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Current status and overview of farm mechanization in Pakistan – A review

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Abstract: Economic growth in Pakistani agricultural sector lags behind growth in industry and services, creating an ever widening rural-urban income fissure. Agricultural mechanization plays a strategic role in improving agricultural production and productivity in developing countries. The average farm size in Pakistan is small (2.5 acres) and small and marginal land holdings (less than 2.0 ha) account for 85% of land holdings. Mechanizing small and non-contiguous group of small farms is against 'economies of scale' for individual ownership of farm machinery. It was observed that there was a direct correlation between farm power availability and productivity during the past six decades. Being an agrarian country, mechanization can be called as back bone of Pakistan's economy as it optimizes the use of biological, chemical and hydrological inputs. So far, Pakistan has only experienced selective farm mechanization as this concept has remained limited to use of tractors only and at the country level, the temporal analysis shows that an increase in tractor population from 1975 -1984 was about 341% while it was 61% from 1984-1994. At present there are about 0.94 million tractors in Pakistan, which alone provides 0.84 hp/acre. Land preparation is the only operation that is nearly 100% mechanized in the country for almost all crops with 901 thousand chisel plough and 108 thousand Mould board ploughs. The market of planting and spraying machinery has grown from 70 and 21 thousands in 2004 to 295 and 1438 thousands in 2014 respectively due to the inclination of the farming community towards mechanized sowing and spraying. The thrasher's market in Pakistan is estimated at 20,000-30,000 units annually by sales resulting in nearly 100% mechanized threshing operation for cereal crops. By increasing the available horse power per hectare and by the proper management of agricultural machinery the average crop yield can be enhanced.

Keywords: farm mechanization, tractor population, farm power, agricultural machinery

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1 Introduction

Economic growth of Pakistan is firmly linked with the agriculture. Agricultural sector accounts for 21% of the gross domestic product (GDP) and with all other agro-based products brings 80% of the country's total export earnings (Majeed and Saifullah, 2014). Agricultural productivity is affected by mechanical, biological, hydrological, and chemical inputs. Contribution of the mechanical inputs in farming is considered in terms of farm mechanization (Yamin et al., 2010). To optimize the use of biological, hydrological and chemical inputs, farm mechanization plays a vital role. In Pakistan, farm mechanization started in early fifties in the form of private tube wells to pump the ground water for irrigation purposes with the help of mechanical power (Chaudhary & Hussain, 1986). However, initially a large number of farmers were reluctant to adopt the farm machinery due to their illiteracy and rigidity for the use of the conventional methods (Yamin et al., 2011). But with the passage of the time, farm mechanization proved to be beneficial in increasing agricultural productivity by saving time, water and other agricultural resources.

The agricultural production is low in Pakistan as compared to the other countries of the world. This is mainly due to the non-availability of appropriate

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agricultural machines to the farmers at the right time, thereby delaying the farm operations particularly at sowing and harvesting of the crops (Tahir et al., 2003a). Inefficient selection of agricultural machines due to low buying power of farming community, non-availability of standardized products and their seasonal utilization is also responsible for limited productivity of county's farmlands (Ahmad et al., 2004). Furthermore, limited number of repair and maintenance facilities around the country resulted in reduced life and poor performance of agricultural equipment (Tahir and Azeden, 2015). Additionally, the horse power per acre available in the country is just 0.84, which is low compared to the neighboring country India (1.01), China (1.57) and Japan (2.83) (Baruah and Bora, 2008). This low power input at the farms of Pakistan has resulted in crop losses of 15%-20% in cereals and 40% to 45% in fruits and vegetables, which can be minimized by increasing power availability for performing timely crop production, harvesting and post-harvesting operations. Appropriate mechanization can also save 15%-20% seeds, 15%-20% fertilizers, 20%-30% working time and 20%-30% labor at the farms. In addition, it can increase cropping intensity by 5%-20% and 10%-15% crop productivity (Singh, 2006).

In Pakistan, agricultural mechanization is limited to tractor and cultivator only. Due to conventional farming ways and less involvement of innovative technology, country is facing serious problems of yield gap (FAO, 2012). There is huge gap between production potential and average yield (Figure 1). Moreover, the drastic increase in the population is seriously threatening the food security policies of the country. Therefore, a serious escalation in agricultural productivity is essentially required to secure the agricultural future of the country. The latest technology should be involved in agricultural sector, to foster agricultural productivity and to fill yield gaps.

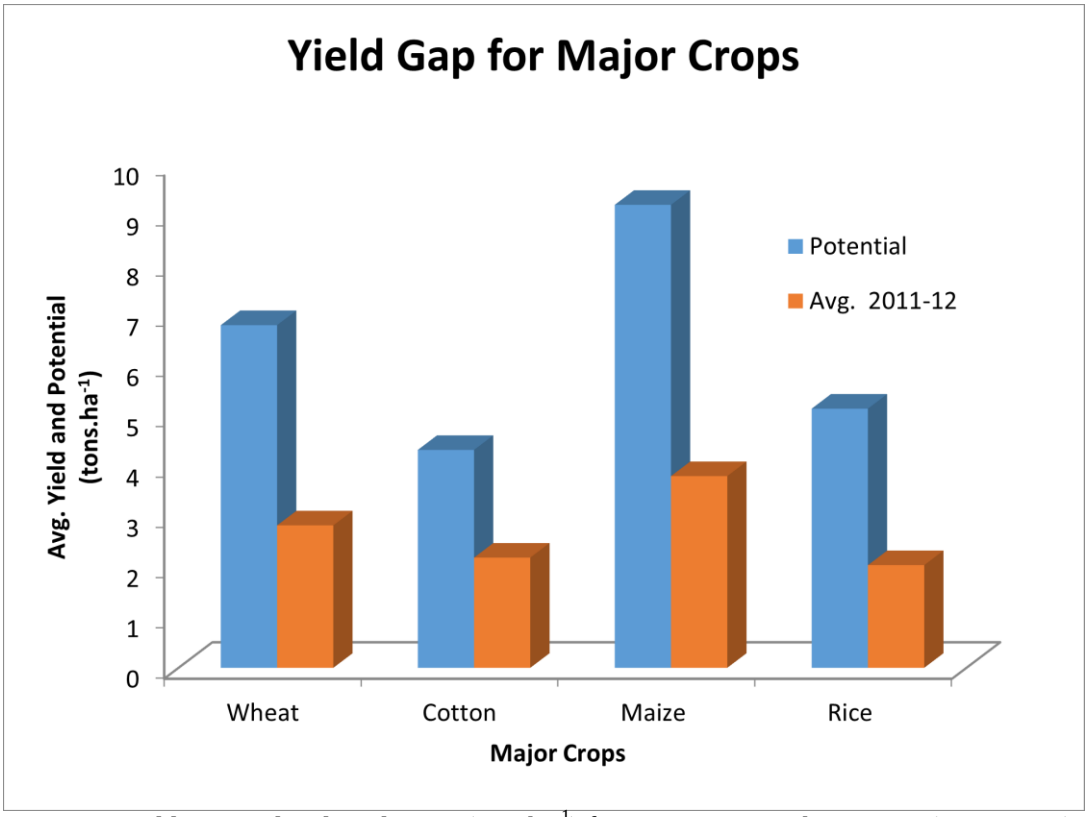

Figure 1 Yield potential and production (tons.ha^{-1}) for major crops in the country (FAO, 2012)

Successful implementation of farm mechanization requires an effort by policy makers, institutions and extension workers to train and educate the local farmers and then introduce new mechanical techniques, modify, expand and adapt these techniques. This will be possible when the farm mechanization status in the country is

critically reviewed in the context of the policies and strategies made by government in the past. This paper is focused on providing the first hand information about the status of different agricultural machines existing in Pakistan. This information will help the policy makers to identify the benefits of promoting agricultural machines to ensure food security for the future generations of the country.

2 Present status of farm mechanization

Pakistan is a low income generating country. Agriculture is its most important sector due to its primary commitment of providing healthy food to the fast growing population. In order to improve the productivity of land, appropriate mechanization strategy should be developed and adapted by keeping in view the previous trends of farm mechanization in the country. This article will summarize the information regarding the level of mechanization in the country and try to highlight the weak areas of the field.

2.1 Farm power availability

Farm power is an essential component of modern farm mechanization program. Although, the tractor is among one of the major sources of power available at farm level yet the draft animals, agricultural workers, small scale diesel engines and electric motors (Table 1) are used as a source of power in the country's agriculture (Iqbal et al., 2015). The number of tractors was around 300 thousand by the end of 20th century and there was nearly 100% increase in number of tractors from 2002 to 2007 (GOP, 2008). The number of tractor grew from nearly 700 thousands in 2008 to 948 thousands in 2014, having a power ranging from 50 - 80 hp, but majority of them fall in 50 horsepower category (GOP, 2015). Punjab province contributes more than 80% in terms of tractor population in the country (USAID, 2009). Based on the population of tractors in Pakistan for the year 2013-14 (GOP, 2015) and on total agricultural area of 22.68 million hectares (GOP, 2011), there is one tractor for every 24 hectares of cultivated area. Assuming 50 hp per tractor, available power in country is just 0.84 hp/ac against recommended power of 1.0 hp/ac (FAO, 2012). In order to achieve the suggested power requirements, an induction of approximately 110 thousands of tractors was recommended by the year 2015. The current manufacturing facilities available in the country are enough to produce the required number of tractors as almost all the manufacturing facilities are working on single shift basis.

Table 1 Different sources of farm power available in country

Power Source	Average HP capacity	Population	Available HP
Tractors	50	948,919	47445950
Work animals	0.5	200000	100000
Human labor	0.1	$38.6*10^6$	$3.86*10^6$
Tubewells	16.75	1075073	18007473

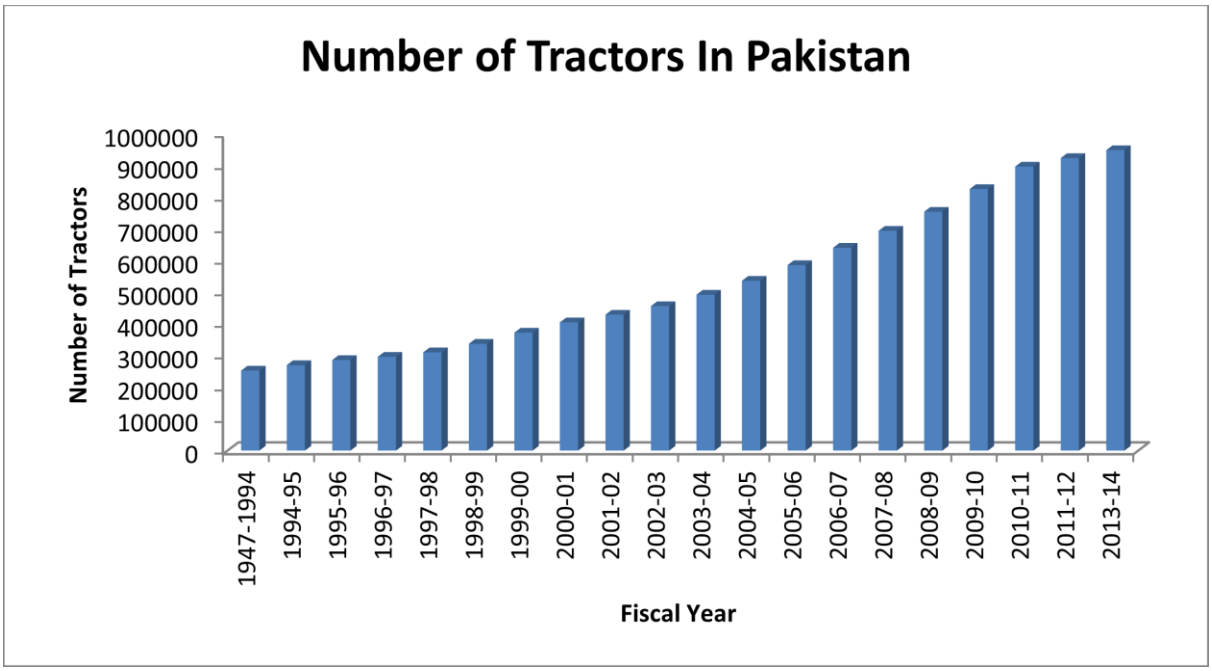

Figure 2 Increase in number of tractors (GOP, 2015)

2.2 Mechanization for land development

In olden days seed was scattered on the land and accepted the resulted meager yields. Today's agriculture, in addition to other inputs for the crop production; mechanical energy is provided to boost the agricultural productivity (Yamin et al., 2011). Pakistan is expecting to have double population and become 4th largest nation by 2050 from current status of the 6th most populous state of the world (Feeney and Alam, 2003). The total cultivated area has increased by just 40% during past 60 years, while there was more than 4 times increase in population with urban expansion of over seven-folds resulting into mega-cities as well as rising population pressure on cultivated land (Ahmad, 2007). Despite that wheat production has increased by five-fold but the country is still marginal importer of wheat (GOP, 2009; GOP, 2010). Total agricultural land in the country is 30.95 million hectares out of which only 22.68 million hectares is being actually cultivated (GOP, 2011). Total cropped area decreased from 23.76 million hectares to 22.54 million hectares during 2009 to 2014 due to severe floods, water scarcity and salinity issues in the country resulting in increase of cultivable waste land from 8.14 to 8.27 million hectares over the same period (GOP, 2011). A considerable part of this cultivable 8.27 million hectares waste could be brought under cultivation by harnessing the available water resources, and using mechanical power.

Cultivable waste land development can be done by using earth moving equipment through tractor front mounted blades, dozers, excavator and land levelers. Tractor mounted front blades are available through private sector while bulldozers for land development are available from the public sector. This cultivable waste land can economically be developed for cultivation through the use of crawler tractors/bulldozers only. The existing fleet of 338 operational bulldozers in Punjab (GOP, 2015), 84 in Sindh (GOS, 2015) is insufficient to convert 3.52 million hectares of cultivable waste land into the productive. It is estimated that with the present strength of bulldozers, it will take about 100 years to develop the entire cultivable waste land of Province Punjab.

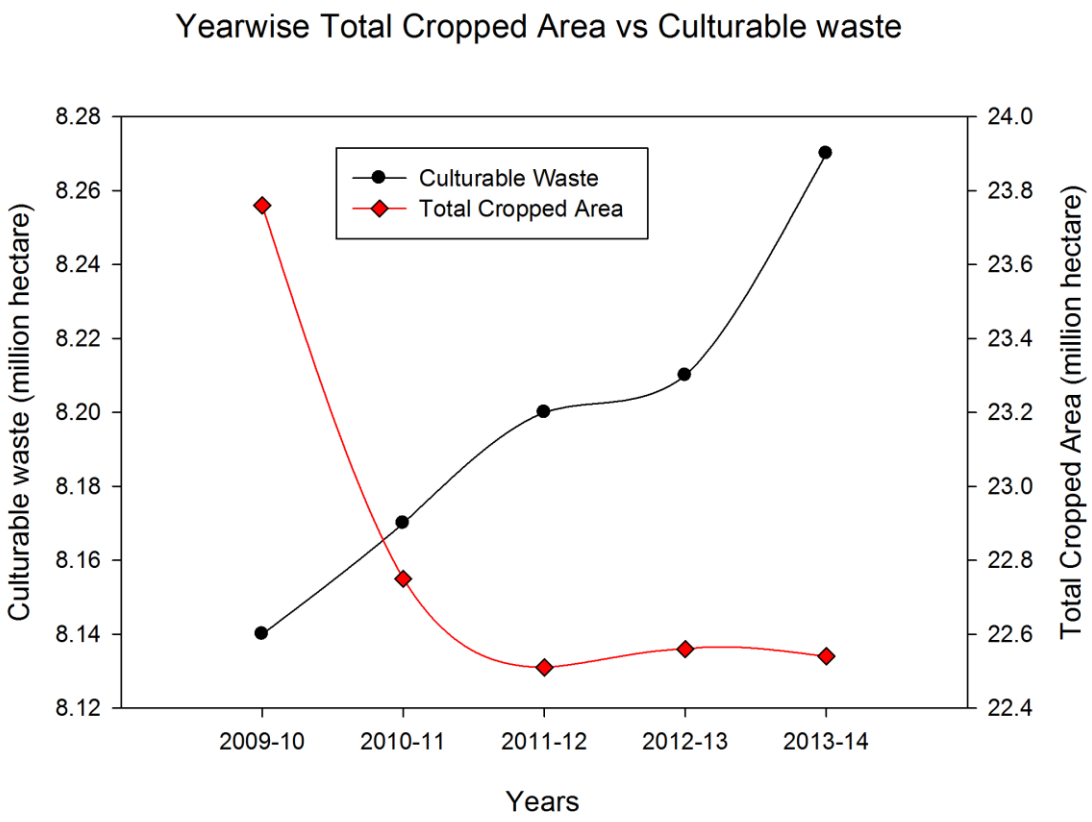

Figure 3 Total cropped area and cultivable waste in the country in Million Hectares (GOP, 2011)

2.2 Mechanization for tillage and seed bed preparation

Tillage implements are required to destroy pest's shelters and to disrupt their lifecycles, aerate the soil, eradicate weeds, incorporate crop residue, manure, fertilizers and pre-emergence weedicides, and to make other farm cultural practices easier to undertake (Ashraf et al., 2003). Tillage equation of Pakistan consists of primary and secondary tillage operations (Iqbal et al., 2008). Primary tillage is opening of the compacted soil with the help of different ploughs to break the hard pan caused by compacted soils. Additionally, primary tillage is also responsible for inversion of soil, uprooting of weeds and stubbles (Ashraf et al., 2003). Secondary tillage on the other hand is performed after primary tillage for lighter or finer operations as after primary tillage, the fields are left with large clods with some weeds and partially uprooted stubbles (Ahmad et al., 2015).

Cultivator is the most widely used implement for primary as well as secondary tillage of soil and is growing radically during the last four decades. The availability of the cultivator in the country has augmented from 369 thousands in 2004 to 901 thousands in 2014 (GOP, 2015), whereas the share of moldboard plow, disc plow, disc harrow, rotavator and chisel plow has enlarged from 40 to 189, 29 to 142, 23 to 94, 47 to 113 and 8 to 47 thousands respectively, during the same period (Table 2). Continues increase in the cultivator is due to its low draft requirement and also its price is considerably less as compared to the other tillage implements. Repeated use of cultivator not only creates hardpan which adversely effects root development/penetration, but it does not fulfill the purpose of tillage as described above (Ahmad et al., 2015). Most of the progressive farmers do use mould board plow and disc plow for primary tillage and disc harrow and rotary tiller (rotavator) for secondary tillage specially for sowing of wheat after paddy and cotton in Punjab. Conservation tillage practices such as

zero tillage for sowing of wheat in fields with rice stubbles (Iqbal et al., 2012), permanent beds tillage for sowing of cotton on beds of previous crop (Ishaq et al., 2002) and mulch or stubble tillage for retention of previous crop stubbles in the field (Iqbal et al., 2008) are also practiced on limited scale not only to minimize cost of tillage and seedbed preparation, but also to mitigate greenhouse gases.

Table 2 Growth of different tillage implements during the last four decades (GOP, 2015)

Years	Cultivator	MB Plough	Disc Plough	Disc Harrow	Chisel Plough	Rotavator
1984	146863	7319	6355	8140	712	2101
1994	236272	28413	20372	12233	6535	5594
2004	369866	40050	29218	23764	8514	47919
2014	901473	189784	142338	94892	47446	113870

2.3 Mechanization in sowing and planting

The selection of suitable sowing equipment can play an imperative role in suitable crop establishment by maintaining the sowing depth appropriately (Tanveer et al., 2003). The optimum plant population and row to row distance can only be achieved if appropriate sowing machinery is used. The main reason for low crop yield in Punjab is scanty plant population (Iqbal et al., 2015). Due to time limitation or high cost of tillage and seedbed preparation, most of the farmers spread seed through broadcasting (Iqbal et al., 2012). This trend of lower or partial mechanization in sowing continues to exist in the other provinces of the country which neither provides desired plant population nor results in proper yield.

Mechanized sowing of wheat crop around the country is usually accomplished by seed drills equipped with fertilizer attachments (Abbas et al., 2009). Coulter drills and zone disk tiller drills along with disk type furrow openers are used to mitigate the problems offered by stubbles of paddy, sugarcane and cotton (Munir et al., 2012). Wheat drills along with conventional tillage and seed bed preparation methods are utilized in manually harvested rice fields. However, the conventional land bed preparation methods delay the sowing process by three to four weeks leading to the poor crop stand (Younis et al., 2006).

For sowing of row crops like cotton, maize, sunflower, groundnut and others, multi-crop planters are commonly used which maintains designed plant to plant distance (Farooq et al., 1992). Use of such planters may also require more than recommended seed rate (Singh et al., 2005). In order to overcome this problem, pneumatic planters, inclined/vertical seed plate planters are used in Punjab on a very limited scale. A rapid increment has been observed in the market share of the sowing machinery with an annual sale of approximately 22 thousand implements over the last one decade (GOP, 2015). The growth in the number of drills and planters is just 52 thousands during the 1984 to 1994 (GOP, 2004), whereas the market of these implements has grown from 70 thousands in 2004 to 295 thousands in 2014 due to the inclination of the farming community towards mechanized sowing. The increment in purchase of sowing machine was more than 200% and this promptly increasing trend during the last ten years illustrates that farming community has now realized the adaption of suitable sowing machinery is indispensable for proper crop stand, which is the key to success.

The market for self-propelled (walking and riding type) rice transplanters in Pakistan was almost zero 5-6 years back as the rice transplantation was done completely manually with the use of labor. Presently, many companies in Pakistan are importing rice trans-planters from China and Korea and marketing them in the rice-wheat zones of country.

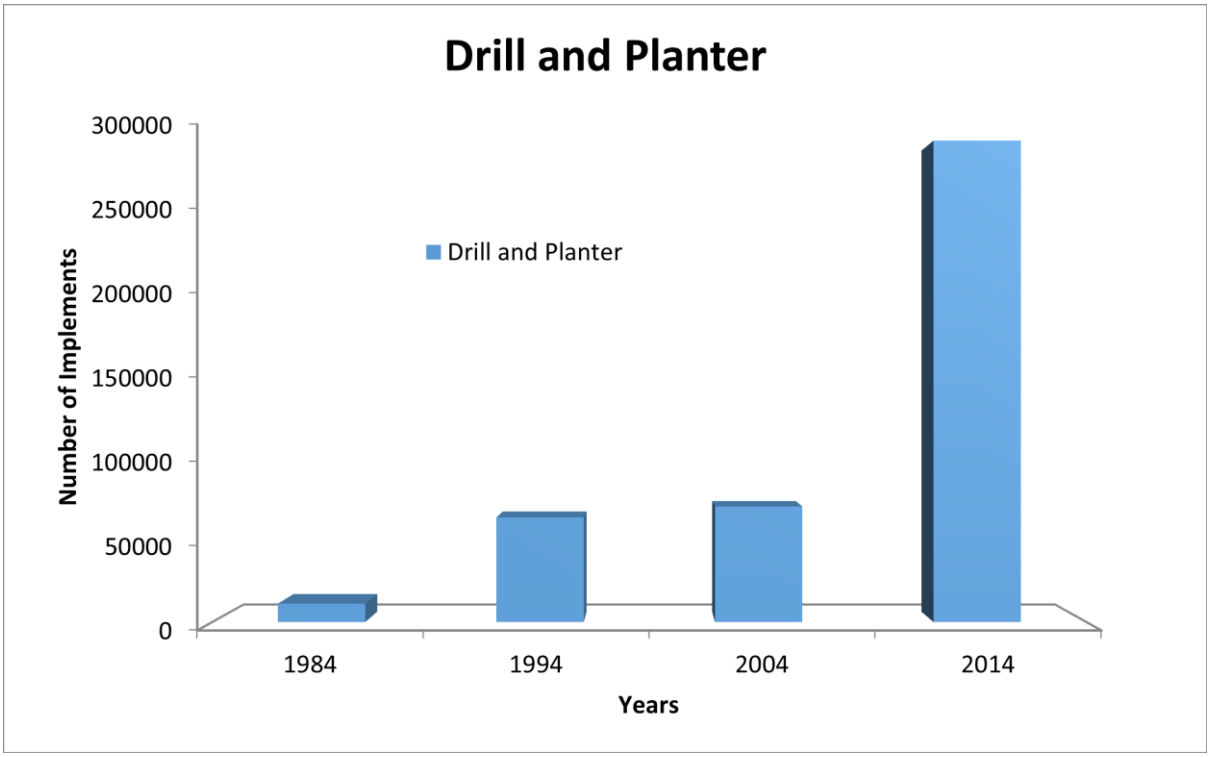

Figure 4 Drills and planters growth in Pakistan (GOP, 2015)

2.4 Mechanization in plant protection

Weeds are the major yield limiting factor that uptakes the plant nutrients, compete with crop, harbor diseases and insects, and hinders the harvesting operation (Kinsman, 1993). The efficacy of applied agro-chemicals is largely dependent on the spray structure, droplet size, fluid velocity and entrained air characteristics (Miller and Ellis, 2000). The chemical application efficiency in Pakistan was reported to be only 50% and has been attributed to the use of poor quality spray machinery (Ejaz et al., 2004). Currently, weeds around the country are managed mechanically and chemically. Intercultural tools like bar harrows and rigid type tine cultivators are most commonly utilized for crops sown on flat beds (Safdar et al., 2011).

Knapsack sprayers (manually operated and power operated) and tractor mounted boom sprayers are most widely used for application of pre as well as post emergence weedicides in the country (Tahir et al., 2003b). Tractor operated sprayers used in Punjab are mostly of boom type for field crops while canon type mist blowers are also used for orchards (Ejaz et al., 2004). The booms of locally manufactured tractor mounted sprayers are generally rigid type which tends to sag resulting in non-uniform application (Rehman, 1994). In locally made sprayers, generally pressure control system (control flow valve) is not installed due to which the pressure at the nozzle tip does not remain uniform which again results in non-uniform application (Tahir et al, 2003b).

The sprayer manufacturing industry has undergone through a serious change as the market share of this equipment grew from 21 to 1438 thousands during last ten years (GOP, 2015) which was just 20 thousands in 1994 (GOP, 2004). A tiny growth of approximately one thousand sprayers during the span of 1994 to 2004 is due to the reluctance of farming community towards the adaption of agrochemicals for the eradication of the weeds and their adherence to the use of mechanical methods for the weed control (Iqbal et al., 2015). Most of the sprayers used in the country are of hand held type knapsack sprayers and commonly used in the wheat-cotton cropping system of the country (Rehman, 1994). This briskly increasing trend showed that the consumption of agrochemicals has increased abruptly during the last decade due to the shortage of the labor resulting in the reduced use of the conventional methods.

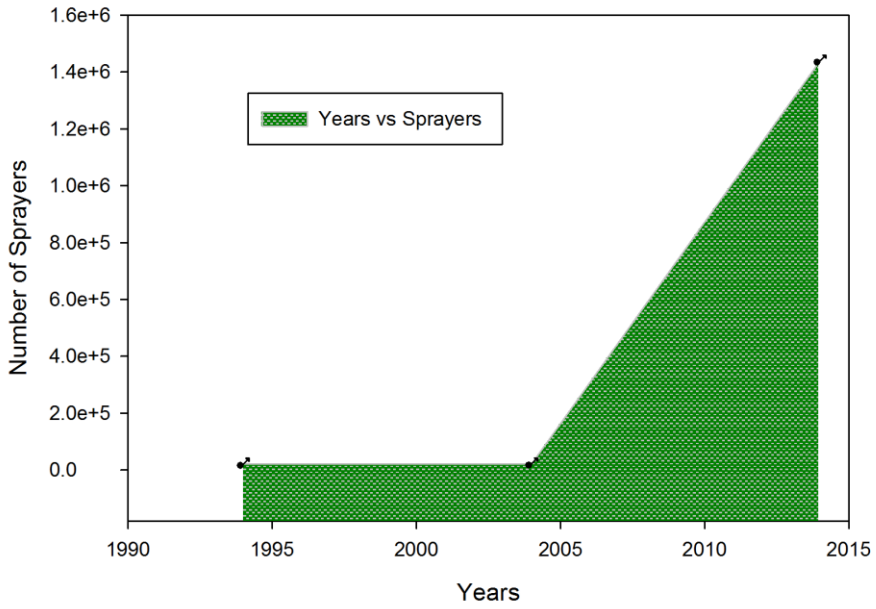

Figure 5 Growth of sprayers (GOP, 2015)

2.5 Mechanization in harvesting and threshing

Harvesting of cereal crops, in Pakistan, is a major problem since long as this operation is still mostly done by hands (Tahir et al., 2003a). Tractor mounted reaper windrowers and combine harvesters are also used to a greater extent. Harvesting losses due to delayed harvesting as well as use of inappropriate harvesting machinery for wheat, rice and other oilseed crops has been estimated to be around 10%-15% (Ali and Khalid, 2015). Harvesting of rice done with wheat combines results in excessive grain loss and reduced rice recovery. This also results into increased grain breakage during milling operation (Sheikh et al., 2003).

Presently, wheat threshing in Pakistan is almost fully mechanized (Tahir et al., 2003a). Threshing of wheat is mostly done with the help of stationary threshers which are powered through tractor PTO, engine or electric motors. The commercially produced wheat threshers are although of high throughput capacity but are heavy in weight and thus costly, energy inefficient, ergonomically unsafe (Ahmad et al., 2013). Threshing of basmati rice is generally done manually, but on a very limited scale head feeding type threshers are also used. For threshing of coarse grain rice, whole crop threshers are also available (Sheikh et al., 2003). Chickpea in the country is usually threshed with little modifications in wheat thresher and by incorporating proper size sieves. However, this threshing mechanism reduces the overall marketability of the produce (Peksen et al., 2013).

The market share of the reaper windrower was just 13 thousand during 2004 (GOP, 2004) which is now 66 thousand. The major growth over the last couple of the years is due to indigenization and due to the introduction of self-propelled type reaper windrower in the market due it cost effectiveness. The thrasher's market in Pakistan is estimated at 20,000-30,000 units annually by sales resulting in nearly 100% mechanized threshing operation for cereal crops (Ahmad et al., 2013). The tractor mounted stationary thresher grows from 137 thousands in 2004 to 353 thousands in 2014 (GOP, 2015). The growth of combine harvester is quite slow and grew from 3 thousands to 29 thousands during the last ten years. This slow growth is due to the high cost of the machine and relatively small farm size which makes it unaffordable for local small land holders (Tahir et al., 2003a).

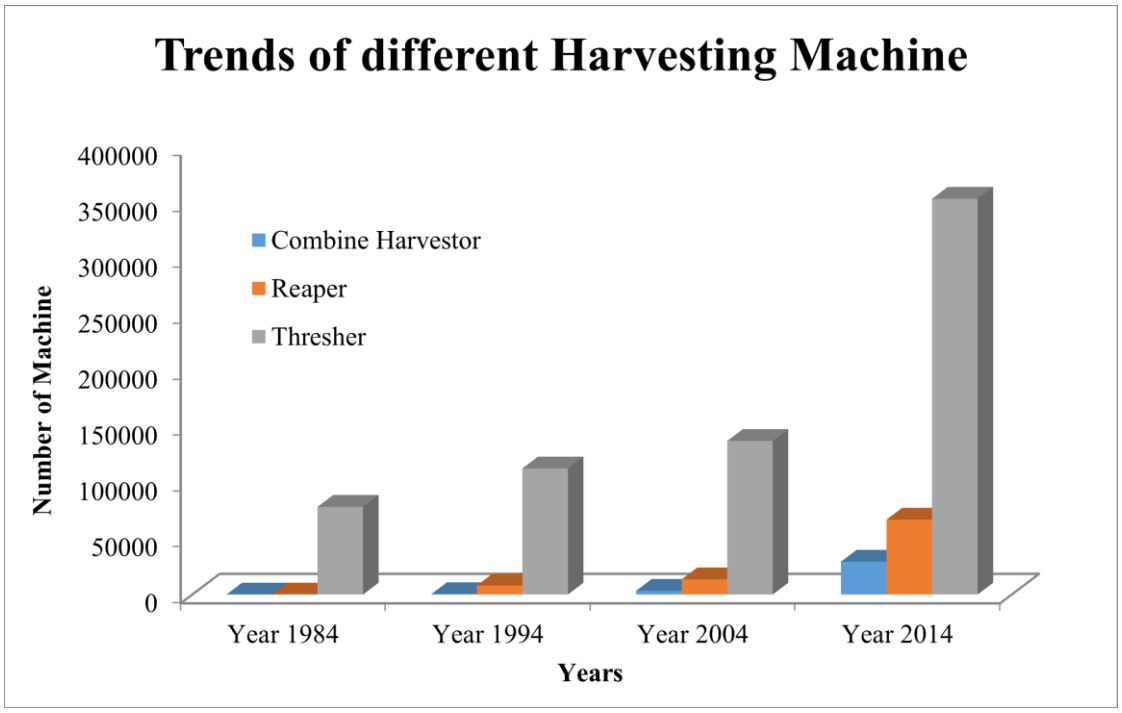

Figure 6 Growth of harvesters (GOP, 2015)

3 Conclusion

The yield gap can be covered by introducing advanced farm equipment and the increased use of farm equipment. But due to industrial and housing colony revolution, cultivable waste is also increasing due to which total cropped area is reduced on yearly basis. To maintain the crop yield and to fulfill food requirements, use of machinery viz. drill, planters, tractors, harvesting machinery and sprayers is enhanced. A lot of opportunities exist in Pakistan to get benefits from this sector but this can only be realized by introducing effective policies and strategies at the government level. The strengthening and effectiveness of research institutes of the country are also necessary which will ultimately lead to a better utilization of innovative machinery for better productions.

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