Mechanization in Bangladesh: Way of Modernization in Agriculture

M. A. Hossen

Senior Scientific Officer
Farm Machinery and Post-harvest Technology Division
Bangladesh Rice Research Institute (BRRI), Gazipur-1701, Bangladesh

Abstract − *Mechanized agriculture is known as mechanize agriculture deal with tools, implements and powered machinery as inputs to increase farm worker productivity greatly mechanizing the work of agriculture. In recent times, powered machinery has replaced many farm jobs once carried out by manual labour. Agriculture modernization is mostly depends on the promotion of agricultural mechanization that helps to boost up the agricultural and food production. It is vital inputs for agricultural crop establishment, protection, harvesting, processing and adding values which have been neglected historically in Bangladesh. Lack of available farm power in agriculture always compromise the timely and faster land cultivation, labor productivity, crop management, post-harvest losses, yield and value addition. Therefore, development of any area in agriculture is understood by the levels of agricultural mechanization. Agricultural mechanization level of an area is identified in terms of kW per hectare, hectare per tractor, number of tractors for 1000 hectare, and hectare per tractor. Agricultural mechanization has been accelerated in Bangladesh in the recent years. Over the last two and half decades, farm power increased significantly in the country. During last 58 years, it has been increased from about 0.24 kW/ha in 1960 to about 1.82 kW/ha in 2018 which is still low compared to the major industrialized countries of Japan, Italy, France and UK. Many factors and constraints are associated in promotion of mechanization level. Lacking of skilled and experienced workforce almost in all levels of manufacturing, repair & maintenance and sales after services, scarcity of qualified and skilled manpower related to design, drawing, reverse engineering and manufacturing process, lack of modern capital machinery at producers' level and lack of quality and graded materials in production are the major hinders in quality agricultural machinery production and promotion in competitive manner. Type of agricultural machines or required the level of mechanization in any region depends on the socio-economic condition of the people, environmental factors, availability of agricultural labour and technological inputs. Promotional activities (training, demonstration, subsidy on quality machinery); formulates and execute effective short, medium and long terms strategic plan; strengthening capacities on research and development; effective linkage among the different stakeholders; production industries of the selective technologies; appropriate machinery selection, identification and dissemination based on soil, crops and cultures of 88 agro-ecological sub regions; and strengthening standardization played an important roles in promotion of mechanization. Mechanization strategies should be formulated with the specific objectives of studying of soil types, land topography, socio-economic conditions, cropping pattern, average yield, yield potentiality and constraints in each sub regions; present status, potential needs in future marking the priority of different agricultural machinery based on each operation of crop production and processing; region based impact of farm mechanization on yield, production cost, cropping intensity and employment of labor; and present infrastructure facilities and future needs for promotion of farm mechanization status, manufacturing, marketing, after sale services, repair and maintenance facilities, available parts locally etc of agricultural machinery. Government strategies, enhancement of research capacity, effective linkages among the different GOs and NGOs, regional based potential assessment, priority ranking and subsidy on quality machinery, manufacturing capacity building, formation of farmers groups, skilled manpower development, infrastructure reform, ensure sales after service and available spare parts and quality materials are the major approaches to ensure sustainable mechanization as well as sustainable crop production.*

Keywords − Constraints *of mechanization, Appropriate machinery selection, Objectives of mechanization strategy formulation and Available farm power.*

I. Introduction

Bangladesh formally adopted the sustainable development goals (SDGs) and started working on attaining SDGs in 2015 which is built on the Millennium Development Goals (MDGs) and focuses on building a sustainable Bangladesh where environmental sustainability, social inclusion and economic development are equally valued. In accordance of the SDGs to 'Leave No one Behind', the Government of Bangladesh has been taken holistic approach towards implementation of the SDGs by 2030 [12]. The first and second goals - "No Poverty" and "Zero Hunger" are associated with the

present demand of mechanization in rice production. Bangladesh is in the advanced stages of agricultural transformation. Sustainable agriculture mechanization will play a significant role to maintain this transformative. By 2050, Country population is expected to reach 215.4 million. As a result, demand of consumption of staple cereals is also expected to increase radically. However, 44.6 MT of clean rice will be required to ensure sustainable food security [16]. To ensure cereal food security alone in 2050, more than a doubling of production is required [23] from gradually reduced arable land (hectares per person) (Fig. 1). The average size of owned land stood at 0.61 ha in 1988 and significantly declined over time to peak at 0.48 ha in 2007 - a decline of 21 per cent over the last two decades and further decreased to 0.39 ha in 2014 [3].

Total arable land (hectares) in Bangladesh was 7,764,210 as of 2015 [14]. Arable land as a share of land area for Bangladesh was 59.6 % in 2016. Between 1989 and 2016, arable land as a share of land area was decreasing on average by 0.72 % each year, although before that, it grew from 67.7 % in 1969 to 73.4 % in 1989 (Fig. 2). Though Bangladesh agricultural land as a share of land area fluctuated substantially in recent years, it tended to decrease through 1967 - 2016 period ending at 70.6 % in 2016 (Fig. 3). The average value of arable land for Bangladesh during that period was 66.2 percent with a minimum of 58.9 percent in 2012 and a maximum of 73.4 percent in 1989 (Fig. 2).

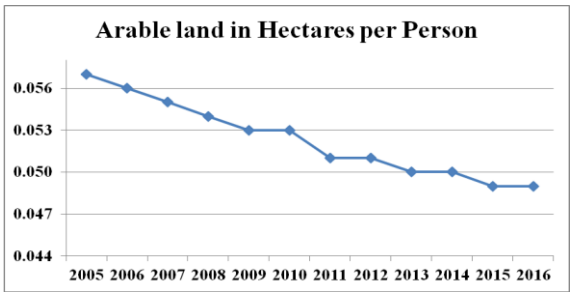

Fig. 1 Bangladesh: Arable land in Hectares per Person [5]

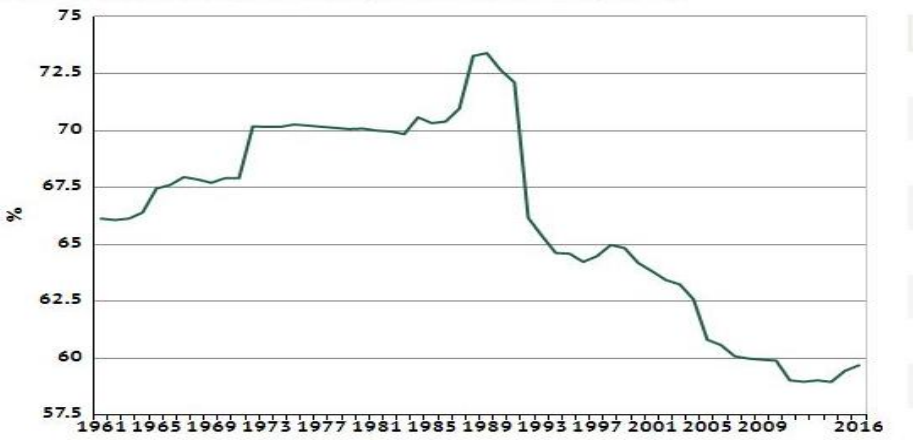

Fig. 2 Arable land as a share of land area [22]

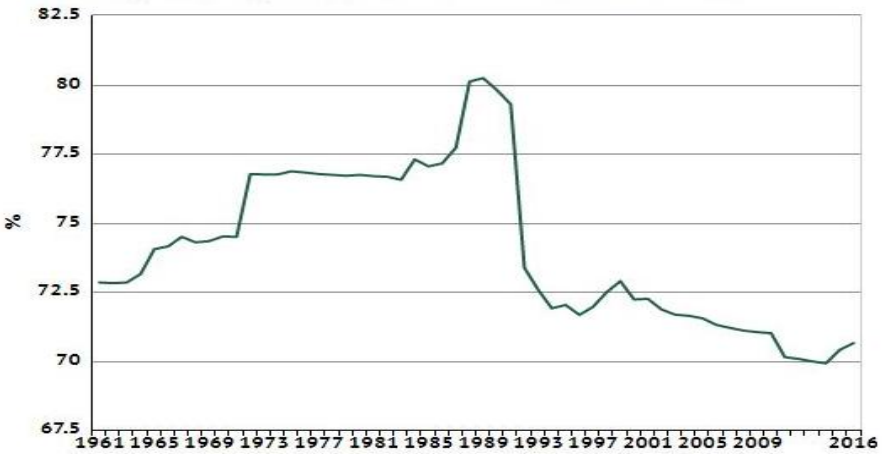

Fig. 3 Agricultural land as a share of land area [22]

The yearly reduction of arable land (0.47%) to non-arable land due to population pressure, urbanization and some non-agricultural purposes is a major concern to agricultural community. Thus, getting more food from less and fragmented arable land would be one of the most challenging issues for the country ensuring appropriate mechanization.

The cropping pattern in Bangladesh agriculture dominantly consist of rice based crops. About 75% of the total cropped area covered by rice

when other crops covered the rest of the cropped area (Fig. 4). Aus, Aman and Boro season separately occupied 8.94, 49.12 and 41.94% area under rice cultivation (Fig. 4). From 2013-14 to 2017-18, total crop area increased about 8% when rice area increased only 2% (Fig. 5).

Rice area, total production, rate of production and cropping intensity increased significantly over the last 45 year. Besides these, employed labor in the agricultural sector decreased remarkably due to increase rural to urban migration with the expansion of non-farm employment opportunities, causing seasonal rural labour shortages [25]. From 1991 to 2018, the average employment in agriculture during the period was 54.84 percent with a minimum of 40.15 percent in 2018 and a maximum of 69.51 percent in 1991 (Fig.6).

In addition, Bangladesh agriculture is strongly interrelated with climatic factors. In agriculture, rice production is affected by deviation in temperature. The effects of climate change (early flooding, flash flood, uneven distribution of rain, severe fluctuation of temperature, seasonal drought, tropical cyclones and storm surges) are already evident in the agro-ecosystem of the country as subtropical region. Introduction of climate resilience variety, timely planting and harvesting and proper management by ensuring appropriate mechanization might help to mitigate the climatic impact on rice production.

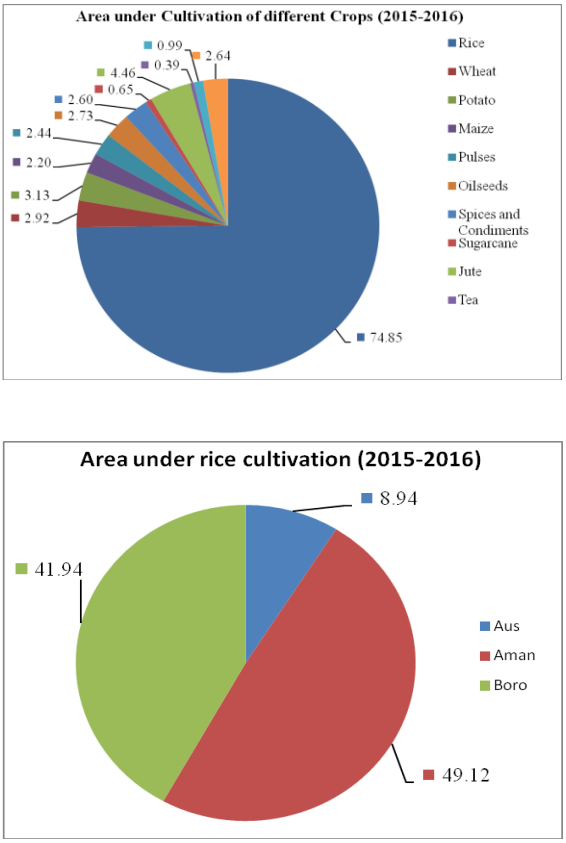

Fig. 4 Area under cultivation of different crops and rice, 2015-2016 [1].

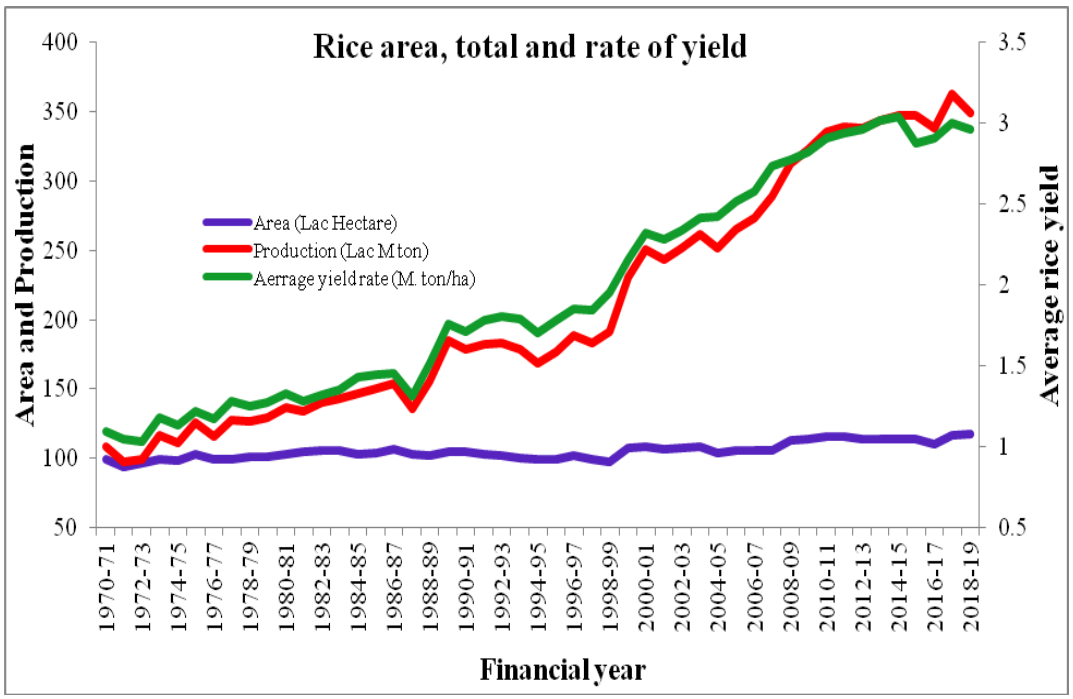

Fig.5. Total rice area, total rice yield and rate of yield from 1970-71 to 2018-19 [2]

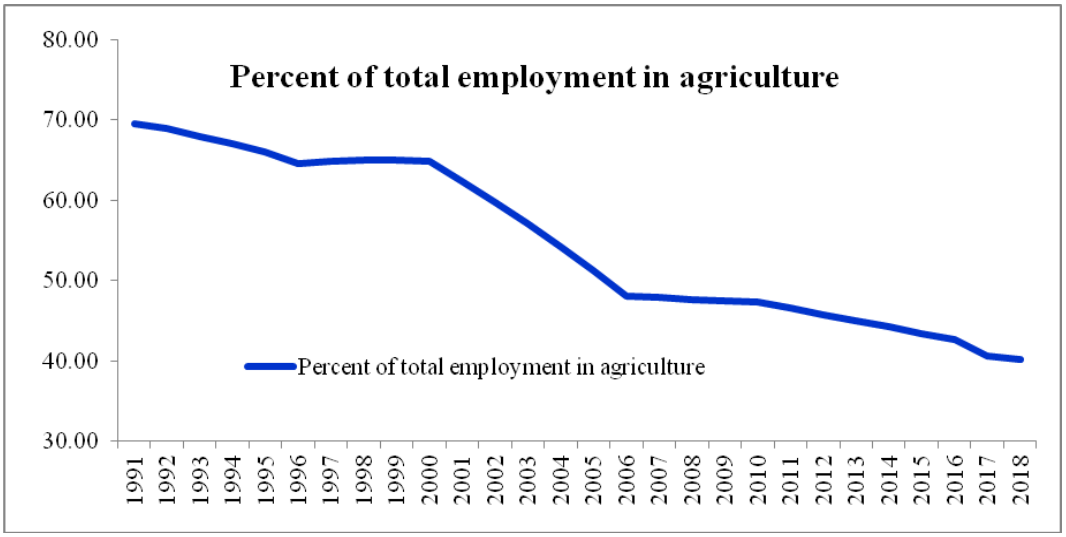

Fig. 6: Percent of employment in Agriculture [2]

In order to make agriculture attractive and sustainable to future generation, rice mechanization is essential for enhancing productivity. Such mechanization will allow timely and faster operation with less drudgery because young generation will not involve themselves with the traditional agriculture as like as hapless farmer labouring behind a wooden plough drawn by a pair of bullocks tilling the fields under the scorching sun. Only modernization in agriculture ensuring mechanization can attract the young generation which will help to increase the cropping intensity by reducing the turnaround time and faster all operation of agricultural activities. However, agricultural mechanization is played a key role in the agro-food value chain process for sustainable production intensification [4]. Therefore, the present paper is mostly focused on the way of modernization in rice production.

II. Importance of mechanization

Agricultural mechanization is the process whereby equipments, machineries and implements are utilized to boost agricultural and food production. It is the application of machineries, equipments, implements and machinery technologies in different farm activities to increase marginal output in food production and poverty eradication. It is vital input for agricultural crop establishment, protection, harvesting, processing and adding values which have been neglected historically in Bangladesh. It determines the efficiency and productivity of all inputs used as direct and indirect inputs in crop production. Mechanization in agriculture requires not only advances in machinery development but also the close cooperation of many issues such as environmental, agricultural, social and economic conditions [18]. It is also benefits from technologic innovations and it is site-specific and dynamic [20]. According to FAO [11],
agricultural mechanization generally involves inputs such as manufacture, selection, distribution, using, repairing, maintenance of mechanical devices (powered machinery, implements, tools) and systems in agricultural operations and their management in crop production with seeds, fertilizer, water, labour, and time [9], but it is often associated solely with tractors and agricultural machinery. Agricultural mechanization is also recognized as one of the greatest engineering achievements of the 20th century that is still differs enormously across the world. Clarke [7] also defined that the adoption of machine in farming operation is increasing day by day in worldwide as it is proven in saving of cost of production and increasing net income of the farmers. Therefore, one of the most important criteria for any area development of agriculture is the levels of agricultural mechanization. It was argued that the agricultural mechanization level of an area in terms of kW per hectare, hectare per tractor, number of tractors for 1000 hectare, and hectare per tractor [19]. Lack of available farm power in agriculture always compromise the timely and faster land cultivation, labor productivity, crop management, post-harvest losses, yield and value addition. Available power supply to agriculture means that all tasks can be completed at the right time and faster way and quality of production can be controlled to ensure market prices while conserving natural resources. Effective and highly efficient technology helps to produce more crops by using less power. Sustainable agricultural mechanization assists to ensure postharvest operation, quality processing, marketing activities and development of value chain effectively as well. To ensure the future challenges in agriculture especially in rice production, agricultural modernization by improving level of affordable mechanization is earnest needed in Bangladesh.

III. History of mechanization

1) The 1960S – Initiation of machinery introduction: The Government of East Pakistan

imported Power Tillers and Power Pumps in the late 1960s as a part of' 'Green Revolution' activities. The Government of Bangladesh also allowed continued import of farm machinery after independence to help mechanize farming activities. During this decade, the 4WT and irrigation equipment (DTW and LLP) were introduced in Bangladesh. The service of 4WT were promoted in the Cumilla area under the cooperative based model of BARD, Cumilla [17] whereas BADC installed DTW in the northern part of the country to supply free of charge irrigation water resulted in limited success [13]. The cooperative based 4WT service were closed due to both technical and management problems at the end of 60s when BADC started its rental service of LLP with rental fees and fuel at 75% subsidy. Throughout the 60s, popularity of LLP increased with the increase of adoption of boro HYV rice in the low lying areas of the country. It is also noted that the overall irrigation system was manual and improved IRRI varieties were yet to be popularized in the country.

2) The 1970S- Public sector involvement: During the 1970s, public investment was made in installing DTWs and increased to around 9000 by 1978. BADC initially continued to own, operate and manage a large number of DTWs and LLPs during the 70s. By the mid of 70s, the total number of LLPs was 35,000 and covered three quarters of the total irrigation area at the time. In 1980 government reduced the tax to 15% and BADC stopped renting out the LLPs rather started selling the new and old reconditioned LLPs to the farmers. In 1979, the government decided to change its policy of direct involvement in the input market and to privatize the marketing of irrigation equipment. This policy change involved the selling off of existing and new LLPs and DTWs, initially to farmers' cooperatives and later to individual farmers. The Bangladesh Krishi Bank (BKB) BKB started its own program of providing credit to facilitate the purchase of STWs through its appointed private farms [13].

3) The 1980s – abolished standardization and deregulation: The 1980s was the most important decade for agricultural mechanization in Bangladesh. In 1981-82, BADC starts offering rental DTWs for sale at subsidized prices with credit from commercial banks and the private sector's import of small diesel engines is banned in response to drawdown of aquifer during the 1983 drought. President Ershad abolished standardization requirements of imported machineries in 1988 and made the market open for import of agricultural

machines (especially power tillers and pumps) at a nominal tariff following a devastating flood that caused loss of large population of draught animal. This action, combined with market liberalization and the lowering of tariffs, resulted in what could be termed as a flood of small engines and associated tillage, pumping and other equipment. In 1987-89, Private sector bans on small engine imports are removed, import duties are eliminated, standardization requirements for equipment are abolished, and tube wells boring restrictions are withdrawn. Overall, during this decade STW and 2WTexperienced a major boost, the number of STWs increased from 93,000 in 1982 to 260,000 in 1990 with a 200% growth [15]. These reforms probably contributed the most in accelerating the mechanization in Bangladesh and continued in the latter decades. In 1995 import of power tiller/2WT was made duty free, along with credit support for purchase of these machineries.

4) The 1990s to date – growth of private sector and increased demand of mechanization: Over the last two decades, a significant number of rural people have migrated to urban centers, looking for higher paying jobs and an escape from agricultural labor. Cropping intensity increased from 153.74% in 1980 to 180.88% in 2010. While research organizations have been innovating and modifying existing machines, private sectors are involved in modifying the machines imported mainly from China and India. While there as many as fifteen manufacturers producing and replicating a number of locally designed machines, there are numerous workshops supporting the current status of mechanization. Documents suggest that around 40,000 small and medium sized metal workshops around the country have been supporting the sector by producing different non-precision machines (weeder, threshers etc.), supplying spare parts as well as providing much needed repair and maintenance services [26]. Importers of machines have been selling the products either through their designated outlets (4WT) or through widely distributed dealers and retailer network (2WT and Diesel engines mainly). It should be noted that local level spare parts manufacturers have been growing to produce specific spare parts of 2 WT, 4 WT and for pumps. It is mainly expanded after national Agricultural Policy of 1999 which is emphasized to meet the deficit of animal draught power through import of machines and raw materials needed for local fabrication with tax relief, providing credit to both users and traders and encouraging formation of user groups / cooperatives for owning or custom hiring of agricultural machinery to help mechanization. But this was not yet implemented fully.

IV. Present development of mechanization

Agriculture plays an extremely important role in Bangladesh's economy as well as agricultural mechanization which has been accelerated in Bangladesh in the recent years. Its level of overall development is still relatively low compared to other South Asian countries. Over the last two decades, the use of mechanical farm power has increased rapidly. However, agriculture contributes 14.23% to national

GDP and employs about 40.6% of the country's population [8]. Raising more crops with high productivity is a path for meeting the future food requirement of Bangladesh. Development, introduction and adoption of high capacity, precision, reliable and energy efficient machinery is the serious need for conservation and sensible use of production inputs.

V. Available power in agricultural operation

Farm Power is an essential input in agriculture for timely field operations for operating different types of farm equipment like operating irrigation equipment, tillers/ weeders/ threshers/ shellers/ cleaners/ graders and other post harvest equipment. Level of available power in agriculture is one of the key indicators for measuring the degree of mechanization. During last 58 years, the average farm power availability in Bangladesh has increased

from about 0.24 kW/ha in 1960 to about 1.82 kW/ha in 2018 (Figure 7). Farm power availability in major industrialized countries such as, Japan, Italy, France and UK are 8.75, 3.01, 2.65, and 2.50 kW/ha, respectively [21]. The power availability in Bangladesh increased from 0.4 Kw/ha in 1990 to around 1.4 Kw/ha in 2011 whereas India's power has also achieved steady growth from 0.92 Kw/ha in 1995/96 to 1.84 Kw/ha in 2012. Many countries witnessed remarkable growth in mechanization. For example: China's power availability per hector reached 3.56 Kw in 2011 and its overall mechanization rate raised from 35% in 2004 to 59% in 2013 [6].

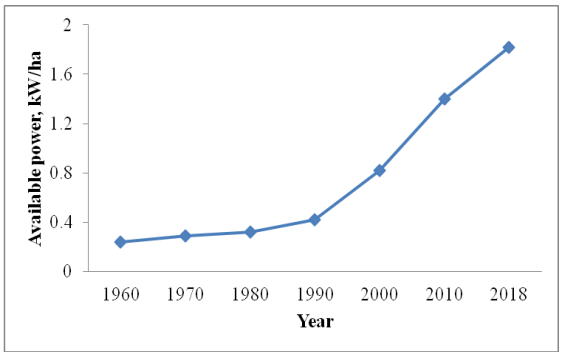

Fig. 7 Status of mechanical power in agriculture over the period

Table 1. Operation based mechanization level in Bangladesh

Operation	Methods	Percentage
Land preparation	Tractor (2 WT and 3 WT) (Tractor, Leveller, Plough, Tillage equipment, Harrower)	98
	Animal/Traditional	2
Planting	Mechanical (Planting machine, Transplanter, Seeder)	5
	Manual/Traditional	95
Intercultural Operation		
Weeding	Mechanical (Power weeder, manual weeder)	8
	Manual	92
Fertilizer	Mechanical (applicator)	5
	Manual	95
Pesticide /Herbicide application	Mechanical	92
	Manual	8
Harvesting	Reaper (PTO reaper, Self-propelled reaper, Combine Harvester, Reaper, Tripper, Stripper header)	7
	Manual (Sickle)	93
Threshing (rice)	Mechanical	97
	Manual	3
Post-harvest	Mechanical (Dryer)	5
	Manual	95
Processing	Mechanical (De-husker, Whitener, Separator, Polisher)	98
	Traditional	2
Storage	Modern	15
	Traditional	85

Source: BARC, BRRI, BARI, DAE, BAU, MoA, Mechanization road map of Bangladesh, 2016.

VI. Factors involved to increase mechanization level in Bangladesh

- Appropriate policies and strategies preparation and implementation
- Subsidies/credit/taxation (import duties, tax on industry) based on importance of the technology
- Research and development efforts
- Research facility and capacity of the research organization
- Target oriented extension service opening agricultural engineering wings over the country

- Farm structure and farm road
- Specialized services establishing entrepreneurship (more accessibility and affordability to farmers through custom hiring/leasing).
- Appropriate training, machinery service provider, available spare parts and skilled operator
- Effective linkage among different stakeholder.

VII. Constraints of Agricultural-Machinery Manufacturing

As a promising sub-sector, agricultural machinery manufacturing industries are running through many constraints.

- There is lacking of skilled and experienced workforce almost in all levels of manufacturing, repair & maintenance and sales after services.
- There is scarcity of qualified manpower in this sub-sector and therefore, lacking of knowledge and skill related to design, drawing, reverse engineering, manufacturing process and quality control, which resulted in production of poor products compromising with the quality and faces hard in marketing and achieve sustainability in the field.
- Lack of modern capital machinery at producers' level resulted in low productivity, poor quality of products, delay delivery of products, increase production cost etc because mostly inexperience small and medium enterprises are involved in this sub sector.
- Lack of quality and graded materials in production. Foundries, pump and spare parts manufacturing solely depend on the imported raw material of pig iron, ship breaking scraps and local scrap iron, steel, brass etc. The supply of old ships for ship breaking industries decreases in recent years due to international competition, especially with China and India.
- The high price and unavailability of raw materials creates a great threat to the domestic Agricultural-machinery and spare parts production in terms of production cost and quality compared with the imported machines and spare parts especially imported from China.

VIII. Up-take of appropriate machinery for rice mechanization

Mechanization in this study is regarded in its broadest sense of implying any tool or practice used to plant, produce and harvest or process an agricultural crop. The major factors of up-take machinery can be stated as follows-

- Machinery user capacities are important factors to invest in agricultural machinery, and to provide services and thus create access to machinery for the other users.
- Farm holding, land size and agricultural practices significantly and positively affected the adoption of agricultural machinery ownership in Bangladesh.
- Appropriate machinery and technology suitable in our conditions, sales after services, repair & maintenance facility, availability of spare parts also played an important role to expand the machinery status.
- Subsidy on machinery and loan facilities significantly and positively affects agricultural machinery ownership.
- The provision of subsidize purchase and loan facilities played an important role to increase the rate of adoption of appropriate machinery.
- Farm infrastructure positively affects the adoption of agricultural machinery in any country. It is thus important to improve the infrastructure in parallel to expand the up-take status of agricultural machineries under any program/project.

Up-take of appropriate machinery for rice mechanization is depends on many other factors which can be summarized in Fig. 8. Appropriate technology/machinery, type of agricultural machines or the level of mechanization needed in any region depends on the socio-economic condition of the people, environmental factors of the respective regions, availability of agricultural labour in that region and technological inputs.

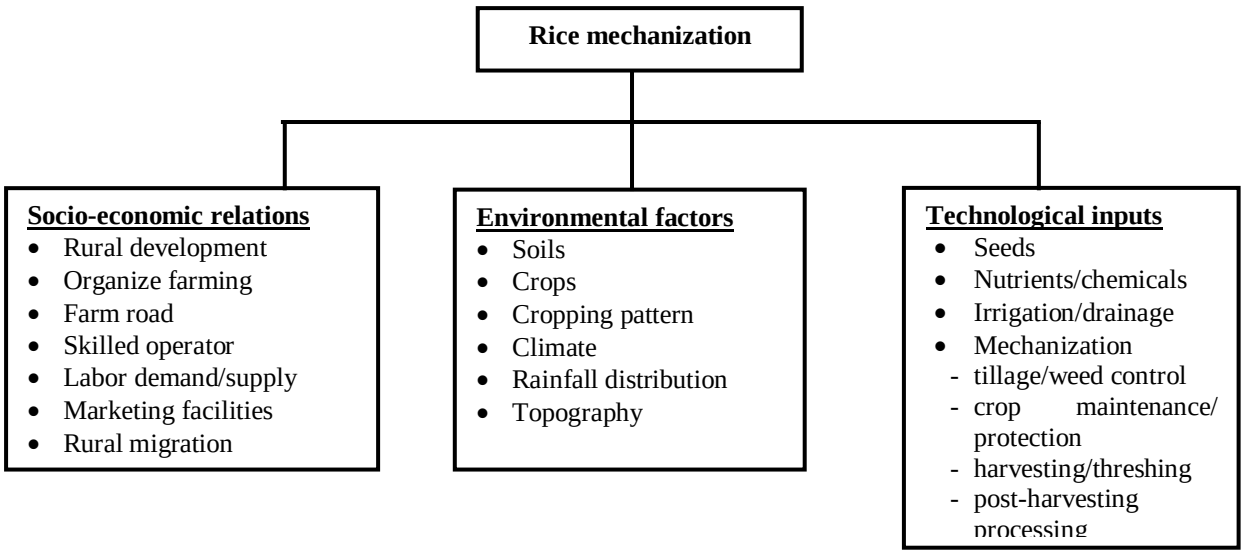

Fig. 8. General aspects of machinery up-take for mechanization

IX. Ways of promote sustainable farm mechanization

Training, demonstration, subsidy on quality machinery, formulates and execute short, medium and long terms strategic plan, strengthening capacities on research and development, effective linkage among the different stakeholders, selective technology based production industries and disseminate appropriate machinery based on soil, crops and cultures of different areas.

- Training: Enhanced effective and hands-on-training on farm machinery and technology. Farm Machinery and Technology Training Institute might be established for providing long and short term training.
- Demonstration: Season, soil, crop and location wise large scale demonstration of all modern machinery and technology at farmers' field.
- Subsidy for Purchase of machinery: Subsidy through a specialized program for all categories of farmers based on priorities of the technology and locations ensuring special benefit to establish custom hiring services.
- Selection and identification of appropriate machinery and technology for-
  - Haor agriculture
  - Hill agriculture
  - Gender friendly equipment and machinery
  - Soil, crop and location specific machinery and technology
  - Reverse engineering and manufacturing
- Quality machinery and technology: Quality is the first priority. Ensure standards quality for power tiller, tractor, rice transplanter and combine harvester; standard specifications for all machinery and technology; revive and strengthen testing institute and implement ANTAM code for certification mandatorily.
- Formulate short, medium and long-term mechanization strategy for each Agro-Ecological Zones of Bangladesh. There are 30 Agro-Ecological Zones (AEZ) in Bangladesh. This 30 AEZ are sub divided into 88 agro-ecological sub regions. Again these are divided into 535 agro-ecological units. Mechanization strategies should be formulated with the specific objectives stated as follows:

a. To study the soil types, land topography and socio-economic conditions of all agro-ecological sub regions.

b. To study the cropping pattern in each AEZ/sub regions, average yield, yield potentiality and constraints.

c. To identify the present status, potential needs in future marking the priority of different agricultural machinery started from land preparation to the post-harvest processing for different crops/cropping systems in each sub regions.

d. To identify the potential needs for short, medium and long terms mechanization strategies in each AEZ/sub regions based on each operation of crop production and processing.

e. To study the region based impact of farm mechanization on yield, production cost, cropping intensity and employment of labor.

f. To study the present infrastructure facilities and future needs for promotion of farm mechanization status, manufacturing, marketing, after sale services, repair and maintenance facilities, available parts locally etc of agricultural machinery.

X. Conclusion

Multi-direction approaches are precondition to increase the mechanization status for modernization in Agriculture to meet the future needs. Operational Government strategies, enhancement of research capacity, effective linkages among the different GOs and NGOs, regional based potential assessment, priority ranking and subsidy on quality machinery, manufacturing capacity building, formation of farmers groups, skilled manpower development, infrastructure reform, ensure sales after service and available spare parts and quality materials are the major approaches to ensure sustainable mechanization as well as sustainable crop production. Further, strengthening of testing standardization and safety measures might also played a vital role in promotion of mechanization.

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