Early trends, current status and future prospects of farm mechanization in Asia

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Abstract: During the last five decades, Asia has made considerable development in the field of agricultural machinery. During the year 1960 the condition of mechanization was very poor and most of the farm operations were performed manually. A positive correlation between the farm power availability and the productivity was observed during past three decades for several Asian nations including China, Pakistan, India, and Bangladesh. The previous trends have shown that Pakistan, India and Bangladesh have experienced only the selective farm mechanization which was found to be initially limited to the use of heavy tractors only. In addition to the full-scale tractors, China, India and Bangladesh have adopted the power tillers and small-scale tractors to co-op with the fragmented small farms, however, in Pakistan the current inclination is towards to the bigger tractors. Asian countries like Nepal, Sri Lanka, Bhutan and Cambodia have relatively low mechanization index and lags behind the other neighboring Asian countries. At present, the farm machinery sector has become much better and Asia now has the largest sales of farm machinery in the world. The sales of farm machinery are even better than North America which is the pioneer in this sector. Besides for this incredible development in the field of agricultural machinery, there are still many Asian countries where most of the farm operations are performed manually thus resulting in the poor crop production compared to the other mechanized regions of the world.

Keywords: farm mechanization, Asia, agriculture, agricultural machinery, mechanization strategy

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1 Introduction

The global population is expected to be 9.6 billion by the end of 2050 (Gerland et al., 2014) resulting to dramatic escalation in the consumption of rice, wheat, maize, fish and other meat products, especially in the developing countries (Godfray and Garnett, 2014). The food security can be ensured by doubling the current production (Tilman et al., 2011). The population problem is severe in the South Asia with dense population clusters recording 399 million poor people in 2011 (World Bank, 2015). In these countries, about 30% to 75% of the population is dependent on the agriculture (World Bank, 2017b) with an average farm size ranging from 0.53 to 2.1 ha (Hossain et al., 2007; PBS, 2010; Singh, 2013). The arable land per capita in Pakistan, India, Bangladesh ranged from 0.17 ha to 0.36 ha in 1960, however, severe floods, water scarcity and salinity issues resulted in the shrinkage of the per capita land to only 0.12 ha to 0.24 ha (Mottaleb et al., 2016; Rao and Gulati, 1994; ur Rehman et al., 2016). Agriculture is still a leading source of income for majority of the population in rural areas, however, the expansion of the non-farm employment opportunities causes the rural population to migrate to cities resulting in the seasonal labor shortages particularly at the time of sowing and harvesting the crops (Zhang et al., 2014). In that context, agricultural mechanization has been advocated as a tool for increasing the land productivity and sustained agriculture (Kienzle et al, 2013;

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Sims and Kienzle, 2017).

Mechanization is a set of different technological tools and expertise that can be used to ensure the increased productivity by performing the field operations in timely manner (Abbas et al., 2017; Kepner et al., 2003). Agricultural yields are usually affected by chemical, biological, mechanical and hydrological inputs. Contribution of the mechanical inputs in farming are generally considered in terms of farm mechanization (Yamin et al., 2010). Farm mechanization play a significant role in the optimization of all the inputs (Yamin et al., 2010). Traditionally, Asian farmers performed most of the farm operations including land preparation, land levelling, tillage, sowing and spraying either manually or using different draught animals (camels, horses, buffalos, mules and bullocks) (Devendra, 2012; Joshi, 2011). Therefore, in the past, agricultural yields were comparatively very low due to the fact that most of the crops were sown by manually. However, currently most of the sowing operations are done by mechanically due to which the yield of crops is far better than the old days (Yamin et al., 2011).

The agricultural productivity of most of the Asian countries is still low compared to the countries in North America and Europe. A very major reason is the non-availability of the appropriate agricultural machines at the right time. This phenomenon is very typical in the sowing and harvesting season (Tahir et al., 2003). Another reason is the inefficient machinery selection due to the low power of farming, non-availability of the standardized product and their seasonal usage (Ahmad et al., 2004; Mehta et al., 2014). Among the Asian countries, China is the only country with an agricultural total factor productivity (TFP) of 3.8% (Zhou and Zhang, 2013). The findings of study conducted by Zhou and Zhang (2013) indicted that an increase in agricultural inputs resulted in 40.6% increase in the agricultural output growth. The study further concluded that the China's agricultural output growth belonged to the type of induced technology innovation. A trend similar to China can be adopted by other neighboring countries for indigenizing and innovating the technology in the field of agriculture mechanization to improve the output growth and overall productivity. Successful implementation of farm mechanization requires an effort by policy makers, legislators, institutions and extension workers to train the local farmers and then introduce new mechanical techniques, modify, expand and adapt these techniques (Paman et al., 2018). This paper is focused on providing the information about the status of different agricultural machines available in different Asian countries.

2 Early trends of farm mechanization in Asia

The traditional means involving draught animals and human labor prevailed as a major source of farm power in Asia until 1980 (Ansari and Raza, 1984; Oshiro, 1985; Chaudhary and Hussain, 1986; Lin, 1992; Kim et al., 2013). The rapid industrialization resulted in earlier adoption of cultivators and tractors in Japan (Morioka, 1976) followed by the Republic of Korea (Yu et al., 2015). Japan lead the development of power tillers in Asian regime in collaboration with the Germany and United States of America (Binswanger, 1986). The indigenization of power tillers resulted in a remarked growth of 2.5 million units in 1965 (Kisu, 1983). The rapid industrialization and urbanization resulted in upgradation of power tillers to commercial four-wheel tractors (Oshiro, 1985; Yu et al., 2015). The number of power tillers in Republic of Korea grew from 1000 units in 1965 to approximately 290,000 by the end of 1980 (Cho, 1983). Farm mechanization trends of China indicated the assimilation of about 5000 small low power tractors (15 horsepower) from the former Union of Soviet Socialist Republics (USSR) (Adekola et al., 2014). A tractor industry was also established in China in 1976 to foster mechanization in country with the help of USSR (Timmer, 1991).

Mechanization of wet rice-lands resulted in the adoption of small power tillers in Southeast Asia. The growth of power tillers in Thailand and Philippines increased from 26 and 14 units in 1980 (Herdt, 1981) to 56 and 20 units per thousand hectares of rice-land during 1990, respectively. The preparation of rice-lands in other Southeast Asian regions showed slower adoption of power tillers (Barker and Cordova, 1978). The adoption of mechanization in South Asia initiated with the import of first tractor in 1914 followed by the installment of pumping systems in 1930 (Singh, 2015a). Across the

Indian plains, farm power supplied by tractors and power tillers increased from 0.020 and 0.001 in 1972 to 0.230 and 0.003 kW ha^{-1} in 1992 (Mehta et al., 2014). In Pakistan, agricultural mechanization was initiated with water pumps in 1950's (Chaudhary and Hussain, 1986). This trend of mechanization was followed by the adoption of tractors, which grew from 18,909 units in 1968 to 97, 373 units in 1980 (Chaudhary and Hussain, 1986). These statistics even grew to 401,700 units by the end of 2004 (GOP, 2004). The farm power mix of Bangladesh consists of power tillers, tractors and lift pumps. The early trends of mechanization showed a rapid rise of power tillers which rose from 200 units in 1977 to 100,000 units in 1996, however a very steady growth of only 1700 tractors was observed during that period (Roy and Singh, 2008). Similar to Bangladesh and Southeast Asian countries, the major sources of farm power in Sri Lanka, Nepal and Bhutan were small power tillers / two-wheel tractors (Justice and Biggs, 2013). However, the mechanization index of Nepal and Bhutan is still very low and lags behind the other counties of South Asia (Biggs and Justice, 2015).

3 Current status of farm mechanization

3.1 Farm labor drain and mechanization

Most of the Asian countries are heavily dependent on the agriculture for economic growth and poverty management (Moon and Lee, 2013). Despite the economic structure of this region has changed considerably due to the rapid industrialization and urbanization, agriculture is still a key player for providing job sources to majority of Asian populations (Turok and McGranahan, 2013). The share of agriculture in the gross domestic product (GDP) (Table 1) and percentage of population involved in agriculture (Figure 1) of different Asian countries indicates the heavy reliance of agriculture

Table 1 Contribution to GDP by agriculture in Asian and Pacific countries (%) [World Bank, 2017a]

Country	Percentage of GDP associated with agriculture					
	2002	2005	2008	2011	2014	2016
Afghanistan	38.47	31.75	25.39	24.51	23.46	21.91
Nepal	38.59	36.35	32.73	38.29	33.81	32.98
Bhutan	26.34	23.18	18.97	17.12	17.74	16.43
Pakistan	23.35	21.47	23.11	26.03	24.87	25.23
India	21.46	19.51	18.44	18.53	18.02	17.35
Bangladesh	21.69	19.6	18.47	17.71	16.11	14.78
Sir Lanka	14.28	11.82	13.38	9.603	8.59	8.215
Maldives	6.74	7.83	5.658	4.122	3.54	3.212
Cambodia	33.19	32.74	35.23	37.11	30.92	26.66
Myanmar	54.53	46.69	40.28	32.49	27.83	28.2
Magnolia	21.50	22.06	21.41	11.79	14.72	13.31
China	13.30	11.64	10.25	9.44	9.06	8.56
Fiji	15.32	14.06	12.69	10.87	11.45	11.26
Indonesia	15.46	13.13	14.48	13.51	13.34	13.45
Iran	7.90	6.62	6.39	5.879	9.34	N/A
Japan	1.39	1.12	1.06	1.081	1.07	N/A
Malaysia	8.99	8.26	9.97	11.45	8.88	8.65
South Korea	3.76	3.15	2.59	2.517	2.33	2.19
Philippines	13.15	12.67	13.24	12.72	11.33	9.65
Thailand	8.70	9.20	10.08	11.59	10.08	8.34

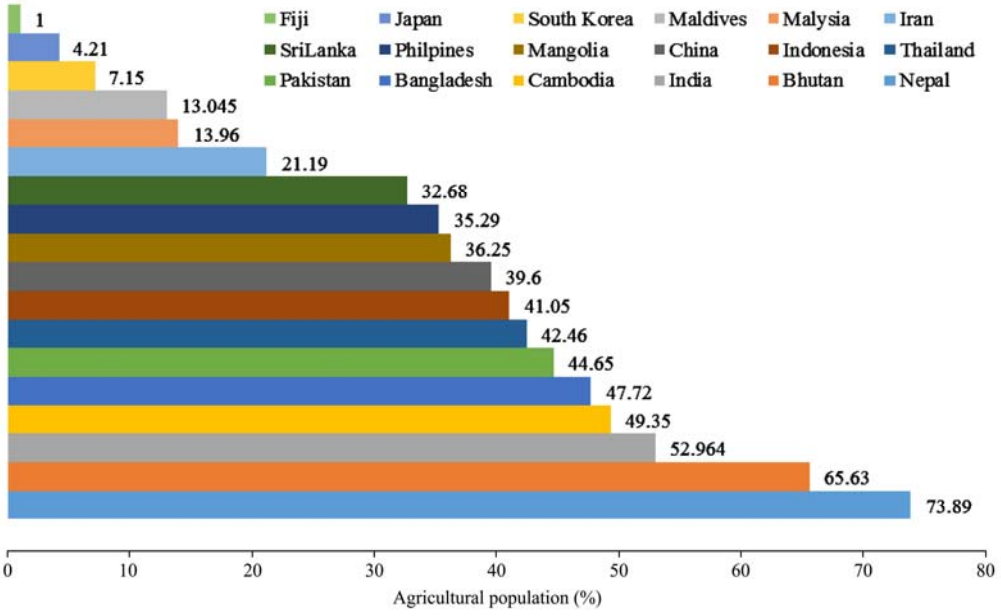
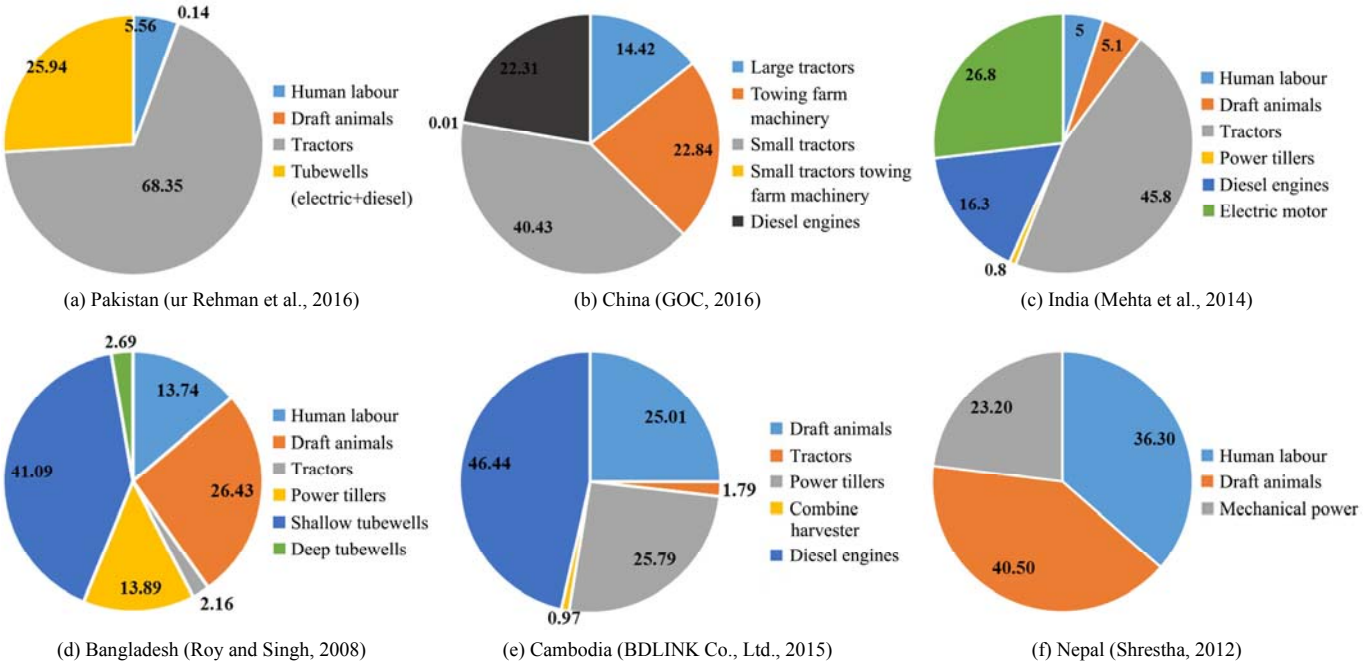


Figure 1 Involvement of population in agriculture sector as percentage of the total employment in different Asian countries (World Bank, 2017b)

sector on farm labor. The share of agriculture in the GDP of South Korea is less than 5% which shows that agriculture is not an important sector in the economy of this country now. About 74% of total population in Nepal is involved in agriculture, however only the contribution of this sector to agriculture is about 33%, thus indicating a wide gap in terms of productivity (Lindberg and Sproule, 1998). Similarly, agriculture has a share of approximately 25% in GDP of China, Pakistan, India, Thailand, Indonesia, and Philippines but the population involved in agriculture sector in these countries is around 30%-60% (World Bank, 2017b). Malaysia and Korea are the only countries where the population involved in agriculture is less than 10%, however the contribution of agriculture to GDP of these economies is proportional to the farm labor. Though, with rapid industrialization, agriculture has lost its fair share in the GDP of many Asian countries, it is still a key player in most of the Asian countries with a considerable share of population being employed by agriculture. Based on the previous trends, a decrease in the total number of farm operators can be projected (Chang and ur Rehman, 2017; ILO, 2014).

3.2 Current dynamics of Asian farm power sources

Currently, different types of power sources are being used for performing different farm operations in Asia. These include tractors (both four-wheel - 4WT and two-wheel- 2WT, self-propelled machines), draught animals and human labor. Strictly speaking, many Asian countries are still using human power (Figure 2) for performing different farm operations such as rice transplanting, spraying, sowing, seed broadcasting and fertilizer application, harvesting of crops and vegetables, threshing of crops by beating action, weeding and loading of agricultural products for transportation (Mehta et al., 2014; Roy and Singh, 2008; Shrestha, 2012; Singh, 2015a; ur Rehman et al., 2016). About 5% of the total farm power available to the Pakistani and Indian agricultural sector is through the human labor (Mehta et al., 2014; ur Rehman et al., 2016). Bangladesh is currently using 14% of the human power for agricultural production. Nepal and Cambodia have the highest share (36% and 25%, respectively) of the human power involved in agriculture. China is the only selected country where no human labor was found to be involved with agricultural production (GOC, 2016). Similarly, India is using about 5%, while Bangladesh and Cambodia are using approximately 25% of the draught animal power. Currently, Pakistan is the only country with less than 1% of the draught animals associated with the agriculture. Even more than the human labor involvement, Nepal has the highest share (40.50%) of draught animals. China, Pakistan and India are the only countries with significant proportion of the large 4WT. The farm power mix of Pakistan includes 68.35% of the



(a) Pakistan (ur Rehman et al., 2016) (b) China (GOC, 2016) (c) India (Mehta et al., 2014)

(d) Bangladesh (Roy and Singh, 2008) (e) Cambodia (BDLINK Co., Ltd., 2015) (f) Nepal (Shrestha, 2012)

Figure 2 Percent share of different farm power sources available in the selected countries of Asia during 2008-2015

tractors, while in India and China around 45.8% and 14.42% of the farm power is associated with 4WT. In Bangladesh and Cambodia, only 2.16% and 1.79% farm power are accessible through the 4WT, respectively. Two-wheel tractors are mostly used in Asian countries for performing the tillage operations as well as for transportation of agricultural products (Biggs and Justice, 2015). The 2WT are also refereed as the power/rotary tillers because of their use for the tillage applications. Currently, China, Bangladesh and Cambodia are the biggest consumer of the power tillers with 40.43%, 13.89% and 25.79% of the total available farm power, respectively. Sometimes, 2WT are also be used to operate threshers and pumps by providing a belt and pulley mechanism (Biggs and Justice, 2015). Electric motors and stand-alone diesel/gas engines are used for the water pumps, graders, processing machines, threshers, cleaners and winnowers in many Asian countries. Currently, China, Pakistan, India, Bangladesh and Cambodia have 22.31%, 25.94%, 43.1% (26.8% + 16.3%), 43.78% (41.09% + 2.69%) and 46.44% share of electric/engines in the total farm power. Though some of the selected countries have the high share of the mechanical power (4WT, 2WT, engines, electric motors), they are not enough to achieve the required high productivity goals (Sims and Kienzle, 2017).

3.3 Mechanical/electrical power sources available in Asian region

The water and land resources in Asia are overburdened at present and there is a need to efficiently use these resources by providing significant energy inputs so that the increasing food demands can be met efficiently (Sims and Kienzle, 2017). Farm mechanization can play an important role in applying the inputs like fertilizers, water, seeds and chemicals efficiently at proper place, time and quantity (Abbas et al., 2017; ur Rehman et al., 2016; Yamin et al., 2011). The use of animal power as power source has been significantly decreased in Asia since 1990s (Pearson, 1993). The use of animal power in India was decreased up to 50 million in 2010 which was 85 million in 1975 and it is predicted that it will decrease to 18 million in 2030 (Mehta et al., 2014). The power availability for farm mechanization in India was 2 kW ha^{-1} during 2013. Tractor was a major source of power with 46% contribution and the share of electric motors and animal draught power were 27% and 5% respectively (Mehta et al., 2014). Most of the draught animals in Bangladesh were killed by cyclones and these animals were replaced by two-wheel tractors (UNDRO, 1988; Mottaleb et al., 2013; Mottaleb et al., 2016). Currently, there are more than 700,000 power tillers are used to prepare over 80% of the cropland in Bangladesh (Ahmmed, 2014). Similarly, in China the draught animals will be completely replaced by tractors in 2025 (Bai, 2014). In regard to the water pumping, it has been observed that water pumping and crop processing are the agricultural operations where the mechanization level is high as compared to the harvesting operations and crop caring operations (Pingali, 2007). Though there is a problem of water table depletion due to over pumping of groundwater (Glazer and Likens, 2012), the use of pumps for pumping ground water has been increased many times in Asia during the last few decades (Mehta et al., 2014; Molle et al., 2003; Roy and Singh, 2008; ur Rehman et al., 2016). In India, the number of ground water pumps grew from 100,000 in 1960 to 25 million in 2007 (Moench, 2002; Shah, 2013). In Punjab province of Pakistan, the number of pumps increased from few thousands in 1960 to 0.8 million in 2014 (Qureshi, 2015). Similarly, in Cambodia the number of water pumps was only 0.06 million in 2001 and it increased up to 0.231 million in 2012 (Saurth, 2014). Currently, 55% of the cropland in Bangladesh is irrigated with a total of 1.63 million tube wells and lo lift pumps (BBS, 2011; BADC, 2013). Most of the farm operations in Korea, Japan and Russia have already been mechanized. Similarly, land preparation and agricultural products transportation process have been mechanized in many Asian countries like Pakistan, China, Malaysia, India, Vietnam, Thailand, Sri Lanka and Bangladesh, which use four wheels and two wheels tractors. Combined harvesters are common farm machines in Malaysia, and it is also becoming a common machine in many other Asian countries like China, Thailand and India. There are many Asian countries like Nepal, Bangladesh, Indonesia, Fiji, Thailand, India and Vietnam where animal power is still being used for many farm operations. Similarly, many farm operations like spraying, rice transplanting, weeding, crop harvesting

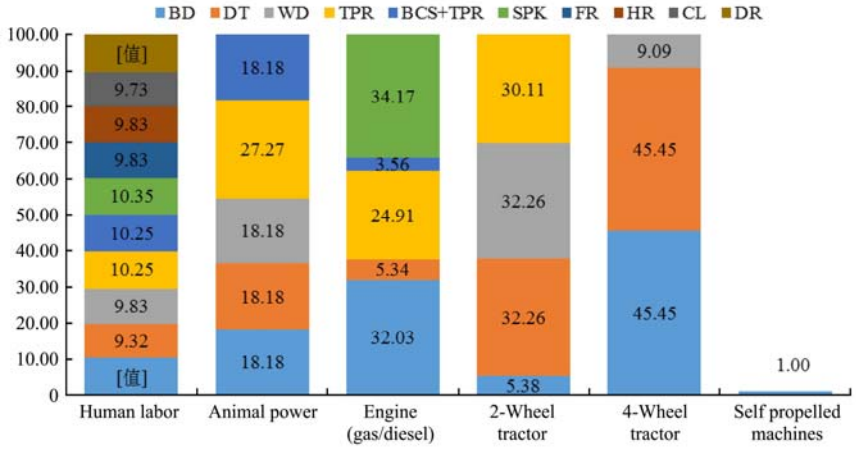
seed broadcasting, picking of fruits, sorting and cleaning are still being done manually in many Asian countries except Korea, Japan and Russia. The number of 4W tractors, 2W tractors, irrigation pumps and combine harvesters and power available in selected countries is given in Table 2.

Table 2 Number of four-wheel tractors, two wheel tractors, pumps and combine harvesters and available farm power in Asian region [Singh, 2015b]

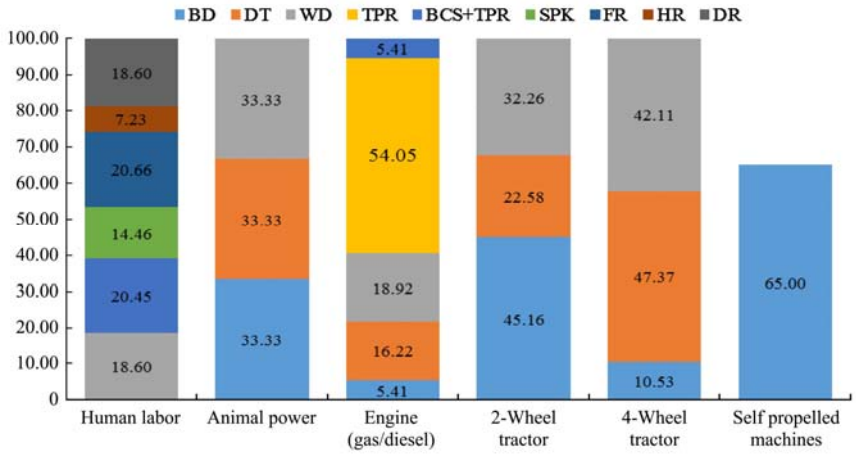
Country	4W Tractors (000's)		2W Tractors (000's)		Irrigation pumps (000's)		Combine harvesters (Units)		Power (kW ha^{-1})	
	1990	2013	1990	2013	1990	2013	1990	2013	1990	2013
Bangladesh	5	60	10	700	220	1729	0	130	0.3	1.83
Cambodia	0.3	9.5	0.5	152	1	256	0	4580	-	1.32
China	814	5270	6981	17523	7255	22068	39588	1421000	2	5.7
India	1200	5430	31	440	12900	28000	4500	38000	0.75	2.02
Indonesia	4	2.8	17	71	-	-	-	-	0.3	-
Rep. Korea	31	278	739	640	326	350	32900	78854	-	10.6
Malaysia	2.5	8	2.1	35	70	N/A	44	1700	0.24	0.2
Nepal	6	30	1	12	23	550	0	-	0.22	-
Pakistan	231	573	5	2	288	1050	1300	9000	0.75	1.1
Philippines	6	-	32	-	107	-	-	-	0.39	-
Russia	1366	260	N/A	N/A	79.4	5.2	407800	67900	2.67	1.48
Sri Lanka	15	1.5	24	2.8	52	-	-	1099	0.43	-
Thailand	45	334	583	1750	851	2320	2250	15000	0.89	2.5
Vietnam	5.2	170	20	380	168	2170	0	20000	0.61	1.7

3.4 Level of mechanization for different operations

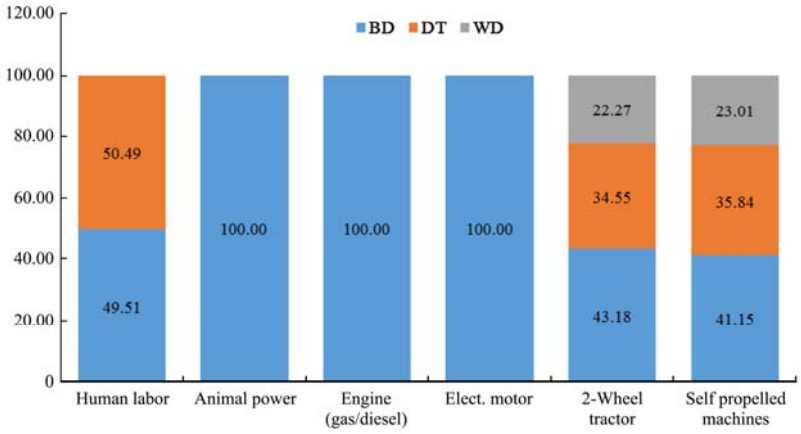
The level of mechanization varies from crop to crop for different operations in Asia. Similarly, it also varies from region to region in large countries like China, India, Pakistan and Russia (Singh et al., 2015a). It also varies for same crop for different operations in same country (Tahir et al., 2003). In 2013, the mechanization level of China for crop planting, tillage and harvesting was 59.5%. The mechanization level for panting was 48.8%, for tillage 76% and for harvesting it was 48.1% (Figure 2).



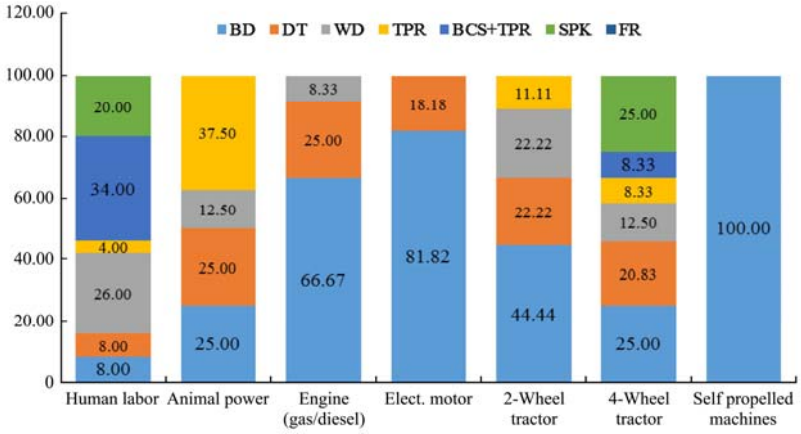
(a) Bangladesh



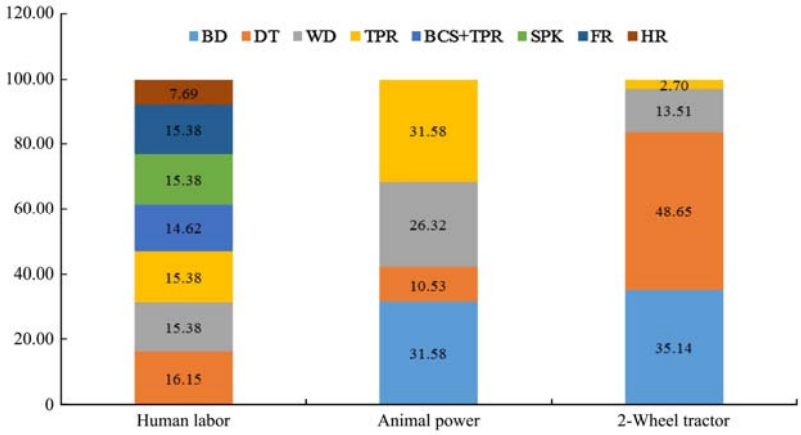
(b) Cambodia



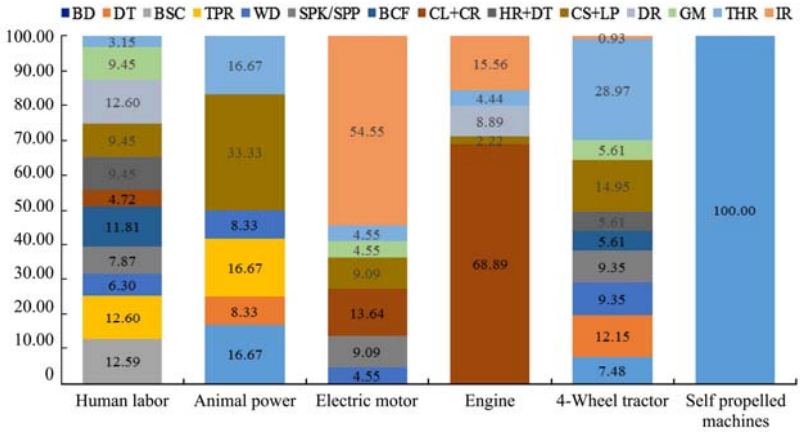
(c) China



(d) India



(e) Nepal



(f) Pakistan

Figure 3 Present status of agricultural mechanization in Asia-Pacific countries [Singh, 2015b]

The mechanization level of wheat was the highest with a value of 93.7%, rice was at the second rank in mechanization level with a value of 73.1% and maize was at third with mechanization level value of 59.5%. The mechanization level for tillage operation of wheat, rice and maize were 98.9%, 95.1% and 76% respectively and for sowing the mechanization level were 86.7%, 31.7% and 84.1% respectively. The mechanization level for harvesting of wheat, rice and maize crop were 93.8%, 80.9% and 51.6% respectively. The mechanization level varies for the same crop and same operation in different parts of China.

4 Future prospects of farm mechanization

4.1 Local production and imports of farm machinery

In 2015, there was a sale of about US$ 50 billion of agricultural machinery in Asia which is the largest in the world (World Bank, 2015). In 2012, the global export value of the agricultural machinery was US$ 120 billion with China and India having a share of US$ 50 billion and US$ 15 billion, respectively. Asia has become one of the largest manufacturers of agricultural machinery. According to a report from FAO about 30.48 percent of globally sold tractors in 2004 were produced in Asia, and India was the largest seller of tractors in Asia in 2004. About one third of the world tractor production take place in India. India had produced about 0.31 million tractors in the year 2007, 0.35 million tractors in 2008 and 0.35 million tractors in 2009. There are about 13 industries in India for manufacturing of tractors and many other industries for producing other agricultural machinery and tools. Due to this rapid increase in the production of agricultural machinery and tractors the total power availability of the country has also been increased from 0.295 kW ha^{-1} in 1991 to 1.231 in 2001 and it is increasing at the rate of 41.7 percent per year. China is at second position in terms of production of tractors in Asia and it is expected that the production of tractors and other farm machinery will increase more in the future.

China, Korea, India, Pakistan and Japan are the major producers of four-wheel tractors (two axle) in the Asian region. Other Asian countries usually import tractors form these countries of Asia. Two-wheel (one axle) tractor are also being produced in many Asian countries like Japan, Thailand, Indonesia, India, Vietnam, China and Korea. Other Asian countries like Cambodia, Bangladesh, Laos, Nepal and Sri Lanka import two-wheel tractors mainly from China. Cambodia also purchase two-wheel tractors from Thailand. Combined harvesters are mainly produced in Japan, India, Korea and China. Thailand also produce track type combines which is mainly used for harvesting of rice from wet fields. Other countries of Asia are importing combines from these countries.

Most of the Asian countries are producing electric motors and engines (Diesel and Gasoline) except Nepal, Laos, Fiji and Cambodia. Similarly, many Asian countries are producing farm machinery powered by two or four-wheel tractors. But some of the Asian countries are still importing these from Korea, India, Japan, Thailand and China.

In 2012, there were about 2040 large scale agricultural machinery manufacturers in China with annual output value of RMB 338.2 billion Yuan and the value of agricultural machinery import, and export was about USD 11.255 billion. The total power of agricultural machinery was about 1.039 billion kilowatts. The number of large and medium sized tractors was about 5.2702 million and that of combine harvesters was about 1.4210 million.

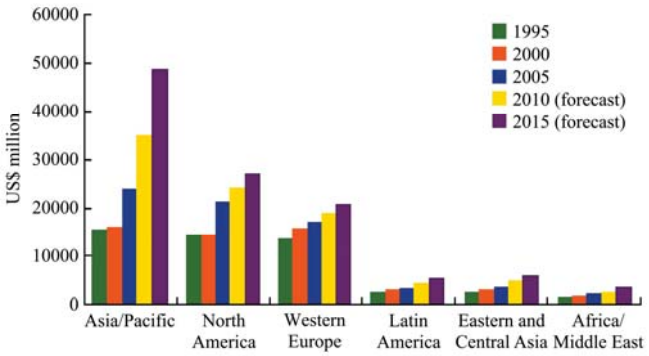


Figure 4 World sales of agricultural machinery 1995-2015 (Mrema et al.,2014)

4.2 Challenges

4.2.1 Small land holdings

Most of the farm in Asian region are small (<2 ha). It has reported by World Bank that about 90% of the small farms of the world are in Asia (Mrema et al., 2014). The number of small farms in Asia is about 500 million. The average land holding of Asian farmers is about 1 ha. The average land holding for Bangladesh, India, Nepal and

China is 0.5 ha, 1.2 ha, 0.7 ha and 0.54 ha respectively. In some Asian countries, this land is made up of many small plots which are scattered at different places in the same country. The large size machines like tractors and combines cannot be purchased for the small pieces of land. Most of these small farmers are poor and they have no capacity for investment even for small two wheel tractors. These farmers usually rent equipment in the peak season when there is shortage of labor. The size of operational plot can be increased by consolidating the land holding at one or two places which will reduce the cost of operation of large machines for the farmers.

4.2.2 Limited manufacturing capacity

The number of well-developed farm machinery manufacturing industries is small in Asian region. India, Korea, Japan and China are the only countries who have well established farm machinery industries in their countries. Some countries like Pakistan, Indonesia, Vietnam and Thailand have also manufacturing industries for farm machines but usually import many machine components from other countries. Similarly, some of the countries like Philippines, Bangladesh and Sri Lanka manufacture the farm equipment like seed drills, irrigation pumps plow, threshers and harrows at local level but they import the prime movers like motor, engine and tractors form other countries. Few countries like Fiji, Nepal, Mongolia, and Cambodia have very limited capacity for the manufacturing of farm machinery and they import the farm machines from other countries of Asia. The use of such equipment may result in fatal accidents and injuries.

4.2.3 Shortage of power and fuel

Most of the Asian countries currently are facing the energy crises due to which there are regular shut down. Due to these load shedding, workers sit idle for many hours in factories. Due to this problem the productivity of the workers decreases, and the production cost increases. These frequent shutdowns also affect the quality of the product. Small and medium sized industries cannot afford their own power generation plant, but large industries usually have their own power plants.

These large industries are also facing the problem of fuel shortage for their own power plant in many countries. Due to the increased cost of fuel, these industries have to increase the cost of the products. It is therefore necessary for the government to supply reliable power to these industries to produce good quality and cheaper products.

4.2.4 Need for institutional framework at regional level

The use and manufacturing of farm machinery is gradually increasing in whole Asia. Currently, the main challenge of the region is the need of collaboration between the industry and research and development institutes so that the quality of the product can be increased, and the cost can be decreased. In Europe and North America, the academic and research institutes are working with collaboration which is the main reason of success of farm machinery manufacturing industries in these regions. Therefore, the collaboration between the industries and research institutes should be encouraged for licensing and patenting innovative technologies in the region. There is also a need of standards and testing of the technologies which is being developed in this region. The Asian and Pacific Network for Testing of Agricultural Machinery (ANTAM) is the main institute of Asia which provide this opportunity by establishing testing centers at regional level.

5 Conclusions

Mechanization has a huge impact on the agriculture development as well as on the livelihood of the farmers in Asia. There is a vast gap in agricultural mechanization in different regions of Asia as well as in the different regions of the same country due to the lack of transfer of technology and testing standards. There is a need of development of mechanization in Asian region for the development of agriculture as well as the increasing food demands of the region. ANTAM should be established with its sub centers in all the Asian countries so that the quality and standards of produced machinery can be checked at local level in each country. There is a need to develop a policy of mechanization for each Asian country for the development of mechanization in each country.

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Nomenclature

BC	Broadcasting
BCS	Broadcasting Seed
BCF	Broadcasting Fertilizer
BD	Bund Making
CC	Crop Care
CE	Crop Establishment
CL	Cleaning (Winnowing)
CR	Crushing
CS	Corn Shelling
DR	Drying
DT	Ditch Making
FR	Fertilizing
GM	Grass Mowing
HR	Harvesting
HRC	Harvesting with Combine Harvester
HRR	Harvesting with Reaper
IR	Irrigation
IRE	Irrigation using Engine
IRM	Irrigation using Electric Motor
LL	Land Leveling
LP	Land Preparation
LPD	Land Preparation Dry
LPW	Land Preparation Wet
PL	Planting
PR	Processing
SP	Spraying
SPK	Spraying using Manual Sources (Knapsack)
SPP	Spraying using Power Sources
SW	Sowing
TH	Threshing
THW	Threshing Wheat
THR	Threshing Rice
TP	Transplanting
TPR	Transplanting Rice
TP	Transport
WD	Weeding
N/A	Not Available