Towards Sustainable Agricultural Mechanization in Pakistan

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1. Country Profile

The Islamic Republic of Pakistan is an ancient civilization, although its political boundaries were drawn only sixty six years ago, when it gained independence on 14 August 1947. Initially comprising East and West Pakistan, separated by 1770 kilometers of India, its present territory since December 1971 is confined to the former West Wing, which has a total area of 79.61 million hectares[1]. It mainly comprises of four provinces i.e. Balochistan, Khyber Pakhtunkhwa, Punjab and Sindh. Pakistan lies between the latitudes of $23^0$30' and $36^0$45' North and between the longitudes of 61^0 and $75^0$31' East. This territory is a region of diversified relief, with mountains to the north and west, and arid and semi-arid expanses to the south and east. Down in the centre is a flat fertile plain, fed by the Indus and its tributaries. Beneath the northern part of this plain, hydrologist found a huge fresh water lake, equal in volume to ten times the annual discharge of the rivers flowing above. The Indus plain has the largest canal irrigation system in the world, making cultivation possible despite scanty and erratic rainfall and ranges of extreme temperature[2].

Pakistan is bound by Himalaya, Karakoram and Hindukush mountain ranges in the north which host the world's largest ice reserves. These mountains are the water tanks over the roof, which provide water to the reservoirs. Climatically Pakistan, located in the north of the tropic of cancer, possesses a great range of diversity, from some of the hottest in the world in the Jaccobabad and Sibbi districts to the snowy cold of Laddakh and Balochistan. In the plains, minimum temperature in the month of January varies from 4^0C to 15^0C and June/July from 25^0C to 30^0C. The maximum temperature in January varies from 17^0C to 24^0C and in June/July from 32^0C to 45^0C. Jaccobabad has even recorded an absolute maximum of 53^0C. Pakistan suffers from a general deficiency of rainfall. Under the influence of the troughs of westerly waves as well as frontal systems, the northern half of Pakistan receives substantial rainfall over low elevation plains and snowfall in mountainous regions during winter season. Summer adds monsoon to Pakistan which contributes about 60% of the annual total

precipitation from July to September[3]. In the plains, rainfall varies from 127 mm in upper Sindh to 1250 mm in the Himalayan sub-mountain areas.

The population in Pakistan, since its inception in 1947 has multiplied more than five times to 184.35 million on 1 July 2013 whilst the production of wheat, a staple food crop has increased only three fold[4]. The gap between food supply and demand requires concerted efforts to increase agricultural production with a view to ensure self-sufficiency in food commodities besides contributing to food and nutritional security for all in the country.

Despite movements of people from farms to cities, the country remains predominantly rural. A little under two thirds of the country's population lives in rural areas. The literacy rate in Pakistan which was estimated at 58 percent (70 percent male and 47 percent female) during 2011-2012 is still behind other countries of the region[1].

Pakistan's economy is characterized by; a predominance of agriculture; a strong industrial base with a large domestic market and an ample supply of skilled human resource. In general, Pakistan enjoys a well-developed physical infrastructure and good communication facilities.

2. Agriculture

Agriculture is the single largest sector and driving force of Pakistan economy. In 1947, agriculture was dominant sector of the country and contributed 53 percent to the gross domestic product (GDP). Its share in the GDP has fallen considerably since then, while the share of manufacturing, construction and services has risen. Although agriculture's share in the GDP has declined considerably between 1949-50 and 2012-2013, from 53 percent to nearly 21.4 percent, it remains leading sector of the economy. Employment share of agriculture has declined by far less (from 66 percent to 45 percent) over the same period[1].

Agriculture and agro-based products also account for approaching two thirds of the total foreign exchange earnings from exports. They supply many of the major industries with raw materials and consume around one third of the industrial finished goods. In terms of contribution to national income, employment, markets for industry and supply of raw materials or products for export, agriculture remains the foundation of Pakistan's economy[1,4].

The total geographical area of Pakistan is 79.61 million hectares, out of which Balochistan, Khyber Pakhtunkhwa, Punjab and Sindh Provinces have 34.72, 10.17, 20.63 and 14.09 million hectares areas, respectively. **Table 1** gives the land utilization statistics of Pakistan. Pakistan's agriculture mainly depends on the canal irrigation system. Out of the total cultivated area of 22.05 million hectares, 18.92 million hectares (86 percent) are irrigated and the balance 3.13 million hectares (14 percent) are rainfed[4].

Table 1: Land Utilization Statistics of Pakistan, 2011-2012[4]

(Million Hectares)

Province	Geographical Area	Total Area (4+5+6+7)	Forest Area	Not Available for Cultivation	Culturable waste	Cultivated Area (8+9)	Current Fallow	Net Area Sown	Area Sown More Than once	Total Cropped Area (9+10)
1	2	3	4	5	6	7	8	9	10	11
Punjab	20.63	17.54	0.50	2.81	1.71	12.52	1.69	10.83	5.71	16.54
Sindh	14.09	14.09	1.03	6.56	1.47	5.03	2.86	2.17	0.85	3.02
Khyber Pakhtunkhwa	10.17	8.37	1.33	3.94	1.20	1.87	0.61	1.25	0.50	1.75
Balochistan	34.72	17.80	1.41	9.84	3.92	2.63	1.52	1.11	0.01	1.12
Pakistan	79.61	57.80	4.27	23.15	8.30	22.05	6.68	15.36	7.07	22.43

Agricultural production is dominated by crop production. Wheat, rice, cotton and sugarcane are the principal crops. Wheat crop is grown in Rabi (winter) along with oilseeds, coarse grains and pulses. The most important Kharif (summer) crops are cotton and rice, depending upon the ecological zone. The busiest periods in farming occur between April and June, and October and November, when harvesting of the major crops overlaps with land preparation for the next crop. The power and labor constraints are felt most severely where water availability permits double cropping on the same land. The area, production and yield of the four major crops are given in

Table 2. Over time, share of the cropped area accounted for various crops has changed (**Table 3**).

Table 2: Area, Production and Yield of Major Crops, 2011-2012[4]

Crop	Area ('000 ha)	Production ('000 tonnes)	Yield (kg/ha)
Wheat	8649.8	23473.4	2713.8
Cotton	2834.5	13578.6*	814.8**
Rice	2571.2	6160.4	2395.9
Sugarcane	1057.5	58396.4	55221.2

*000 bales; ** Lint

Table 3: Distribution of Cropped Area[4]

(Percent of cropped area)

Crops	1959-60	1969-70	1979-80	1989-90	1999-2000	2009-2010	2011-2012
Food Grains	54.8	58.3	56.0	54	56	58	58
Cash Crops	12.1	14.5	14.9	16	18	18	18
Pulses	11.6	8.0	8.1	7	6	6	6
Oilseeds	4.1	3.2	2.8	2	3	3	3
Vegetables	0.7	0.7	0.8	1	1	2	1
Condiments	0.3	0.3	0.6	1	1	1	1
Fruits	0.6	1.2	1.5	2	3	4	4
Others	15.8	13.7	15.1	17	11	9	10

N.B. Vegetables include Potatoes

Food grains : Wheat, Rice, Jowar, Maize, Bajra and Barley.
Cash crops : Sugarcane, Cotton, Tobacco, Sugar beet, Jute & Guarseed.
Pulses : Gram, Mung, Mash, Masoor, Mattar, other Kharif and Rabi Pulses.
Oilseeds : Rapeseed & Mustard, Sesamum, Groundnut, Linseed, Castorseed and other oilseeds.
Condiments : Chillies, Onion, Garlic, Coriander, Turmeric and Ginger.

3. Agricultural Mechanization

3.1 Overview

Agricultural mechanization is an important input in modern agriculture. It improves productivity of land and labor besides increasing cropping intensity and helping in timely crop stand establishment, cultural practices, harvests and reduction in post-harvest losses. It also results in considerable savings of fodder and feed through a reduction in bullock population. Thus, a transition from subsistence to commercial farming can be achieved through diffusion of modern, efficient, cost-effective

mechanization technologies to the farming systems. The efficient use of scarce agricultural resources coupled with an accelerated agricultural mechanization is therefore, of extreme importance[5].

Agricultural mechanization is selective in Pakistan and only those operations are mechanized for which there is constraint of labor or power or a combination of both. The effects of mechanization are overall positive. It has not only increased on-farm income and labor productivity but also generated off-farm employment in manufacturing, supply/servicing of agricultural machinery, supply of other inputs and post-harvest handling of increased agricultural production[6].

The most popular forms of mechanization in Pakistan are; bulldozers, power rigs, tube wells and tractors with cultivators, wheat threshers, sprayers and trailers. Mould board plough and disc plough for deep tillage are gaining popularity. **Table 4** shows population of tractors and important tractor operated machinery available in the country according to census of 2004[7] compared with the censuses of 1975, 1984 and 1994. It reflects increasing trends of their use.

Table 4: Ownership of Selected Tractor Drawn Machinery in Pakistan[7]

(Numbers)

Census Year	Tractor	Machinery							
		Cultivator	Mold Board Plough	Bar / Disc Harrow	Disc Plough	Drill / Planter	Ridger	Trailer	Thresher
2004	401663	369866	40050	23764	29218	70810	71338	242655	137270
1994	252861	236272	28413	13233	20372	64126	10987	176412	112707
1984	157310	146863	7319	8140	6355	11251	4711	98787	78377
1975	35714	31619	2734	2373	2938	1174	1174	18074	5635

Bulldozers and power rigs are operated and maintained by the public sector on subsidized rates to the farmers whereas tractors and other machines are owned by large and medium sized farmers themselves. The medium sized farmers generally provide their tractors and other farm machines on rental basis to their neighboring small farmers in addition to their own use.

The organizations dealing with the issues related to agricultural mechanization in Pakistan include: Ministry of National Food Security & Research; research and development institutions; agricultural machinery manufacturers; financial institutions; federal and provincial autonomous bodies; provincial directorates of agricultural engineering; and, agro-services. A National Board for Agricultural Mechanization (NBAM) headed by the Federal Minister of Food, Agriculture and Livestock was set up in 1981 with the mandate of advising the government in the formulation of agricultural mechanization policies and strategies. The NBAM has established two committees namely, Farm Mechanization Promotion Committee and Farm Machinery Standardization Committee. These are responsible for the introduction of suitable farm machines and development of farm machinery standards in the country, respectively.

3.2 Research and Development

Agricultural mechanization has been recognized as a tool for modernizing agriculture. It involves introduction of appropriate agricultural mechanization technologies and their availability either through import or local manufacturing. Mechanization technologies imported from industrialized world may not suit as such due to differences in agro-climatic, agro-technologic and socio-economic conditions and thus need adaptations and indigenization in order to make these affordable by end-users, using available raw materials, skills and production techniques. Hence, Research and Development (R&D) in agricultural mechanization sector is imperative to derive maximum benefit[8].

The need for R&D institutions on agricultural mechanization was established relatively late in Pakistan. Currently, Agricultural & Biological Engineering Institute (ABEI), NARC, Islamabad under Pakistan Agricultural Research Council (PARC) at Federal level, Agricultural Mechanization Research Institute (AMRI), Multan under Government of Punjab and Agricultural Mechanization Research Cell (AMRC), Tandojam under Government of Sindh are solely engaged in farm machinery

research and development work. Furthermore, Centre for Agricultural Machinery Industries under Government of Punjab and Agricultural Light Engineering Program (ALEP), Mardan under Government of Khyber Pakhtunkhwa are engaged in farm mechanization promotion activities in the respective provinces.

Agricultural Universities located in the provinces of Balochistan, Punjab and Sindh and University of Engineering and Technology, Peshawar (Khyber Pakhtunkhwa) are also contributing in operational and academic research in the field of agricultural engineering. Tractor manufacturers and financial institutions are also playing an important role in promotion of agricultural mechanization in Pakistan.

ABEI and AMRI are involved in R&D, testing and evaluation of local and imported farm machines, adaptation of imported machines to suit local conditions, improvements in locally manufactured machines and rendering technical assistance to farm machinery manufacturers by providing engineering drawings, prototypes, professional services of engineers and technicians and arranging field demonstrations of the machines to the end-users. Both ABEI and AMRI have undertaken a considerable amount of work in developing/adapting farm machines[9] (Table 5). A number of machines like; seed drill, zero-till drill, reaper-windrower, wheat thresher, groundnut digger, groundnut thresher, maize sheller, potato digger, sunflower thresher, paddy threshers and sugarcane planter have been commercialized on large scale by local farm machinery manufacturing industry.

Faculties of Agricultural Engineering and Agricultural Engineering Departments of the Agricultural Universities are engaged mainly in teaching of undergraduate and post-graduate students. They are also conducting basic and applied research through graduate students.

In private sector, tractor manufacturers have made significant efforts in indigenization of tractors by deleting substantial quantities of imported components. Local manufacturing of tractors has not only saved foreign exchange but also

provided employment opportunities by establishing assembly lines at tractor manufacturers' premises and through vending industries. There were five firms which were licensed in assembly/local manufacturing of tractors in collaboration with the foreign firms of different makes, namely; Massey Ferguson (MF-240 & MF-265/MF-375), Fiat (Fiat-480 & Fiat-640), Belarus (MTZ-50 & UMZ-6AKM), Ford (3600 & 4600) and IMT (540 & 560).

Table 5: Salient Achievements of the R&D Institutions

Description	**Agricultural & Biological Engineering Institute (ABEI), NARC, Islamabad**	**Agricultural Mechanization Research Institute (AMRI), Multan**
Mechanization technologies developed and commercialized	Tractor front mounted reaper-windrower, groundnut digger, groundnut thresher, sunflower thresher, paddy thresher, pneumatic row crop planter, zero-till drill, fertilizer band placement wheat drill, canola thresher, wheat straw chopper-cum-blower, hand operated groundnut shellers, ABEI olive oil extractor, wood shredder, and Mobile seed processing unit.	Seed drills, planters, ridger, bed shaper, weeders, wheat thresher, rotary slasher, potato planter, groundnut digger, maize sheller, rotary tiller, boom sprayer, fertilizer spreader, axial flow pump, seed cleaner grader, hand dibbler, furrow bed/shaper planter, soil hard pan tester, bullock drawn implements, and mobile bhoosa chopper and baler.
Mechanization technologies being developed	Rocket seeder, pto disk plough, paddy transplanter, vegetable planter, turmeric dryer, solar-cum- gas fired dryer, mini seed cleaner cum grader, flat bed dryer for canola, sunflower & maize, date dryer, mango picking & pre-cooling technology harvester and nursery raising plant.	Power tiller, chain trencher, fodder cutter bar, sugarcane base cutter, pneumatic drill, rotary ditcher, briquetter, ejector pump, maize cob harvester, cheaper biogas planter, vegetable nursery transplanter, groundnut sheller, rice thresher, seed-bed finisher, stubble shaver, and orchard sprayer.

There are however, two firms which are at present mainly engaged in tractor manufacturing and they have achieved around 85% deletion. The major issues of the tractor manufacturers include; allocation of insufficient resources for R&D of matching implements and limited effort for introduction of agricultural machinery other than tractors.

There were 15 farm machinery manufacturers in 1959. As a result of liberal government policies such as rebate in import duty for raw material, exemption of sales and income tax, their number increased to around 500. Local farm machinery industry is producing farm implements/machines for land development, seedbed preparation, crop stand establishment, inter-culture, harvesting and threshing, crop protection and farm produce haulage[10].

3.3 New Mechanization Technologies Development Initiatives

3.3.1 Agricultural & Biological Engineering Institute (ABEI), Islamabad

ABEI Rocket Seeder

The Zero-tillage drill has some limitations while sowing wheat in combine harvested paddy fields. It has therefore, been improved by incorporating innovative paddy stubble-cum-straw separating mechanism while sowing under a collaborative project of the Australian Centre for International Agricultural Research, Canberra duly involving a local manufacturer. A technology package for raising crop with this machine has been developed and is being promoted by the ABEI. The machine is being commercialized through local agricultural machinery manufacturing industry. It is an energy-efficient, lightweight and compact machine by design.

Fertilizer Band Placement Wheat Drill

This machine has been designed and developed at ABEI for placing fertilizer (DAP) about 5 cm away and 5 cm deeper than the wheat seed in order to improve fertilizer use efficiency. Its field capacity is 0.5 ha/h. It saves 50% phosphate fertilizer as compared to the broadcast method, and helps in achieving around 10% more yield. Farmers can get substantial financial benefit by using this technology.

Olive Oil Extractor

The prototype unit of the adapted olive oil extractor was evaluated and demonstrated at farmers' fields in Punjab and Khyber Pakhtunkhwa Provinces in collaboration with Barani Agricultural Research Institute, Chakwal, the collaborative manufacturer, Khyber Pakhtunkhwa Olive Promotion Project and other stakeholders. Test results indicated that the fruit processing capacity of oil extractor varied from 32 to 38 kg/h with total oil recovery ranging from 10 to 20 percent. The late harvested olive fruit yielded more oil recovery as compared to early harvested fruit irrespective of the variety. The mechanically extracted olive oil was graded as extra virgin in accordance with the world edible oil standards.

Portable Small Seed Cleaner-cum-Grader

A portable small seed cleaner-cum-grader was conceptualized and developed at ABEI. It is suitable for cleaning and grading small quantities of cereals, oil seeds, vegetables seeds, grasses, herbs and medicinal plants seeds. The cleaning and grading is achieved by air classification and sieves, that can remove light & small

impurities and at the same time shriveled/immature, damaged and non-viable seeds are separated. Different grades of seeds are obtained by changing the sieves. High germination rates are achieved using cleaned and graded seed by this grader. The output capacity of this 0.746 kW electric motor driven machine is estimated as 150 kg/h in case of wheat.

Flat-bed Dryer for Groundnut and Ear-corn

The Flat-bed dryer is being adapted at ABEI Prototype Workshop for groundnut and ear-corn drying. Drying rates for groundnut and ear-corn were estimated as 4 and 1 percentage points per hour, respectively. Groundnut and ear-corn grain drying with this machine is comparatively is less costly as compared to traditional drying.

Mango Picking & Pre-cooling Technology

The loss during manual picking of mango in Pakistan is about 30% which affects its quality and demand in international market. This technology has a potential of reducing considerably labour requirement (about 65%) and harvesting time besides ensuring quality mango for world market. This would benefit the farmers besides helping in improving economy of the country through export of quality product. Picking capacity of the machine on an average was recorded to be 600 kg/h.

Portable Bucket-type Milking Machine

A mechanical milking system was developed for water buffaloes and cows. MoU was signed with a collaborative manufacturer. Technical assistance was rendered to the manufacturer for fabrication of a couple of prototype units at his premises. The machine was tested on cows and buffaloes. It is capable to produce vacuum pressure upto 70 kPa. The vacuum pressure was adjusted to 44-46 kPa for water buffaloes and 42-44 kPa for cows. The pressure worked well for producing the required pulsation and continuous vacuum suction.

Vegetable Planter

This machine was developed for planting vegetable cash crops such as Peas and Okra. The row spacing and plant-to-plant distance can be adjusted as per requirement. The seed damage is negligible. Maintenance of the machine is easy as most of the replacement parts are available locally. It is technically and economically a viable machine.

Turmeric Dryer

A batch-type turmeric dryer was designed and developed for drying turmeric produce in the field after harvesting. Preliminary field testing of the unit was done during harvesting season in 2013. The machine consisted of five major components; namely heating source (diesel burner), heating unit (heat exchanger), drying chamber, turmeric collectors (trays) and fan/blower. The drying capacity of the machine is about 1.5 tons per batch.

3.3.2 Agricultural Mechanization Research Institute (AMRI), Multan[11]

Seed Cleaner Grader

AMRI Seed Cleaner Grader is used to clean and grade seeds of crops like wheat and paddy. This machine is operated by either a 50 hp tractor pto or 2 hp electric motor. Cleaning process is done with the help of fan and sieves. This mobile machine has an output capacity of 0.5 ton/h with >98% cleaning efficiency.

Rota Drill

AMRI Rota Drill is used for sowing of wheat in manually harvested paddy fields. Seedbed preparation and sowing is done in a single pass. It saves time, energy and cost of production. Coulter tines are fitted which cut the crop residue and ensure continuous metering of seeds. Field capacity of the machine is 0.4 ha/h with a 48 kW tractor. Due to timely sowing better yield can be achieved.

Air-Assisted Boom Sprayer (Foldable Boom)

This spray machine has been designed and developed with the objectives to reduce the spray drift, minimize wind dependency and pesticide doses. Main advantages of this sprayer are to maximize field work rates and treatment timing. In this sprayer, an axial blower is used to deliver air through a sleeve mounted above the boom and nozzles. The blower is operated by hydraulic motor which is driven through hydraulic pump of the tractor. Air from the sleeve produces a curtain which directs the sprayer cloud into the crop canopy and

reduces lateral displacement of the spray in a crosswind. The reduction in spray drift permits the use of nozzles with a finer sprayer or allows a faster forward speed. The other features are hydraulic jacks for boom height adjustment and folding on both sides mechanically without manual labour.

Specifications

Field capacity	2.50 ha/h
Power requirement	48 kW (64 hp tractor)
Effective boom swath	10.7 m (20 Nozzles)
No. of nozzles / Nozzle spacing	20 / 510 mm
Hydraulic Pump pressure	60 bar
Tank material	Fiber glass
Tank capacity	450 L
Pump output @ 3.0 bar	80 L/min

Orchard Sprayer (Cannon Type)

This is a tractor rear mounted sprayer used especially for orchards. A high pressure air blast is generated with the help of a pto operated high speed blower. The air stream assists in breaking up the liquid into small particles, acts as a diluent to prevent the drops from coalescing and serves as the vehicle to carry these fine droplets to the surface to be treated.

Specifications

Field capacity	2.50 ha/h
Power requirement	48 kW (64 hp tractor)
Tank material	Fiber glass
Tank capacity	450 liters
Pump output @ 3.0 bar	60 L/min
Effective swath	40 m

Liquid Fertilizer Applicator

AMRI liquid fertilizer applicator is used for applying fertilizer in the form of liquid, which injected directly to the root zone of the crop. It

improves the application efficiency without any wastage while conventionally fertilizer is applied with drill or the broadcast method. In both cases, significant fertilizer loss occurs.

Specifications

Field capacity	0.75 ha/h
Power requirement	37 kW (50 hp tractor)
Tank capacity	500 lit.
Nos. of discs	4
Nos. of injectors	4
Row to row distance	762 mm

Sugarcane Ridger

Sugarcane ridger is a tractor rear mounted implement. It is used for making ridges for manual planting of sugarcane crop. It is also used for earthing up of sugarcane crop along-with weeds eradication which results in high crop yield. The implement cover 2 rows and the fertilizer attachment is optional.

Specifications

Field capacity	0.4 ha/h
Power requirement	45 kW (60 hp or above)
Row spacing	1220 mm
Fertilizer box capacity	100 kg

Stubble Shaver

This is a tractor rear mounted pto driven machine used for sugarcane ratoon crop. It is used to shave the crop just below the ground level which helps in increasing crop production besides controlling borers of sugarcane.

Specifications

Field capacity	0.4 ha/h
Power requirement	37 kW (50 hp or above)
Working width	1500 mm

No. of blade	12
Blade speed	1000-1100 rpm
No. of rows	2

Fodder Cutter (Lower Gear Drive Type)

This is a tractor rear mounted pto driven machine having two drums and three double edged cutting knives on each drum. The pivoted blades are securely mounted on the disc, which cut the fodder through impact action. This can be used for cutting of rabi & kharif fodders. The harvested fodder can easily be collected subsequently.

Specifications

Field capacity	0.25 ha/h`
Power Requirement	37 kW or above
Working width	1220 mm
Blades speed	75 m/s

3.4 Machinery Standardization

Agricultural machinery manufacturers in Pakistan are producing machinery for a wide range of agricultural operations, each following its own design specifications depending upon availability of raw materials and customer requirements. This has resulted in marketing of a variety of non-standard agricultural machinery to the farmers. In the case of excessive wear and tear or damage to components of machinery, farmers generally find it difficult to repair or replace them. Replacement of parts is costly and farmers travel considerable distances to secure spares. The solution lies in availability, awareness and enforcement of standards relating to agricultural machinery in the country.

Pakistan Standards and Quality Control Authority (PSQCA) is the apex national standards body in the country. The main activities of PSQCA include; establishment and enforcement of Pakistan standards, registration of inspection agencies and

testing of industrial raw materials and finished products against national or international specifications of standards. PSQCA is administratively attached with the Federal Ministry of Science and Technology. It has technical links with international, regional and other national organizations involved in this field and acts as an agent for the procurement and sale of their standards. More recently, all ISO standards (about 14000) have been directly adopted as Pakistan standards. All Pakistan standards, developed earlier, are being reviewed and the standards which can be replaced by ISO standards would be re-designated and only those standards would be retained as Pakistan standards which are specific to local products, raising number of Pakistan standards to about 15000.

Agricultural machinery standardization efforts in Pakistan have been focused on those machines which would promote appropriate technology, code of practice for improvement in efficiency, operation and utilization of agricultural machinery and those which would result in reduction of operating costs and maintenance. PSQCA has brought out some 25 basic standards related to agricultural machinery and has prepared standards on some of the components of tractors such as power take-off (pto); drawbar; attachment of mounted implements; mounting for front ballast weight; three-point linkage (categories 1, 2, 3 & 1N) and, lynch pins; and, operator's work place access and exit dimensions, and seating accommodation dimensions. Pakistan standards on some of the tractor- and animal-drawn equipment and their parts such as mould board plough, agricultural discs, cultivators (including tines, shovels and sweeps) scrapers, seed-cum-fertilizer drill (including seed feed roller and furrow openers) agricultural sprayers and trailer, knife back and knife sections for harvesting machines have also been developed. PSQCA has also developed national standards on test procedures for determination of power (drawbar and pto), hydraulic lift capacity, turning and clearance diameters, travel speed, noise level, visibility and field performance of agricultural tractors. A number of test codes on agricultural machinery such as seed-cum-fertilizer drill, knapsack (pneumatic) compression sprayer (non-pressure retaining type), manually operated sprayer (piston type), power operated knapsack sprayers, hydraulic spray nozzles for pest

control equipment, diesel engine fuel filters, combine harvester, stationary power thresher for wheat (hammer mill type), type testing of constant speed internal combustion engines, and engine test code (bench test) for the net power determination of agricultural tractors and machines have been developed besides development of safety standards related to some of the agricultural and earth moving machinery[12].

3.5 Mechanization Issues

a) Agricultural mechanization R&D is mainly confined to the public sector. The existing capabilities and operational funds of the public sector R&D Institutions are inadequate to cope up with the rate of technological advancements and awareness creation among the farming community about usefulness of agricultural mechanization.
b) There are little agricultural machinery R&D activities in the private sector due to the fear of copying of their products.
c) There is little coordination among the existing agricultural mechanization R&D Institutions in the country.
d) The planning approach is top down. Therefore, the research projects are, in general, not demand driven and hence, have little impact.
e) Monitoring and evaluation of research work in subjective.
f) Agricultural machinery R&D has so far concentrated on mechanizing crop production operations. Little attention is paid to mechanizing vegetables and fruit production, post-harvest technologies, livestock mechanization, renewable energy resources etc.
g) Un-awareness of manufacturers about agricultural machinery standards, non-availability of the standards in Urdu (national language) and their enforcement.

3.6 Recommendations

a) The existing capabilities of public sector agricultural mechanization R&D institutions should be strengthened.
b) There is a need to establish R&D institutes like AMRI (located in Punjab) in other provinces of Pakistan.
c) A National Network for Agricultural Machinery (NNAM) should be established to coordinate agricultural mechanization R&D activities for efficient utilization of available resources. The NNAM should identify researchable issues and then prioritize those as per market demand.
d) Suitable machinery be developed for livestock sector such as harvesting and chopping of fodder, silage making and storage, milking of animals, dairy products etc. at farm level.
e) The scope of agricultural mechanization R&D should be extended to processing agricultural produce for value addition and use of alternate energy sources at farm level.
f) Print and electronic media should be used for promotion of agricultural mechanization technologies by developing and adopting simple informal approaches.
g) In order to improve and maintain quality of locally produced agricultural machinery and provide useful information on performance of the imported machinery besides facilitating enforcement of Pakistan Standards, there is a need for establishment of a centre of excellence in the country. The centre is visualized as a specialized facility located near Lahore (industrial hub), possibly with regional satellites in north and south of the country.
h) Private sector should be encouraged for:
    i) initiation of in-house agricultural machinery R&D activities;
    ii) improvement of quality and standard of their products for meeting international requirements;
    iii) improvement of their manufacturing set-ups in order to manufacture machines and implements according to international market demand at competitive production cost; and,
    iv) establishment of agricultural mechanization services provision, especially of costly agricultural machinery to the end-users.

4. Conclusion

Agriculture sector is considered as one of the main drivers of economic growth in Pakistan. It not only provides food (both fresh and processed) but also inputs for industries such as textiles (e.g. cotton and wool). The national economic growth demands that agriculture sector grows at a healthy rate and that it has to be highly efficient and competitive besides ensuring food and nutritional security for all in Pakistan and surplus for exports. Costs of production of various crops are however, not competitive due to low productivity levels mainly owing to inefficient farming practices. Challenges of the free market and globalization have further necessitated modernization of agriculture by developing appropriate strategies including development/introduction, testing and commercialization of efficient, cost-effective and sustainable agricultural mechanization technologies in the country. Some progress has been registered in this respect. However, a great deal of concerted efforts by both public and private sector organizations in harmony are needed for development and promotion of appropriate and sustainable agricultural mechanization in the country.

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