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Agricultural Mechanization Research & Development in the Islamic Republic of Pakistan

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Research and development (R&D) is an essential step for success of mechanical interventions. This is done in both local and imported machines. Farm machines imported from industrialized countries may not suit due to differences in agro-climatic and socio-economic conditions and may need improvements. It is also needed to make the locally developed products affordable by using available raw materials, technical skills and production techniques.

In Pakistan, the farm machinery R&D is presently confined to public sector institutions and almost non-existent in private sector. The organizations involved in R&D are:

- Agricultural and Biological Engineering Institute (ABEI), NARC, Islamabad
- Agricultural Mechanization Research Institute (AMRI), Multan
- Faculties of Agricultural Engineering/Agricultural Engineering Department of:
  a) University of Agriculture, Faisalabad
  b) Sindh Agricultural University, Tandojam
  c) University of Engineering & Technology, Peshawar

In addition, Agricultural Light Engineering Program (ALEP), Mardan was basically set up for promotion of small and medium sized workshops engaged in manufacturing and servicing of farm tools/implements. It contributes to development and introduction of power rotary hoe, mould board plow, rotavator, hand tools, and imparting training to technicians in production techniques.

Both ABEI and AMRI are involved in testing and evaluation of local and imported farm machines, development of new machines/adaptation of imported machines to local condition, improvements in locally manufactured machines and technical assistance to local farm machinery industry. Salient achievements and development projects of ABEI and AMRI are described in Table1.

Table 1. Mechanization technologies developed and commercialized

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, soybean thresher, paddy thresher, pneumatic row crop planter, zero-till drill, fertilizer band placement drill, canola thresher, wheat straw chopper-cum-blower, milking machine, mobile seed processing unit, and olive oil extractor.	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	Pak seeder, PTO disk plough, 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 machine, nursery raising plant, hot-water treatment plant for eradicating mangoes fruit fly infestation, and wood shredder.	Trencher, fodder cutter bar, sugarcane base cutter, pneumatic drill, rotary ditcher, briquetter, ejector pump, biogas plant, groundnut sheller, seed-bed finisher, stubble shaver, and orchard sprayer.

Agricultural and Biological Engineering Institute (ABEI) formally known as Farm Machinery Institute (FMI) of NARC of the Pakistan Agricultural Research Council (PARC) is engaged in design/development of farm machines and post-harvest processing technologies along with developing energy efficient agricultural machines. First, a demand driven machine is designed/developed or adapted. Then first prototype is fabricated at ABEI prototype workshop. After successful field evaluation, an MOU is signed between PARC and collaborating manufactures to mass produce developed machine locally. ABEI of NARC/PARC provides technical assistance to the industry in providing production drawings, prototype and services of engineers and technicians. With collaboration of manufacturers, the locally developed machines are demonstrated to farmers/end users. Research and development process is given in Figure 1. Impact of commercialized machines is given in Figure 2.

Figure 1. Farm Machinery Research and Development Process

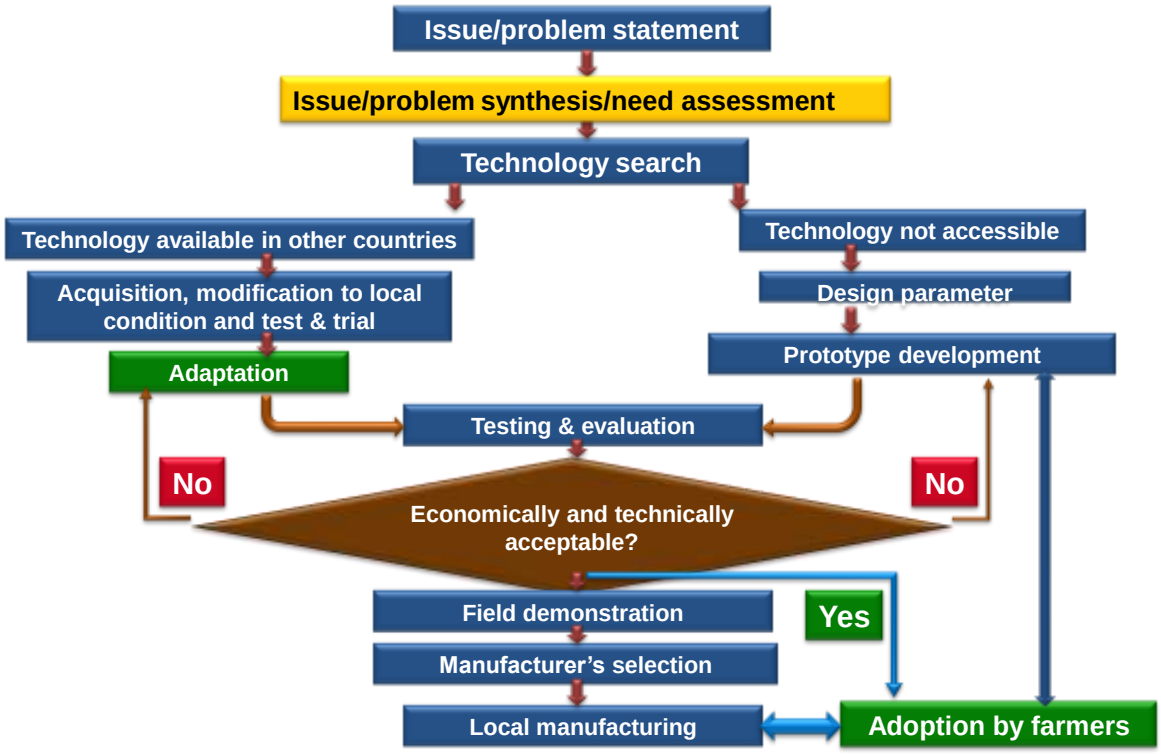

Figure 2. Impact of commercialized machines

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, now their number has increased to around 5000. Local farm machinery industry is producing farm implements/machines for land development, seedbed preparation, and crop stand establishment, inter-culture, harvesting and threshing, crop protection and farm produce haulage. Local content of developed machines is given in Table 2.

Table 2. Manufactured and imported farm machines/implements

No.	Item	Origin	Local content (%)
	Tractors		
1.	Belarus MTZ-50 (41KW)	USSR	68 (no more in business)
2.	Fiat-480 (37 kW)	Italy	85
3.	Fiat-640 (48 kW)	Italy	85
4.	NH-70-54 (63 kW)	Italy	85
5.	NH- 55-56 (41kW)	Italy	85
6.	Ford-4610 (46 kW)	UK	-
7.	Ford-3610 (37 kW)	UK	-
8.	IMT-560 (48 kW)	Yugoslavia	-
9.	IMT-540 (37 kW)	Yugoslavia	40
10.	MF-265 (46 kW)	UK	87
11.	MF-240 (37 kW)	UK	85
12.	MF-360 (45kW)	UK	85
13.	MF-375 (56kW)	UK	85
14.	MF-385 (63kW)	UK	85
15.	MF-210 (19 kW)	Japan	-
16.	Power tillers	China	20
	Land development implements		
17.	Front blade	Pakistan	100
18.	Rear blade	Pakistan	100
19.	Land leveler	Pakistan	100
20.	Cultivator	Pakistan	100
	Planting implements		
21.	Seed Drill	Pakistan	100
22.	Maize and cotton planter	Pakistan	100
23.	Groundnut planter	Pakistan	100
24.	Ridger	Pakistan	100
25.	Ridger (Imported)	Pakistan	60
26.	Post hole digger	Pakistan	100
27.	Potato planter	Pakistan	100
	Weeding and hoeing implements		
28.	Bar harrow	Pakistan	100
29.	Sprayers and broadcasters	Pakistan	100
30.	Power sprayer	Pakistan	100
31.	Power sprayer	Italy	60
32.	Scraper	Pakistan	100
33.	Plank (iron)	Pakistan	100
34.	Border disk	Pakistan	100
35.	Border disk	UK	60
36.	Ditcher	Pakistan	100
	Primary tillage implements		
37.	Moldboard plough	Pakistan	100
38.	Disc plough	Spain/Pak.	60
39.	Chisel plough	Pakistan	100

40.	Chisel plough	Spain	100
41.	Rotary cultivator	Italy	60
42.	Rotary cultivator	Yugoslavia	60
43.	Rotary cultivator	West-Germany	60
44.	Sub-soiler	Pakistan	100
	Secondary tillage implements		
45.	Disk harrow	Spain	60
46.	Disk harrow	Pakistan	90
47.	Disk harrow	Australia	80
48.	Wheelbarrow sprayer	Pakistan	100
	Harvesting machinery		
49.	Reaper-windrower	Pakistan	100
50.	Combine harvester	Denmark	Nil
51.	Potato digger	Pakistan	100
52.	Groundnut digger	Pakistan	100
	Threshing machinery		
53.	Wheat thresher	Pakistan	100
54.	Multi-crop thresher	Pakistan	100
55.	Sunflower thresher	Pakistan	100
56.	Maize sheller	Pakistan	100
	Handling & haulage machines		
57.	Trolley	Pakistan	100
	Others		
58.	Cane crusher	Pakistan	100
59.	Chaff cutter	Pakistan	100
60.	Manure spreader	UK/Pak.	100
61.	Grain dryer	Pakistan	100
62.	Sugar extractor	Pakistan	100
63.	P.T.O pulley	Pakistan	100
64.	Pump	Pakistan	100
65.	Diesel engine (high speed)	China	60
66.	Milk production machinery	12 local different technologies	90
67.	Farm level food processing machinery	4 local different technologies	100
68.	Machinery livestock and poultry	2 local different technologies	100
69.	Lawn mowing machinery	10 local different technologies	100
70.	Horticultural equipment	2 local different technologies	100

Presently, most of the farm operations are fully to partially mechanized except sowing operation of rice, sugarcane, and maize which are performed by manual labor. Similarly, harvesting operation of maize, cotton, sugarcane and pulses is not mechanized (Table 3).

Table 3. Mechanization of crop production operations

Crop	Land Preparation	Sowing	Irrigation	Spraying	Inter-culture	Harvesting	Threshing
Wheat	Semi-mechanized	Low mechanized	Semi-mechanized	Low mechanized	Nil	Semi-mechanized	Fully mechanized
Cotton	Semi-mechanized	Fully mechanized	Semi-mechanized	Fully mechanized	Fully mechanized	Nil	-
Rice	Fully mechanized	Nil	Semi-mechanized	Nil	-	Semi-mechanized	Semi-mechanized
Sugarcane	Semi-mechanized	Simi-mechanized	Semi-mechanized	Nil	Semi-mechanized	Nil	-
Maize	Fully mechanized	Semi-mechanized	Semi-mechanized	Nil	Semi-mechanized	Low mechanized	Fully mechanized
Potato	Fully mechanized	Semi-mechanized	Semi-mechanized	Fully mechanized	Fully mechanized	Semi-mechanized	-
Pulses (Grams)	Semi-mechanized	Fully mechanized	Low mechanized	Nil	Low mechanized	Nil	Fully mechanized

Mechanization issues

Agricultural mechanization is selective in Pakistan and operations are mechanized for which there is a constraint of labor or power or a combination of both. At present, farm mechanization is limited to crop production. The most popular forms of mechanization in Pakistan are; bulldozers, power rigs, tube wells and tractors with cultivators, wheat threshers, sprayers and trailers. Planting of sugarcane, rice, maize and harvesting of sugarcane, cotton, maize and pulses is not mechanized. Only poultry sector has adopted few innovative technologies. Lots of mechanization work in livestock sector is needed. Less horse power ((1.1kW/ha) per hectare is available, but it is also a fact that tractor horse power is under-utilized on many farms, due to lack of matching implements and inadequate access by small holders. There is lack of required machinery and equipment for mechanized precision farming. Moreover, tractor sales depend on institutional credit. Locally produced agricultural machines and irrigation pumps are not energy efficient and environment friendly.

Combine harvesters are not locally manufactured and the European 2nd hand wheat combine harvesters are being used for rice and wheat harvesting which cause a lot of grain damage/loss and cause poor head rice recovery. Transplanting of vegetables, picking of vegetables and fruits is not mechanized. Mechanization is also lacking in technologies for proper drying and storage of grains, processing units for value addition to agriculture produce at the farm/village level, and livestock mechanization.

The majority of farmers consist of small farmers. Farm machines are an expensive input and it is neither affordable nor financially viable to own these machines individually, particularly by small and medium landholders. On the other hand, large farmers also do not have either enough resources or management skills to manage large land holdings. That is why often they do not invest in farm mechanization technologies. There is already a trend of renting of tractors with tillage implements, sprayers and wheat threshers by individual farmers to their neighbors. Similarly renting of combines by rental companies to individual farmers is also practiced, but small farmers usually do not have access to these facilities and rental companies do not possess all farm machines to cater to the needs of farmers.

Meanwhile, there is lack of standard and quality products. The agricultural manufacturing sector has poor layout of workshops, and they do not hire managerial, engineering and technical manpower. Thus it works on poor designs, and employs poor manufacturing techniques. The availability of quality raw materials and standardization/interchangeability of components is another issue. Usually, manufacturers are not aware of quality standards and government regulations particularly on safety and ergonomic requirements e.g. spraying machinery, PTO shafts, and canopy in tractors, seating comfort and covers on v-belt drives.

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 with the rate of technological advancement and awareness creation among the farming community about usefulness of agricultural mechanization. At the same time, little agricultural machinery R&D is done in the private sector.

Few machinery standards were developed but not implemented. Although a small testing laboratory was established in 1990's at NARC, but it is not functioning any more due to lack of testing equipment.

Agricultural mechanization policies

In 1982, National Network of Agricultural Mechanization was established under the Ministry of Food, Agriculture and Livestock, but later on, it ceased functioning.Although many steps were taken for promotion of agricultural mechanization in the country but formal mechanization policy and strategy do not exist until now.

The government is striving for modernization of agriculture. The use of modern and latest farm machinery and equipment plays an important role in the timely sowing and harvesting of crops. The tractor sale in the year 1999 was about 20,000 units whereas today it is 65,000 units per annum. The private banks and the State Bank of Pakistan through ZTBL finance the agriculture machinery and inputs with substantial allocation of tractors. The government has given tax rebates on agricultural machinery by reducing GST from 16% to 7% on locally produced agricultural machinery and reduced GST on locally produced tractors from 16% to 10%. Currently, the Punjab Government is implementing a subsidy program on selected farm machinery for small and medium farmers.

It is proposed that the Government should take steps to:

- Increase horse power per acre from 1.1kW /ha to 1.4 kW/ha;
- Increase number of machines and implements for full utilization of tractor horse power and work hours through providing subsidy to selected implements;
- Mechanize various crop production operations through provision of implements to small farmers /service providers;
- Optimize the use of inputs like fuel, water, seed, fertilizer, chemical etc. by adopting mechanized farming;
- Enhance use of machinery custom hiring services;
- Train farmers and end users to increase their awareness and knowledge;
- Provide loan facility to farmers to purchase machinery;
- Provide tax rebates on agricultural machinery;
- Increase contribution of NGOs to promote machinery;
- Demonstrate, exhibit agricultural machinery to the farmers and manufactures.

New innovation/technologies developed

Sisal decorticator machine

Sisal is a wild plant and it grows near railway tracks and at the boundaries of roads in Potohar region of Pakistan. Its fiber is used for making ship ropes, carpets, furniture, and ladies purse. There was a problem to extract fiber from the leaves of sisal plant. ABEI has developed a sisal decorticator machine.

Specifications:

- Mobile machine
- Capacity: 0.5 ton/h and 5 tons/day
- Fiber %: 3
- Efficiency: 99%
- Sisal fiber production/day: 150 kg
- Local components: 100 %(accept engine)
- Power required: 10 hp
- Labor Required: 2 persons

In-bin seed drying &storage technology

Issue: A considerable amount of seed of various crops is wasted during storage of seed.
First prototype (storage bin cum seed drying technology) unit has been developed at ABEI.

Specifications:
Design Capacity: 15 tons
Reduce moisture Content: from 22% to 12%
Time: 2-3 days
Cost of drying sample/ton: Rs 1,600/-

Peas planter

Issue: Planting of peas and okra technology was not available.
ABEI has developed peas planter and it is also suitable for planting okra.

Specifications:
Capacity: 0.40 ha/h
Operational Cost: Rs 2000/ha
Price (Approx.): Rs 120,000/-
Saving: 60% seed saving
Economic benefits: Rs 30,000/ha

Hot water treatment unit

Objective: To kill fruit-fly larvae within pulp using hot water treatment 45-48^{o}C for 60-75 minutes and pulp temperature at 47.6^{o}C.

In 2014, there was an issue of fruit fly attack on mango crop and for taking precautionary measures; work was started for installing large hot water treatment plants as well as installing small hot water units. ABEI was given a task to develop a small mango hot water treatment unit and it was developed within two weeks. The unit was based on Philippine design which was shared by UNIDO, Pakistan.

Specifications:

Capacity: 150 kg/batch
Price (Approx.): Rs 200,000/-
Burner fuel: LPG
Power source: 3/4hp motor for water pump

Onion seed planter for producing sets

Issue: Low supply of onions during offseason.
Partial solution: Introduction of off season planting of onions by sets.
Technology: Onion seed planter to grow nursery for sets production.
The machine has been developed at ABEI prototype workshop.

Onion seed planting

Onion seed growth

Specifications:

Bed width: 20 inch
Lines/bed: 10
Height of bed: 7 inch
Line to line distance: 2 inch
Seed to seed distance: 2 inch
Capacity: 0.25 acre/h
Engine power: 4.5 hp

Small portable solar dryer for fruits and vegetables

Issue: Post harvest losses in fruits and vegetables
Partial solution: Post harvest processing
Technology: Small solar dryer

Specifications:

Capacity: 30 kg load
Drying time: 2 days in summer and 3 days in winter
Cost: Rs. 60000/-
Exhaust system: small fan operated by solar panel
Maximum temperature in drying chamber: 70 ℃ in summer and 50 ℃ in winter

Towards a more resilient, inclusive and sustainable Asia and the Pacific

CSAM, Centre for Sustainable Agricultural Mechanization, is a regional institution of the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), based in Beijing, China. CSAM is built upon the Regional Network for Agricultural Machinery (RNAM) and the United Nations Asian and Pacific Centre for Agricultural Engineering and Machinery (UNAPCAEM), and started operations in 2004. CSAM serves the 62 members and associate members of UNESCAP.

The vision of CSAM is to achieve production gains, improved rural livelihood and poverty alleviation through sustainable agricultural mechanization for a more resilient, inclusive and sustainable Asia and the Pacific.

CSAM's objectives are to enhance technical cooperation among the members and associate members of UNESCAP as well as other interested member States of the United Nations, through extensive exchange of information and sharing of knowledge, and promotion of research and development and agro-business development in the area of sustainable agricultural mechanization and technology transfer for the attainment of the internationally agreed development goals including the Millennium Development Goals in the Asia-Pacific region.

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