anon. 2012)***

Raw Material Availability

Raw material is locally available and quite cheap. Therefore, local manufacturers can buy necessary raw material easily. ***(Anon. 2012)***

Local Workshops Can Do the Servicing

As the machine is locally produced so farmers can avail the maintenance and repair service at local level. Moreover, because of availability of

numerous mechanics, engine problems can also be solved at the local level. ***(Anon. 2012)***

CHALLENGES OF AGRICULTURAL MECHANIZATION

Taxes and Duties on Imported Machinery

The lifting of imports bans together with the withdrawal of taxes and duties had made import of power tillers and pumps with engines so cheap that the local manufacturers are now out of production. **Khalequzzaman and Karim (2007) Kamruzzaman *et. al.,*** 2009

High Price of Imported Machinery

Bangladesh imports many types of Agricultural Machinery. Prices of this machinery are very high. So, it is beyond capacity of purchase of poor farmers **(Ahmed, 1984).Khalequzzaman and Karim (2007) Kamruzzaman *et. al.,*** 2009

Lack of Applied Research on Agricultural Mechanization

Development of market for local products is very slow. The most urgent needs of the country are for problem oriented applied research and commercially oriented machinery design and development. **Khalequzzaman and Karim (2007) Kamruzzaman *et. al.,*** 2009.

Premature release of machines for economical procedure leads to many, field problems and serious farmers' dis satisfaction. **Khalequzzaman and Karim (2007)**

Inadequate Policy and Actionable Plan

There is no comprehensive agricultural policy and actionable plan for agricultural mechanization in Bangladesh, although there are several policy and policy briefs for agricultural sector, however, only few of them encompasses agricultural mechanization as an important issue. In recent years, Ministry of Agriculture initiated steps for having agricultural mechanization 'Road Map2041' and committee for formulation of comprehensive 'National Agricultural Mechanization Policy' and actionable plan. **Alam & Khan (2017). (Islam, 2018)**

Inadequate Knowledge and Skill

The operators (farmers and custom-hire service providers) of agricultural machinery and equipment are mostly unaware of the operation and maintenance schedule of their machine and equipment. The manufacturing sub-sector is lacking of skilled and experienced workforce almost in all levels of manufacturing, repair & maintenance and management of businesses. **Alam & Khan (2017). (Islam, 2018)**

Small and Fragmented Land Holdings

About 84.39% of the rural households are small having 50-249 decimals of land (**BBS, 2017**) and even this small land holding is fragmented into several plots, make the efficient use of small and medium size power tillers, tractors, transplanters, reapers, mini-combine harvesters and other machinery difficult and lead to the problem of frequent turning and make the operation time-consuming, tedious and expensive. **Alam & Khan (2017). (Islam, 2018)**

Limited Extension Services on Agricultural Mechanization

Implementation of appropriate scale agricultural mechanization would be a solution for sustaining the contribution in GDP and growth of the sector. In doing so, DAE can employ Agricultural Engineers at all administrative levels to ensure appropriate scale extension and dissemination program for the implementation of agricultural mechanization in Bangladesh. **Alam & Khan (2017). (Islam, 2018)**

Poor Quality Machines

For sustainable development of agricultural mechanization availability of quality machines and spare parts at farmers' level is essential. Therefore, with the previous experience and capacity Bangladesh can easily reinstate testing and quality certification of agricultural machinery that will help to build farmers' confidence and enhance growth of agricultural mechanization in Bangladesh. **Alam &Khan (2017)**

Poor After-Sales Services

In most of the remote rural areas of the country, there is a scarcity of quality spare parts, replaceable tools and accessories of agricultural machines in spare parts shop of local hat and bazaars. **Alam & Khan (2017)**

Lack of Quality Raw Materials and Spares

Quality raw materials are needed for quality product. In recent time, due to price hike of imported pigiron and ship breaking scrap the foundries are mostly relying on local irons crap, as a result it becomes hard to maintain the quality of products such aspiston & liner, pump etc., especially the hardness of finished product. **Alam & Khan (2017)**

Lack of Testing and Standardization

The existing agricultural machinery and spare parts industries and workshops in the country do not have standardized quality control facilities

to ensure quality of products. There should be a common facility center in every major areas of agricultural machinery and spare parts production either in public or private sector initiatives. **Alam & Khan (2017)**

Limited collateral free credit to farmers

Banks and other financial institutions do not provide collateral free credit to farmers and LSPs. Few agricultural machinery marketing companies are providing collateral free credit to farmers and LSPs only on tractor. A single digit collateral fee credit is necessary for the growth of agricultural mechanization and overall growth of agricultural sector in the country. **Alam & Khan (2017). (Islam, 2018)**

Poor Farm Roads

Mechanized farming needs accessibility of farm machinery to the crop field. However, most of the rural Bangladesh does not have adequate farm roads. Off-road prime movers like tractors and power tillers can move into uneven crop field, however, most of the machines like combine harvesters cannot reach the crop field. **Alam & Khan (2017). (Islam, 2018).**

Opportunities of Agricultural Mechanization Alam & Khan (2017)

- Farmers are aware and ready to adopt appropriate technologies/ machines for increased crop production.
- Use of traditional crop production technologies involving human muscle and animal power become unattractive.
- Custom-hire Service Providers are quite visible in rendering agricultural machinery services to farmers.
- Significant number of mechanics and repair & maintenance work shops are at the vicinity of the farming community.
- Agricultural machinery production sub-sector have gained quite maturity in production and marketing of agricultural machinery.
- Numbers of reputed private sector agricultural machinery importers are quite active in marketing and after-sales services at farmers' level.
- Government is providing up to 70% subsidy in popularizing selected agricultural machinery.
- Credits are available at commercial banks and NGOs.
- Government initiated committee to formulate National Agricultural Mechanization Policy.

Conclusions and Recommendations

Farm mechanization can facilitate increased output of higher value products while eliminating the drudgery associated with human muscle powered agricultural production. So, there is no doubt that the application of farm power to appropriate tools, implements and machines "farm mechanization" is an essential agricultural input in Bangladesh with the potential to transform the lives and economies of millions of rural families. Moreover, agricultural mechanization in its broadest sense can contribute significantly to the sustainable development of food systems globally, as it has the potential to render post-harvest, processing and marketing activities and functions more efficient, effective and environmentally friendly. Farm mechanization led to increase in inputs on account of higher average cropping intensity and larger area and increased productivity of farm labour. That farm mechanization increased agricultural production and profitability on account of timeliness of operation, better quality of work done and more efficient utilization of inputs. That farm mechanization increases on-farm human labour marginally, whereas the increase in off- farm labour Based on the findings of the study, the following recommendations are made.

- There should be a clear adequate policy statement and strategy on agricultural mechanization to encourage farmers to adopt new, easy, economic technologies related to agricultural mechanization.
- Identification of appropriate machinery for farmers and continuance of maximum subsidy to some extent in distribution of agricultural machinery.
- Farm machinery fair can be organized at upazila level annually by DAE for disseminating and promoting locally made/improved/imported cost effective and eco-friendly farm machinery.

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