MECHANIZATION PACKAGE
PUNJAB, PAKISTAN

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UNIVERSITY OF AGRICULTURE, FAISALABAD

Mechanization Package Committee

1.	Prof. Dr. Iqrar Ahmad Khan, (Sitara-e-Imtiaz) Vice Chancellor, UAF	(Convener)
2.	Director General, Agriculture (Ext. & AR) Punjab, Lahore	(Member)
3.	Director General, Agriculture (Field), Punjab, Lahore	(Member)
4.	Director General, Agriculture (Research), AARI, Faisalabad	(Member)
5.	Director General, Agriculture (Water Management) Pb, Lahore	(Member)
6.	Director General, Agriculture (Ext. & AR) Punjab, Lahore	(Member)
7.	Director Agri. Mechanization Research Institute, (AMRI), Multan	(Member)
8.	Dean, Faculty of Agri. Engineering and Technology, UAF	(Member)

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1. Executive Summary

1.1 Pakistan is an agrarian based country. Its labor force and industrial growth is directly or indirectly linked with the agriculture. Punjab is the main production province of the country, which covers 69% of the cropped area of the country. According to the World Bank report (2005), land and water productivity in Pakistan's Punjab is 2-3 times lower compared to those at international benchmark.

1.2 Crop productivity is affected by mechanical, biological, hydrological, and chemical inputs**.** The mechanical input may be defined by the farm power in terms of tractors and implements. Number of tractor owners in Punjab have been reported to be 500,000. Out of these 95% have cultivators, 20% have MB ploughs, 15% have disc ploughs, 5% have chisel ploughs, 5% have rotavators, 10% have disc harrows, 10% have ridgers, and 22% have seed drills.

1.3 The horse power per acre availability in Punjab has been found to be 0.74, which is very low as compared with India (1.01), China (1.57) and Japan (2.83). This low power input at the farms of Punjab 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.

1.4 In the water management sector, the Govt. of Punjab has improved 47,000 watercourses out of 58,000; installed drip/sprinkler irrigation systems on 20,000 acres along with providing laser leveling services which contributed to 30-40% saving in irrigation water.

1.5 Creating awareness and capacity building of farmers, technicians and manufacturers are desirable steps towards farm mechanization. As per guidelines provided by FAO, regarding developing the Agriculture Mechanization Strategies (AMS), three tier approach needs to be adopted viz; 1) situation analysis involving all the stakeholders; 2) development and adoption of improved strategies through public-private partnership, 3) introduction of demand driven technologies coupled with profitability. Mechanization strategies should be technically feasible, economically viable and socially acceptable to promote its sustainability.

1.6 The way forward for promotion of sustainable mechanization may include as 1) enhancement of available farm power, 2) mapping and standardization of agricultural machinery, 3) development of indigenous low cost agricultural machines, 4) provision of incentives and tax rebates through legislation, 5) enhancing awareness of mechanization and providing training opportunities, 6) provision of backup support through adequate repair and maintenance services and availability of spare parts.

1.7 The government of Punjab (GoPb) assigned the University of Agriculture, Faisalabad, Agricultural Mechanization Research Institute (AMRI), Multan, DG Agri. Extension, and DG Water management to identify the issues pertaining to farm mechanization and develop the road map for its improvement. A number of joint meetings were convened at UAF to develop strategies for mechanizing agriculture in the province. This report has been compiled as an outcome of coordinated efforts of the relevant stakeholders. This report attempts to present well defined road map for achieving the anticipated goals in mechanization that would ensure enhanced agricultural productivity.

1.8 The proposed mechanization strategy emphasizes on enhancing availability of farm power, creating awareness of mechanization on farmers income, providing training for producing skilled man power, building data bank and mapping of farm mechanization status, developing crop zone specific packages of farm machines and implement, reducing cost of

farm machinery by providing subsidies and tax rebates, developing legislation for standardization ad certification, bringing R&D organizations under one umbrella, strengthening / research linkages, encouraging reverse engineering of imported machines for increasing farmers access to farm machinery, promoting value addition at farms, ensuring ergonomic principles of health and safety.

2. History of Farm Mechanization

2.1 Tractor manufacturing industry - Tractor manufacturing industry in Pakistan started with the establishment of Rana tractors (now Millat Tractors Limited) in 1964 and an assembly plant was set up in 1967 to assemble tractors imported in semi-knocked down (SKD) condition. Local manufacturing of the tractors under Government approved deletion program started in 1981 and five firms were licensed to manufacture tractors. The manufacturers of Belarus, Ford and IMT tractors went out of business and now only two manufacturers are actively involved in local manufacturing of tractors. M/s Millat Tractors Ltd. Lahore and M/s Al-Ghazi Tractors Ltd. Dera Ghazi Khan are producing 8 models of tractors in the range of 50 to 85 hp. Both of the companies have well established manufacturing/assembling plants and network of distribution and after sale service throughout Punjab and Pakistan. M/s Millat Tractors Ltd. is producing 45,000 units annually while M/s Al-Ghazi tractors Ltd., has installed capacity of over 30,000 tractors on single shift basis. Besides these two major tractor manufacturers, few other manufacturers are also producing and marketing locally assembled and imported tractors on a limited scale.

2.2 Agricultural implements and machinery manufacturing industry - Agricultural implements and machinery manufacturing industry started with the establishment of Esakhel Estate Farm, Kot Samaba, District Rahim Yar Khan during early 50's which played a vital role in promotion and dissemination of farm mechanization in Punjab by importing first tractor in the country during 1954 and establishing a manufacturing unit for production of implements for mechanized farming with the collaboration of John Deere from USA. The Esakhel Estate Farm provided training to farmers of the area and also provided repair and maintenance services for the tractors and implements. During 1959, there were only 15 farm machinery manufacturers in the country. The number increased to 500 in 1984. The increasing trend of manufacturers during the period of 1978 to 1984 was due to the liberal government policies such as rebate in import duty for raw materials and exemption of income tax (Khan and Farooq, 1993). However, a setback has been observed in this industry by closing/reducing production by medium sized manufacturers due to withdrawal of above government incentives. Local farm machinery industry is producing a wide range of farm machinery except for the complex one like transplanters for vegetables and paddy, combine harvesters, sugarcane harvester, cotton picker, corn picker, fodder cutters cum choppers, balers for silage, hay balers, tedder rakes, mango pruner, carrot washer, fruit and vegetable grader etc.

2.3 Farm Mechanization Research and Development - Farm Mechanization Research and Development in Punjab started with the establishment of Agricultural Engineering Research Division at Faisalabad during 1964 which was later up-graded to the level of full institute in 1976 and was named as Agricultural Mechanization Research Institute (AMRI). Later in 1978, established Agricultural Machinery Division (AMD) which was later up-graded to the level of fully fledged institute and named as Farm machinery Institute (FMI) under the Pakistan Agriculture Research Council. Subsequently, FMI was renamed as Agricultural and Biological

Engineering Institute (ABEI). Both the institutes are actively involved in R&D for design and development, testing and evaluation and promotion of low cost and appropriate farm mechanization technologies. Beside R&D, these institutions also undertake test and evaluation of imported as well as locally produced farm machines for adaptation. Provision of technical assistance to local farm machinery industry and farmers is also responsibility of these institutions. Over the period of last 35 years, AMRI has contributed in development and commercialization of several successful machines including wheat thresher, seed drill, multi-crop planter, groundnut digger, wheat straw chopper, maize sheller, rotary potato digger, weeding-interculture-earthing up tool bar, sugarcane planter, axial flow pump, rotary slasher, biogas plant, seed cleaner/grader, bed and furrow shaper/planter, bed and furrow interculture equipment, hand driller/single row planter and self propelled sprayer, granules applicator, sugarcane ratoon management machinery, multi-crop Sheller, and maize Sheller. Similarly, ABEI has contributed in mechanization through development of zero tillage drill, rice and sunflower threshers, pneumatic planter, conservation agricultural machinery like happy and rocket seeder, solar dryer for fruits and vegetables and fuel fired maize dryer.

2.4 Agricultural Engineering Education in Pakistan - Agricultural Mechanization was set up initially in 1958 in the Engineering College Workshop, University of Engineering & Technology (UET), Peshawar, NWFP, Pakistan and formal education in agricultural engineering was introduced in 1962. The Faculty of Agricultural Engineering & Technology was established in 1961 when the Punjab Agriculture College, Lyallpur was given the status of University of Agriculture, Lyallpur. The main objective of the Faculty was to train manpower to cater the growing needs of mechanized farming in the province of Punjab, Pakistan. This faculty is one of the pioneer faculty of its nature in whole Pakistan. In Nov. 1961, a diploma class of agricultural engineering was first started to support Thal Development Authority (TDA) and agricultural engineering workshop which was substituted with a four years B.Sc. Agricultural Engineering degree in 1963. The faculty comprises of 1) Department of Farm machinery & Power, 2) Department of Irrigation & Drainage, 3) Department of Structures & Environmental Engineering, 4) Department of Food Engineering, 5) Department of Energy Systems Engineering, 5) Department of Fiber and Textile Technology, 6) Water Management Research Centre (WMRC). The overall objective of the faculty is to train manpower through teaching and research in the field of irrigation and drainage, farm power and machinery, structures and environment, textile technology and food engineering. The faculty is very actively engaged in offering courses at undergraduate and postgraduate level to produce the skilled manpower specialized in managing water resources, farm equipment, environment, food, energy and textile engineering and technologies. The faculty is playing a vital role to mechanize the agriculture of Punjab. The faculty has designed and developed agricultural machines like; Multi-crop reaper, Rotary pit digger for sugarcane planting, Multi-operational machine for one pass system, Biogas plants for operating tubewells, Potato Digger, Solar Energy for extraction of juice from medicinal plants, Designed and installed fixed focus Scheffler (10 m^2) solar system for drying crops, distillation of essential oils, nuts roasting, Zone Disk Tiller Drill (Registered by GOP), University Boom Sprayer (Registered by GOP), University Boom Sprayer Test Bench (Registered by GOP), High efficiency irrigation systems etc.

During 1977, B.Sc Agricultural Engineering was also started in Sindh Agriculture University, Tandojam. The BSc. engineering was also expanded and started at Baha-ud din Zakariya (BZU) University, Multan during 2004 and at Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi in 2013.

2.5 Machinery standardization and quality control – Pakistan Standards Institution (PSI) i.e. Pakistan Standard and Quality Control Authority (PS&QCA) is the statuary body to formulate National Standards of Agricultural Machinery, equipment and implements. PSI in collaboration with AMRI and ABEI has approved several standards of Agricultural Machinery, Equipment and Implements and their components. Unfortunately, in the absence of any market force which is generated by end-users / farmers, the manufacturers have entered into negative competition to produce low quality machinery, equipment and implements. As a result of this trend, the pace of PSI work has been slowed down. In the developed World adaptation of the standards to produce quality equipment by the local industry is done on voluntary basis but, the Agricultural Machinery, Equipment and Implements Manufacturing Industry in Pakistan has failed to come up to the expectations of their consumers.

Government of the Punjab, Agriculture Department constituted a committee during December, 1998 to introduce standards of manufacturing for the production of quality machinery, equipment and implements with the TOR's 1) to examine the existing rules and regulations dealing with manufacturing of agricultural machinery and implements, 2) to propose whether any fresh legislation is required, 3) to draw up an action plan for proposed legislation. The committee, after doing necessary spade work, concluded that there is a need to formulate legislation. Accordingly, legislation was drafted and submitted to the Agriculture Department, but the ns are ready nor the government has any set up to regulate the industry.

3. Strength and weaknesses of the existing agricultural mechanization system

Punjab despite having Pakistan's best alluvial soils, diversified weather conditions with most appropriate day night temperature conditions, is facing constraints like low growth rate, low productivity, high cost of production and post-harvest losses, poor quality of produce and exorbitantly high market costs. In spite of these constraints, Punjab's agriculture sector has lot of opportunities to become one of the leading exporters of fresh produce due to increase in demand as a result of increasing population and high cost of production. Besides having lot of strengths and opportunities, Punjab's agriculture suffers from a variety of weaknesses and threats. The production system of Punjab at present is supply based instead of demand driven which results in low prices especially during the peak season. On the other hand, the consumers pay high prices during the off season. This not only generates low return to farmers but the consumers also don't get the required quality and quantity of the produce for the price they pay. Farmers lack capacity and knowledge to produce as per market demand. Empowering farmers with the information and ability of producing as per market demand which can increase farmers' income, and increase consumers' satisfaction. As a result of these constraints, Punjab is not only losing national and international competitiveness but the farmers are also not getting proper return which in turn is resulting in low per capita consumption and high poverty in rural areas.

The extent of low crop yield can be seen from Table-3.2.

Table-3.1. Yield of major crops of Pakistan compared with the World's highest yield

Crop	World's Highest Yield (ton/ha)	Pakistan's yield (ton/ha)		Yield Gap (ton/ha)	Yield Gap (Times)
		Potential	Avg. 2011-12		
Wheat	France (7.50)	6.81	2.83	4.98	1.37
Seed Cotton	China (4.00)	4.33	2.19	2.14	2.02
Sugarcane	Egypt (120.00)	300.00	56.00	244.00	2.02
Maize	France (9.90)	9.20	3.81	5.39	1.71
Rice	USA (7.40)	5.15	2.04	3.11	1.66

Source: FAO Statistical yearbook 2012

Table-3.2: Percent increase required to ensure food security by the year 2020

Years	Population (Millions)	Wheat (000 tons)	Cotton (000 Bales)	Rice (000 tons)	Sugarcane (000 tons)
2000	139.41	19024	10732	4803	43606
2006	156.77	23295	12856	5438	54742
2011	177.1	25213.8	11560.1	4823.3	55308.5
2020	210.12	29937	15707.3	6750.1	68238.4
% increase in 2020 over 2011	**19**	**19**	**36**	**40**	**23**

Source: National Institute of Population Studies, Planning Commission of Pakistan Economic Survey of Pakistan (various issues).

Keeping in view the TOR-1, the strengths of the existing farm mechanization system are discussed below;

3.1 Tractor manufacturing industry

M/s Millat Tractors Ltd. Lahore and M/s Al-Ghazi Tractors Ltd. Dera Ghazi Khan are producing 8 models of tractors in the range of 50 to 85 hp. Both of the companies have well established manufacturing/assembling plants and network of distribution and after sale service throughout Punjab and Pakistan. M/s Millat Tractors Ltd. is producing 45,000 units annually while M/s Al-Ghazi tractors Ltd., has installed capacity of over 30,000 tractors on single shift basis. Besides these two major tractor manufacturers, few other manufacturers are also producing and marketing locally assembled and imported tractors on a limited scale.

3.2. Agricultural implements and machinery manufacturing industry

3.2.1 Land development and leveling machinery

According to the Punjab Development Statistics (2011-12), about 3.88 million acres are lying as cultureable waste land which does not include rain fed cultivated area of Thal and Potohar zones. For development of cultureable waste land, tractor mounted front blade and bulldozers are commonly used. Tractor mounted front blades are available through private sector while bulldozers for land development are available from the public sector. This cultureable waste land can economically be developed for cultivation through the use of crawler tractors/bulldozers only. The existing fleet of 338 bulldozers with the Punjab Agriculture Department is insufficient to convert 3.88 million acres of culture able waste land. It is estimated that with the present strength of bulldozers, it will take about 100 years to develop the entire cultureable waste land.

3.2.2 Soil tillage implements

Tillage is performed to destroy pests' 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. Tillage needs to be done at the right time with the right implements to get good tilth, which is a pre-requisite for better crop production. Tillage process is generally accomplished in two stages, namely, primary and secondary tillage. Primary tillage / ploughing is opening of the compacted soil with the help of different ploughs to open the hard and compacted soils. In addition, primary tillage also aims to inversion (whenever necessary) of soil, uprooting of weeds and stubbles. Chisel plow, M.B. plow and Disc plow are main types of primary tillage implements. 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. Disc harrows, cultivators, rotary tillers (rotavator) etc., are commonly used for this purpose. Planking is done to crush the hard clods and to smoothen surface soil and to compact the soil lightly. In Punjab, cultivator is the most widely used implement for primary as well as secondary tillage of soil. 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. 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), permanent beds tillage (for sowing of cotton on beds of previous crop) and mulch or stubble tillage (retention of previous crop stubbles in the field) are also practiced on limited scale not only to minimize cost of tillage and seedbed preparation, but also to mitigate greenhouse gases.

3.2.3 Seedbed preparation implements

The soil of a seedbed needs to be loose and smoothed without large soil lumps or clods so that seeds can be planted easily, and at a specific depth for best germination. After tillage, quality of seedbed plays an important role in crop yield. Sometimes, use of secondary tillage implements does not provide favorable conditions for seed germination and growth; therefore, seedbed preparation implements are used to provide soil aggregates of the proper size. Some of the seedbed preparation implements commonly used in Punjab include clod breaker, cultivator and plank (sohaga). Use of rotary tiller and disc harrow for seedbed preparation is expanding.

3.2.4. Seeding and planting machinery

After proper seedbed, crop stand mainly depends upon proper seeding depth as too shallow seed is prone to birds attack while too deep seed may not germinate due to heavy load of soil on the seeds. For proper yield of any crop, plant population and row to row distance plays an important role which can only be achieved if appropriate sowing machines are used. One of the main reasons for low crop yield in Punjab is inadequate plant population. Due to time limitation or high cost of tillage and seedbed preparation, some farmers spread seed through broadcasting which neither provides desired plant population nor results in proper yield.

3.2.4.1 Seed drill - For sowing of wheat, mostly seed drill (Rabi Drill) with or without fertilizer attachment is commonly used in Barani as well as in irrigated areas of the Punjab. These drills are generally not provided with soil entry prevention system at the back of each pore due to which pores are closed and choked frequently. In fields containing stubbles of cotton, rice and sugarcane, coulter drills are also used which are most effective. In rice harvested fields, generally wheat seed drills are used after conventional methods of tillage and seedbed preparation which delays sowing by 3 to 4 weeks and results in lower yields. For timely sowing of wheat in manually harvested rice fields, zero-tillage drill has been introduced. Another problem for sowing of wheat in combine harvested paddy fields is burning of rice straw as zero tillage or wheat seed fail to handle/manipulate heavy residue present in combine harvested fields. Bed and furrow system of sowing wheat on raised beds not only helps to save water but is particularly suitable for saline soils. Bed drills are also used for sowing of wheat on beds.

3.2.4.2 Crop planter - For sowing of row crops like cotton, maize, sunflower, groundnut and others, multi-crop planters are commonly used which don't place seeds at one place rather seed is more or less dropped in a continuous fashion which requires thinning of plants to maintain desired plant population. Use of such planters also requires more than recommended seed rate. In order to overcome this problem, pneumatic planters, inclined/vertical seed plate planters and are used in Punjab on a very limited scale. Pneumatic and inclined/vertical seed plate planters are capable to place one seed at the desired plant to plant distance. For these planters, seed germination rate must be almost 100%. Hill planting is a technique through which a bunch of 4-5 seeds is placed at one place. This technique is helpful in soils which tend to crust after rains or light irrigation. The collective force of emergence of several seeds placed at one spot ensures seed

germination in such soils. In the absence of hill planting machine, seed placement is generally done manually.

3.2.4.4 Miscellaneous crops sowing machinery -_For proper yield of rice crop, plant population plays an important role which is recommended to be a minimum of 100,000 per acre. Rice nursery transplanting in Punjab is generally done by skilled laborers which hardly transplants 50,000 to 60,000 plants per acre. For planting of sugarcane, sugarcane set planters are also used on a limited scale. In these planters, whole cane is fed vertically or horizontally while sets are cut automatically by the reciprocating blades. For sowing of potato seeds, vertical cup planters are commonly used.

3.2.3 Weed control machinery and equipment

According to field research conducted by the Adaptive Research Farms and AARI, weeds can reduce crop yield up to 40%. For mechanical control of weeds; in wheat sown on flat bed/land, bar harrows are used; in row crops like cotton and maize sown on flat bed, rigid tine interculture tools are used. For earthing-up and side dressing of fertilizers, fixed or expandable ridger wings are attached behind the rigid tines of the interculture tool bar. Sometime, rotary tillers are also used in place of rigid tines for weeding. For control of weeds in sugarcane crop, disc ratooners and rotary weeders are used. For chemical control of weeds, knapsack sprayers (manually operated and power operated) and tractor mounted boom sprayers are mostly used for application of pre as well as post emergence weedicides. Some of the farmers sowing cotton and other crops on beds do apply pre-emergence weedicides through applicators provided with the bed and furrow planters.

3.2.4 Fertilizer application machinery

According to field trials conducted by the Adaptive Research Farms and AARI, fertilizer use efficiency is about 50% which is attributed to inappropriate application (broadcast) machinery and equipment. In Punjab, base fertilizers are generally applied through broadcast which is done manually or through tractor mounted fertilizer broadcaster. Fertilizers to be applied at the time of sowing are mostly applied through drills and planters while subsequent dose in wheat is applied through manual broadcast and in crops grown in rows is applied with the help of fertilizer attachment provided with the interculture tool. Some drills and planters do have provision for band placement of DAP fertilizer. Use of fertigation (applying of fertilizers through irrigation water) in drip irrigated crops is also being used. Some of the progressive farmers do apply fertilizers through foliar application.

3.2.5 Pesticides application machinery

According to field trials conducted by the Cotton Research Institute of PCC Multan, pesticides application efficiency is hardly 50% which has been attributed to use of inappropriate and poor quality of spray machinery and inadequate application methods. In Punjab, pesticides spraying is done using knapsack sprayers, tractor operated sprayers and hand held sprayers. Tractor operated sprayers used in Punjab are mostly of boom type for field crops while canon type mist blowers are also used for orchards. On a very limited scale hand held ULV sprayers are also used. The booms of tractor mounted sprayers are generally rigid which tend to sag which result in non-uniform application.

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.

3.2.6 Irrigation machinery

According to the data provided by the Water Management Wing, water use efficiency (WUE) in Pakistan is lowest in the World (in wheat is 10% of China and in rice it is hardly 5% of Philippines). For irrigation purpose, tube wells are used where canal irrigation is either not available or where it is deficient, tube wells are used for supplementing canal supplies. In riverine areas where water table is within 30 ft, for lifting of water, centrifugal pumps are used, for lifting of water from depths of 30 to 100 ft, turbine pumps are used and for lifting of water from depths of 100 to 200 ft, submersible pumps are commonly used. In hilly areas, some farmers are using jack pumps which have the capability of lifting water beyond 500 ft. The efficiency of the centrifugal pumps is lowest while the same for jack pumps is highest.

3.2.7 Harvesting and Threshing Machinery

Harvesting losses due to delayed harvesting as well as use of inappropriate harvesting machinery of wheat, rice and other oilseed crops has been estimated to be around 10-15%.

3.2.7.1 Harvesting and threshing machinery for cereal crops - Harvesting of wheat and rice is conventionally done using hand sickles. Tractor mounted reaper windrowers and combine harvesters are also used to a greater extent. Harvesting of rice done with wheat combines causes excessive grain losses and internal grain injury and hence reduces head rice recovery and increased grain breakage during milling. 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 output capacity but are heavy in weight and thus costly, energy inefficient, ergonomically unsafe. 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. For threshing of chickpeas, wheat thresher is used after incorporating proper size sieves and adjusting speed of threshing drum and blower but the quality of threshed produce is poor.

3.2.7.2 Harvesting and threshing/shelling machinery for non-cereal crops - Harvesting of non-cereal crops like cotton, maize, sunflower, canola and rapeseed/mustard, groundnut and sugarcane is mostly done manually, but sometimes machines are also used. Cotton picking mechanization is perhaps the most expensive operation of harvesting any crop, as cost of commercially available cotton pickers is in the range of Rs. 15-20 million for a 2 row machine and over 25-30 million for a 4 row machine. Some efforts were made in the past to introduce US made IH and JD cotton pickers of horizontal spindle types, and a vertical spindle harvester from Uzbekistan, but due to exorbitantly high cost of picking, these machines could not meet success. ***The low cost tractor mounted version of cotton picking machine can be produced locally by establishing proper rebuilding facilities which is expected to cost 2-2.5 million for a single row machine and 3-4 million for a two row machine***. Maize and sunflower is harvested with combine harvesters fitted with sunflower and maize headers. Similarly canola and rapeseed/mustard crops are also harvested with wheat combine harvesters. In the absence of headers, the combine harvesters are used as stationary thresher to thresh sunflower heads after 1-2 days of sun drying in the field. For harvesting of groundnut crop, groundnut diggers are also used.

Similarly, sugarcane billet harvesters are also used. For threshing of oilseed crops like canola, rapeseed/mustard, wheat thresher is used after incorporating proper size sieves and adjusting speed of threshing drum and blower but the quality of threshed produce is poor. For shelling of groundnut and maize, shellers are used. The level of mechanization of different farm operations, increase in agricultural machinery and equipment and number of tube wells and tractors is shown in Table-3.3, 3.4 and 3.5 respectively.

Table- 3.3 Estimated Levels of Mechanization of various Farm Operations (2010)

Farm Operation	Extent of Mechanization (%)
Seedbed Preparation	85
Sowing/Planting	25
Weeding/Interculture	40
Spraying	95
Harvesting	40

Source: Agricultural Statics of Pakistan

Table-3.4 Status and trend of selected implements and farm Machinery of Pakistan

Machinery	Year 1984		Year 1994		Year 2004*		Year 2010	
	Total in Pakistan	Punjab	Total in Pakistan	Punjab	Total in Pakistan	Punjab	Total in Pakistan	Punjab
Cultivator	146863	123755	236272	203444	369866	317506	-	-
MB Plow	7319	2780	28413	17980	40050	27093	-	-
Disc Harrow	8140	2734	13233	8302	23764	16032	-	-
Ridger	4711	4030	10984	10872	71338	66806	-	-
Drill	11251	10669	64126	60835	70810	66700	295184	251112
Trolley	98787	81668	176412	145557	242655	195332		
Thresher	78377	71195	112707	96655	137270	122737	353768	265546
Reaper	-	-	8073	-	13600	12528	66958	58099
Combine Harvester	-	-	359	-	3355	2899	29344	21369
Chisel Plow	712	-	6535	-	8514	6719	-	-
Rotavator	2101	-	5594	-	47919	44192	-	-
Cutter Binder		-		-		436	-	1770
Blades	69004	-	164489	-	233126	189965	-	-
Sprayers	-	-	20778	-	21756	20976	1438991	1121110
laser Leveler	-	-	-	-	2785	1692	-	4843

Source: Census of Agriculture Machinery

Table-3.5 Number of tube wells and tractors in Pakistan, 1996–2010

Year	Tube wells	Tractors
Up to 2000-01	659,278	316,783
2001/02	707,273	352,137
2002/03	768,962	395,520
2003/04	950,144	431,579
2004/05	984,294	480,366
2005/06	999,569	537,354
2006/07	1,025,636	601,836
2007/08	1,016,125	664,348
2008/09	1,069,991	727,545
2009/10	1,070,375	811,191

Source: Agricultural Statics of Pakistan

3.2.7.3 Harvesting and post harvesting machinery for fruits and vegetables - Harvesting losses of fruits and vegetables have been estimated to be 40-45% due to unavailability of inadequate harvesting, handling, and post harvesting equipments. In order to minimize harvest losses, maintain quality and increase shelf life, pre-harvest preparation should be made timely which includes lining up sufficient labor, supplies (containers and packaging items) and ensuring that all the tools and harvesting equipment is available and is in operation. Harvesting of fruits and vegetables is mostly done manually by using some sort of harvesting aid like clippers, ladders, scissors, knives, snipers and secateurs.

On-farm processing is limited to the extent of washing, cleaning and bagging of fruits and vegetables and cleaning and grading of grains. Post-harvest processing of grains is mostly done at the processing plants while it is done at the pack houses in case of fruits and vegetables. It has been estimated that post-harvest losses in case of grains are 10-15% while the same for fruits and vegetables is 20-25% because of inappropriate on-farm handling, transportation and use of inadequate post-harvest operations like pre-cooling washing and drying, sorting, grading, disease/insect treatment, protective coating, packing and storage.

4. Proposed agricultural mechanization strategies

According to FAO (1997), an agricultural mechanization strategy (AMS) should create a policy, in which farmers and other stakeholders may have the choice of farm power and equipment suited to their needs. The proposed strategy may also facilitate for importation and domestic manufacture of tools, equipment and machinery, their repair and maintenance, relevant training and extension programs, and promotion of financing systems for the purchase of farm power and related machinery and implements.

4.1 Farm power - Based on estimated population of tractors in Punjab for the year 2012, is 415,000 and based on cultivated area of 30.78 million acres, there is one tractor for every 74 acres of cultivated area. Assuming 55 hp per tractor, available power is 0.74 hp/ac as against 1.0 hp/ac as recommended by FAO. In order to achieve FAO recommended power, the tractor population needs to be raised to 600,000 by the year 2015 that will require annual induction of at least 60,000 @ 10% deletion and non-agriculture use. In order to achieve the proposed target of tractor population, the installed capacity of the both manufacturers is more than enough to produce required number of tractors, because both of the manufacturers are operating on single shift basis.

4.2 Zone wise agricultural machines / implements for crop production

To solve the food security issues, the required zone wise agricultural machines / implements for crop production on priority basis have been given as following:

Name of Implements				
Cotton & Wheat Zone				
Multan, Bahawalnagar, D.G.Khan, Layyah, Vehari, Khanewal, Rajanpur, Muzaffargarh, Lodhran, Pakpattan, Bahawalpur and R.Y.Khan (12 Districts)	1	Laser leveler	14	Mango sprayer mounted type
	2	Disc harrow	15	Broad caster for fertilizer
	3	Rotavator	16	Reaper
	4	Cultivator	17	Wheat thresher
	5	Rabi drill	18	Combine Harvester (Imported)
	6	Kharif Drill	19	Fodder cutter cum chopper
	7	Fertilizer band placement drill	20	Wheat straw chopper
	8	Bed & furrow shapper planter	21	Seed grader / cleaner
	9	Precision planter (for Soyabean, Maize & Sunflower)	22	Post Hole Digger
	10	Cotton ridger with fertilizer	23	Mango Pruner
	11	Bed interculture equipment	24	Fruit picker
	12	Boom sprayer (Tractor Mounted)	25	Sunflower thresher
	13	Knapsack Sprayer		

Rice & Wheat Zone

Sheikhupura, Hafizabad, Gujranwala, Nankana Sahib, Narowal, M.B.Din, Sialkot and Gujrat (8 Districts)	1	Laser leveler	10	Reaper
	2	Disc harrow	11	Wheat thresher
	3	Rotavator	12	Rice Straw shredder
	4	Cultivator	13	Rice thresher
	5	Double coulter drill with fertilizer	14	Combine Harvester (Imported)
	6	Fertilizer Band placement drill	15	Fodder cutter cum chopper
	7	Bed & furrow drill (Wheat)	16	Wheat straw chopper
	8	Knapsack Sprayer	17	Seed grader / cleaner
	9	Broad caster for fertilizer		

Mixed Zone

Jhang, Chiniot, Sargodha, Okara, Faisalabad, Kasur, Khushab, T.T.Singh, Sahiwal and Lahore (10 Districts)	1	Laser leveler	13	Wheat thresher
	2	Disc harrow	14	Combine Harvester (Imported)
	3	Rotavator	15	Fodder cutter cum chopper
	4	Cultivator	16	Reaper
	5	Double coulter drill with fertilizer	17	Wheat straw chopper
	6	Sugarcane Planter	18	Seed grader / cleaner
	7	Fertilizer Band placement drill	19	Post Hole Digger
	8	Sugarcane ridger	20	Sunflower thresher
	9	Precision planter (for Soyabean, Maize & Sunflower)	21	Knapsack Sprayer
	10	Citrus Sprayer	22	Broad caster for fertilizer
	11	Knapsack Sprayer		
	12	Broad caster for fertilizer		

4.3 Post-harvest machinery for value addition much of the food grown at agricultural farms never makes it past the farm gate, contributing to food insecurity. Estimates of the post-harvest losses of fruits and vegetables in Pakistan from mishandling, spoilage and pest infestation are nearly 35 percent indicating one third of what is produced never reaches the consumer for whom it was grown, and the effort and money required to produce it are lost-forever. Fruit, vegetables and root crops are quickly perishable, and if care is not taken in post-harvest activities like handling, grading, processing, packaging and transport, they will soon decay and become unfit for human consumption. Estimates of production losses in mangoes, dates, tomatoes, bananas, chilies and onion sometimes are estimated as high as 50 percent. Similarly post-harvest loses in cereals 15-20 percent has been recorded as high as 20 percent. More than 6.5 million families consisting of 30-35 million people are involved in livestock farming. In rural areas, it complements agriculture income by converting crop residues, agriculture byproducts and wastes

into milk, meat, wool, hair etc. There are 72 million and 39 million animals in Pakistan and Punjab respectively. There are about 785 million birds in poultry estates across the country. Per capita availability of meat is 12 kg, most of which is from buffalo and cattle. Meat sector in Pakistan is working on an informal basis from animal raising to meat selling. Animal traders purchase animals from the rural areas and sell them to the animal markets in the urban areas. Butchers purchase these animals from animal markets and slaughter them in the slaughterhouses. Butchers act as meat traders and dominate the meat market both in rural and urban areas. The animals sold in these markets are generally diseased and culled animals. Butchers/traders prefer to buy these cheap animals. Appropriate use of post-harvest technologies including milk processing and animal slaughtering will minimize the post-harvest losses, increase the market value, quality and food value of farm products and hence would help solving food security issues. Modern post-harvest technologies widely used in developed countries cannot be applied quickly in Pakistan because these are sophisticated, expensive and too large for the small-scale farming systems of Pakistan. Moreover, some small-scale equipment manufacturers in countries like Europe and Japan is too expensive for a developing country like Pakistan. Therefore, following indigenous postharvest technologies be developed:

1. Product cleaning, washing, processing and grading/sorting technologies for cereals
2. **Picking, handling, packaging and storing** technologies for fruits and vegetables
3. Farm to market transports like mini trucks, pick up vans and farm trolleys with shock absorbing (leaf springs) mechanical parts to save the farm products from mechanical injury during transport.
4. TMR Wagon for fodder
5. Small scale milk pasteurization units
6. Small scale animal slaughtering centers
7. CA technologies

4.4 Renewable energy technologies

Energy plays a pivotal role in production and development process. The conventional sources of energy are gradually diminishing leading to unaffordable prices for consumers. Most of the farm activities are hindered due to non-availability of enough energy. The electricity shortfall 3000-5000 MW has resulted severe load shedding in the country and the only solution is the energy conservation, energy efficiency and utilization of renewable energy resources. Potential for different types of renewable energy resources exists in Punjab viz. biogas, biomass, solar (PV and thermal), micro-hydel/canal-fall, biodiesel production etc. The province has the potential to produce 674 MW electricity from animal dung of 39 million animals and 175 MW Power from droppings of 390 Million poultry birds. Moreover, the surplus 44 million tons per annum of biomass can produce 3300 MW (@ 0.667 kWh per kg biomass). Additionally, 30 large sugar Mills are producing 450 MW [@15 MW each mill]. Moreover, Punjab Province is lying in the solar belt having an average solar global insolation of 5–6 kWh m^{-2} day^{-1} which can effectively be utilized for electricity generation employing solar PV technologies. High solar irradiance in summer (1000 W m^{-2}) can also be used for the value addition of different agricultural products employing solar dryers, solar roaster solar distillation systems etc.

University of Agriculture, Faisalabad has developed indigenized RE technologies viz. biogas energy (25 and 40 m^3 plants), solar thermal and PV technologies for rural community. For solving energy crises issues in the province, following RE technologies be locally developed and promoted:

1. Biogas operated Tubewells 25 m^3 and 40 m^3 floating drum biogas plants to operate 0.75 cfs Solar drying for fruits, vegetables, medicinal plants and cereal crops
2. Solar distillation system for the processing of medicinal plants
3. Solar roasting machine for peanuts and groundnuts
4. Solar cookers for community kitchen applications
5. Standalone Solar PV System
6. Biomass Gasifiers for Power Generation
7. Biomass Boilers for Power Generation
8. Energy Auditing system

4.5 Sustainable delivery, associated support system and capacity building of technical manpower

At present, farm mechanization is limited to crop production. Its scope needs to be expanded to introduce post-harvest machinery for proper drying and storage of grains, and processing units for value addition to agriculture produce at the farm/village level. There is a great potential to export fruits and vegetables if efforts are made in proper curing/pre-cooling, sorting/grading and packaging of fruits and vegetables at the farm/community level.

Farm mechanization activities/issues are being tackled by various agencies/institutes but in isolation. For identification of mechanization needs and their solution with little duplication by the agencies involved, AMRI, ABEI, and UAF should jointly work to find priorities mechanization issues, and advise to government of their solutions to ensure their implementation.

The private sector should be persuaded to establish their own R&D to meet WTO obligation of product quality at competitive prices. They should be encouraged to recruit qualified and experienced Agricultural Engineers at their strength and allocate adequate percentage of their turnover for R&D work. The Government shall incentivize tax rebate in lieu of R&D spending as is done for other manufacturing/value addition industries.

The R&D/testing facilities of the public sector R&D institutes should also be upgraded to focus on market driven issues. The R&D institutes like AMRI, ABEI, and UAF (teaching and research) need to be strengthened.

Pakistan Agricultural Machinery and Implements Manufacturers Association (PAMIMA) needs to be encouraged to play its due role of upgrading manufacturers premises facilities, creating their own R&D and producing quality products at competitive prices to meet WTO challenges. It can play active role in establishing raw material banks and common facilities centers at various farm machinery manufacturing clusters. There is a good business opportunity in establishing central facilities of manufacturing of specialized/critical components like gears, sprockets, and fast wearing parts of soil-engaging implements which will promote quality of manufacturing besides creating additional job opportunities for skilled manpower.

Joint venture avenues for sophisticated and complex machinery components like discs for harrows and plows, vegetable and paddy transplanters, combine harvester, sugarcane harvester, cotton picker etc. need to be exploited with attractive government incentives in soft term loan, duty import structure and tax holidays. This will help in upgrading mechanization level, attract foreign investors and create more employment opportunities in this sector.

There is a great potential of increasing farm power level from 0.7 to 1.0 hp per acre as recommended by the FAO for developing countries. To meet this requirement, tractors production per annum needs to be at least doubles by the year 2020.

Farm machinery being an expensive input encourages setting up of rental service centers for their easy access. This will promote widespread use of implements for land preparation, seeding and planting/transplanting, spraying, harvesting and threshing, grading/packing and storage etc.

To promote mechanized farming in the province and to ensure food security, farm machines, implements and tractors were provided to the farmers on cost sharing basis by Government of the Punjab, Agriculture Department during the last couple of decades which imparted positive impact on crop production and helped in timely completion of farm operations. This practice should be continued to attain the sustainable level of mechanization.

Technical manpower for mechanized farming including operators and mechanics of tractor and combine harvesters, tube wells and plant protection machinery and equipment, fabricators/manufacturers of agricultural machinery and implements and service providers for mechanized farming has got limited formal training and lack basic operational and maintenance skills. This is not only harmful for operators but also limit desired benefits of mechanization. There is a common complaint of poor quality of workmanship of the tractor and combine operators which is the root cause of lower land and labor productivity and increased cost of production. At present there are several institutions which are conducting formal as well as informal training of the farmers. Some of the institutions under provincial government are In-service agriculture training schools, Water Management training institute, PIAM, AMRI and RAEDC under Agriculture Department; 8 agricultural machinery training schools under TEVTA and a cooperative agriculture training institute Chak 5-Faiz (District Multan) under Cooperative Department. Similarly, all agriculture Universities and manufacturers of tractors are also conducting training programs. In spite of all this skill of the technical manpower is not up to the mark which can be attributed to the posting of unqualified and un-trained teaching staff, posting of departmental officers on punishment, non-provision of adequate resources etc. In order to obtain desired results, it is proposed that an Agricultural Technology Academy shall be established in Punjab by bringing all of the training institutions as mentioned above under the ambit of the proposed academy. It is also proposed that such academy shall be fully autonomous and the management and teachers shall be hired on market salaries. Government, PAMIMA and tractor manufacturers shall provide seed money so that the proposed academy shall work on sustainable basis. The proposed academy shall have training centers at each District.

4.6 Taxes system and appropriate incentives for manufacturers and end-users - Pakistan has a long history of taxing agriculture under different heads. The tax structure of the country is comprised of three-tier system i.e. federal, provincial and local level. Short of GST, all taxes in agriculture are provincial taxes and are collected through the provincial system.

The GST, a form of indirect tax is levied on producers but ultimately its burden goes on the shoulders of consumers/end users. In the current budget, the government of Pakistan has imposed 17% sales tax on agricultural machinery and pesticides while subsidies on agriculture have been withdrawn since number of years. Withholding tax on purchase has also been levied by the government @ 4%. On the import of pesticides income tax is collected @ of 5.5% at port. Custom duty is also paid by the imports of pesticides @ 0.87% part of total production in part of total production in barani areas. Aggregate tax becomes 23.37% which is being paid by the pesticides sector. While more than 21% tax is being paid by the agricultural implement's manufacturing sector. Because in addition to GST and withholding tax certain other types of taxes are also being paid by the manufactures e.g. education tax, professional tax, social security contribution etc. According to the report of the national taxation reform commission (1986) that agriculture sector bears the heaviest burden of indirect taxes, i.e. 42% of all indirect taxes

although its share in GDP has dropped to 26%. Therefore, the agriculture sector's share of indirect taxes comes to 14.9% as against 14.4% for the non-agriculture sectors on per capita basis. Hence the poorest sector taxes the heaviest burden of taxes. It has further been added that there is no subsidy on pesticides, seeds, farm machinery. For rapid adoption of modern and innovative farm mechanization technologies, the end users i.e. farmers and the manufacturers shall be provided following incentives:

1. Incentives for the Farmers

- Supply of selected precision agriculture machinery and equipment on cost sharing basis
- Provision of interest free short term loans
- Provision of R&D incentives

2. Incentives for the manufacturers

- Refund of GST on implements and tractors after certified sales
- Reduced electricity tariff for tube wells
- Establishment of common facility centers and material banks

4.7 Establishment of National Council - Establishment of National Council for Agriculture Mechanization under the chairmanship of Federal Minister National Food Security and Research Islamabad is needed to achieve the envisioned targets in a befitting manner. The function of the council will be to take policy decisions, review and revise mechanization strategies, monitor the programs of provinces and pursue for support to the farmers, industry and international collaboration for introduction of new machines, technologies and support for private and public sector in the provinces vis-a-vis special packages for low mechanization areas, crops, ecological zones etc. This council may shall after every six months and shall be represented by the Ministries of Industries and Production, Finance, Provincial Agriculture Departments, experts of agriculture machinery research and farmers. A technical expert committee shall be constituted to support this apex forum on technical front and having membership from national and provincial agriculture machinery researchers, academia and progressive farmers.

4.8 Establishment Of Provincial Councils

Establishment of Provincial Councils for Agriculture Mechanization in the provinces under the auspices of Provincial Ministers of Agriculture which should have the same functions as national council except international linkages, national level subsidies and implementation of national programs. Provincial council shall be assisted by Agriculture Mechanization Board headed by a Managing Director with fair representation from public and private sector and responsible for the planning and monitoring of agricultural mechanization program at the provincial level, oversee testing and training activities, collection and analysis of agricultural mechanization data, monitoring agricultural mechanization program meant for testing, training, fabrication, establishment of standardization of machinery and legislation for authorization of machinery inspection, strengthening of agriculture machinery research institutes, training facilities and introduction of agriculture engineering extension. The board should have sufficient funds and autonomy and organize regular interaction between progressive farmers, experts, banks and industries and facilitate group visits by farmers and manufactures of farm machinery to national and international exhibitions.

Pakistan Standards Institution (PSI), Pakistan Standard and Quality Control Authority (PS&QCA) the statuary body, should formulate and implement National Standards of

Agricultural Machinery, equipment and implements. PSI in collaboration with AMRI and ABEI should develop should focus on the followings:

- Legislation to enforce standards for all implements and machines produced locally from soil management to harvesting and post
- Testing of locally produced and imported farm machines by an accredited agency and display of performance and valuation fact sheets by the manufactures for facilitating the buyers
- Hiring of qualified and experienced engineers by the manufacturers and developing in-house facilities to evaluate working of their products for performance and reliability;
- Registration of manufacturers with specialization in preparing different implements, spare parts etc.
- Preparation of instruction manuals for quality manufacturing from selection of steel for different implements for diverse soils and crops and for their products; and
- Providing incentives to the manufacturers on quality products like soft term loan and purchases by the government departments.

5. Road map for mechanizing Punjab

5.1 Proposed Roadmap for mechanizing Punjab, Pakistan

S. No.	Issues	Actions	Responsibilities
1.	Lack of awareness about the impact of mechanization	Create awareness through electronic and print media	Public-private organization
2.	Lack of training and capacity building for skilled manpower	Training and certification as pre-requisite	UAF/R&D organizations
3.	Lack of data bank on status of mechanization and demand driven technologies	Mapping of mechanization and list of demand driven – crop zone specific technologies	GOP
4.	Low availability of farm power (HP/ac)	Provide more tractors on subsidy	GOP/ Public-private partnership
5.	Lack of crop-specific machinery package	Development of mechanization for each crop zone	UAF/R&D organizations
6.	High cost of machines	Indigenization through Reverse Engineering	Public-private organization
7.	Poor quality of local material and machines	Legislation for standardization and certification	GOP
8.	Lack of access to advanced machinery	Service centers at village level with subsidies	Public-private organization
9.	Lack of R&D coordination and weak research-industry linkages	R&D organizations and industries, public-private partnership under one umbrella	GOP UAF R&D organizations Industries
10.	Lack of machines for small, medium and large farmers	Import of demand driven machines for reverse engineering	Public-private partnership
11.	Missing value addition facilities - low cost machines	Demonstration and training for value addition	Public-private partnership
12.	Health and safety hazards	Modifications for ensuring safety	Public-private partnership