MECHANIZATION OF AGRICULTURE - INDIAN SCENARIO

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India and Agriculture

Food grain production has touched 230 Mt in 2008-09 from a mere 51 Mt in 1951-52.The country has attained self sufficiency in food grain production and also have sufficient buffer stock. The country has also made impressive progress in production of food grains, oilseeds, horticultural crops, milk, poultry, etc Among others, the agricultural engineering inputs have played appreciable role in increasing production and productivity through appropriate mechanization inputs for production and post production agriculture enabling timely field operations, conservation and judicious application of water, appropriate post harvest operations to reduce losses, value addition to the produce and by-products for enhanced economic returns and employment generation. . Millions of additional jobs need to be created every year in rural area. Therefore, in the coming years, agricultural engineering has to play a major role in increasing the production and productivity, minimizing losses at production and post-production levels, creating avenues for value-adding to the agricultural produce at catchment level thereby increasing income, employment and providing high level nutrition to underprivileged masses. So far, variety of technologies suitable for varied agro-climatic condition and land holding have been developed and found wide acceptance. To keep pace with the present population growth and consumption pattern, a 6.7% annual growth in food grain production is targeted. The Central Institute of Agricultural Engineering (CIAE) and other institutions are striving to meet the emerging challenges.

Major research achievements in agriculture engineering have been devising methodology and equipment for tillage, sowing, interculture, harvesting, threshing, soil resource conservation, on-farm water conservation and management, proper land-use, enhancement in cropping intensity to 1.37.About 300 improved agricultural equipment/ technologies have been developed countrywide for various pre and post-harvest operations by human, animal, mechanical and electrical power; modernization of rice, wheat, oil, and sugarcane milling industry to some extent, development of technology for value addition and for health and nutrition security.

Though, India has abundant labour force in agriculture (Table 1), non-availability of manpower during peak crop season is a growing problem. The infrastructure needed for agricultural diversification like rural roads, drying yards, storage structures, transportation facilities, packaging and branding system is further strengthening.

Water though essential for human, animal and plant life, is becoming a scarce commodity. Thus proper harvesting and efficient utilization of water is of great significance. Shortage of water will cause drop in crop yields and food security. The overall achievement in the creation of irrigation facilities has been relatively better in India. There is a need to utilize rainwater to increase the gross cropped area by 30 Mha. In irrigated tracts the yield of food grain is almost double that of rain fed area.

India is a predominantly an agricultural economy with 60- 65 % of her population living in villages and earn their livelihood through agriculture and allied activities. Rural population of India was 91% in 1901(Table 2) and may reach to 50% by 2020. Population: Population of India by 2011-12 is estimated to be 1221.91 million with the annual compound growth rate of 1.80 per cent. Rural people migrate to urban areas for employment and better amenities as such opportunities are not adequately available in rural areas. However, these could be created through selective mechanization of agriculture and appropriate post-harvest processing and value addition to the produce in the production catchment. To keep pace with the

present population growth and consumption pattern, food grain requirement of India has been estimated to be 220 Mt by 2010 and 300 Mt by 2025. Thus, actual annual agricultural growth should be at 6.7% to meet demand projections. The small land holdings (Table 3) make the farming uneconomical. Inspite of this, India is a major producer in many crops and other products (Table 4,5& 6).

Table 1 Activity based breakup of population

States	Total workers	Cultivators		Agricultural workers		Household industry workers		Other workers	
All - India		Number	%	Number	%	Number	%	Number	%
Total Population (2001)-→ 1028737000									
Persons	402,234,724	127,312,851	31.7	106,775,330	26.5	16,956,942	4.2	151,189,601	37.6
Males	275,014,476	85,416,498	31.1	57,329,100	20.8	8,744,183	3.2	123,524,695	44.9
Females	127,220,248	41,896,353	32.9	49,446,230	38.9	8,212,759	6.5	27,664,906	21.7

Note: Totals may not exactly tally due to round off
Source: http://www.iasri.res.in/agridata/HOME.HTML accessed on 12.6.2009

Table 2 Variation in population since 1901 in India (in million)

Year	Total	Rural	Urban	% in rural
1901	238.4	212.5	25.9	91.0
1941	318.7	274.5	44.2	86.1
1981	683.3	523.9	159.5	76.7
2001	1028.7	742.5	286.1	68.0
2008*	1147.7	-	-	65.0 **

Source:1.http://www.censusindia.gov.in/Census_Data_2001/India_at_glance/variation.aspx accessed on 07.01.2008, ** Estimated.
2.*http://www.censusindia.gov.in/Census_Data_2001/Projected_Population/Projected_population.aspx accessed on 15.6.2009

Table 3: Number and area of operational holdings by type of holding

Major size Classes	Number, '000			Area, '000 ha		
	1981	1990-91	2000-01	1980-81	1990-91	2000-01
Marginal, <1 ha	50.122 (56.4)	63.389 (59.4)	76122 (63.0)	19.735 (12.0)	24894 (15.0)	30088 ((18.82)
Small, 1-2 ha	16.072 (18.1)	20.092 (18.8)	22814 (18.9)	23.169 (14.2)	28.827 (17.4)	32260 (20.18)
Semi-medium, 2-4 ha	12.455 (14.0)	(13.923 (13.1)	14087 (11.7)	34.645 (21.2)	38.375 (23.2)	38305 (23.96)
Medium, 4-10 ha	8.068 (9.1)	7.580 (7.1)	6568 (5.4)	48.470 (29.6)	44.752 (27.1)	38125 (23.84)
Large, >10 ha	2.166 (2.4)	1.654) (1.6)	1230 (1.02)	37.705 (23.0)	28.659 (17.3)	21124 (13.21)
All size classes	88.883 (100)	1,06,637 (100)	120822 (100)	1,63,724 (100)	1,65,507 (100)	159903 (100)

Note: Figures with parentheses indicate per cent contribution

Table 4. Production of food-grains and pulses crops (million tones)

Crop	Season	2000-01	2002-03	2004-05	2006-07	2008-09*
Total Pulses	*Kharif*	4.45	4.15	4.72	4.80	5.02
	Rabi	6.62	6.98	8.41	9.40	9.16
	Total	11.07	11.13	13.13	14.20	14.18
Total Food grains	*Kharif*	102.09	87.22	103.31	110.57	118.79
	Rabi	94.72	87.55	95.05	106.71	111.06
	Total	196.81	174.77	198.36	217.28	229.85

Source: 1. http://dacnet.nic.in/eands/latest_2006.htm accessed on 6.6.2009

Table 5 Production of specific commodities in India during 2007-08

Commodity	Production, Mt	Source
Vegetable oil	5.57 Mt	http://www.seaofindia.com/Crop_data/Kharif_data_2008-09.pdf accessed on 23.6.2009)
Spices	4.1 Mt from 2.6 Mha	Indian Horticulture Database 2008 http://nhb.gov.in/ accessed on 15.6.2009)
Plantation crops	12 Mt from 3.2 Mha	
Vegetables	126 Mt from 7.8 Mha	
Fruits	63.5 Mt from 5.8 Mha	

Table 6. Agricultural and livestock production in India (million tonnes)

Year	Food-grains	Rice	Wheat	Oilseeds	Sugarcane	Pulses	Coarse cereals	Milk	Fish	Eggs*	Wool**	Horticulture
2007-08	230.78	96.69	78.57	29.76	348.19	14.76	31.89	104.8	7.12	53532	45.1	207.01

Note:- Not available, * million no ** million kg
Source: 1. *Agricultural Statistics at a Glance, 2006,* Directorate of Economics and Statistics, Ministry of Agriculture, Govt. of India (Website: http://www.dacnet.nic.in/eands)

Household Demand for Food raw materials: The food grain demand predictions for 2011-12 are 222.30 million tones (rice 100.71 million tones, wheat 76.51 million tones, coarse grains 24.81 million tones and pulses 19.7 million tones). India produces about 650 million tonnes of food materials of plant and animal origin.

India is a large country with wide agro-ecological diversity having predominance of rainfed agriculture. The total land area is 328 Mha and about 142 Mha is under cultivation, of which about 55 Mha is irrigated and reminder 87 Mha is rainfed. Farmers are left with less time for field operations. Farm mechanization has positive relation with farm productivity; firstly through timeliness of field operation and, secondly, through good quality work.

Present day need is to increase the productivity and profitability of production and post-production agriculture. Younger generation does not want to work in the field. So mechanization is the need for timeliness of operation. Effective engineering interventions and inputs have the potential to result in further useful technology packages for:

- Timeliness and precision in farm activity. Use of zero till drill on 3 million ha has resulted in timeliness of operation and savings up to 200 million US$ (10000 million INR)
- Mechanization for dry land and hill agriculture and horticulture.
- Efficient use of water, fertilizer, seed, pesticide, energy and other inputs.
- Using biomass for alternative economic power sources.

- Post harvest loss minimization to ensure availability of more food, fruits, vegetables and nutrition to population.
- Primary processing of agro produce in production catchments, cold chain activities to enhance in employment and income generation opportunities.
- Overall contribution to employment generation in different areas of agriculture, e.g. service support, etc. for unemployed rural youth and women.

2. Agricultural Mechanization Development

Efficient machinery helps in increasing productivity by about 30% (Table 7) besides, enabling the farmers to raise a second crop making the agriculture attractive. Raising more crops with high productivity is a path for meeting the future food requirement of population. Development and introduction of high capacity, precision, reliable and energy efficient equipment is the need for judicious use inputs. For crop production human, animal and mechanical energy is extensively used. In small and marginal farms, except for tillage, other operations such as sowing/ transplanting, weeding, cotton picking harvesting and threshing (paddy) are normally manually performed.

Table 7 Economic Advantage of Mechanization in per cent

. Increase in productivity up to	12-34
. Seed-cum-fertilizer drill facilitates	
Saving in seeds	20
Saving in fertilizer	15-20
. Enhancement in cropping intensity	5 - 22
. Increase in gross income of the farmers	29-49

Source: Report of the Sub-Group on Agricultural Implements and Machinery for Formulation of 9th Five Year Plan, Govt. of India.

Mechanization also imparts capacity to the farmers to carry out farm operations, with ease and freedom from drudgery, making the farming agreeable vocation for educated youth as well. It helps the farmers to achieve timeliness and precisely meter and apply costly input for better efficacy and efficiency.

Adoption of Mechanization: At present in India, tractors are being used for tillage of 22.78% of total area and sowing 21.30% of total area. Although, utility of manually and bullock operated equipment has been established but the response of the farmers has been selective. The bullock drawn seed-cum-fertilizer drill and manual paddy transplanter have not been universally accepted in spite of financial incentive from the Government. Due to limited use in a year and economic advantage of many items, some improved implements could not replace the local alternatives.

The land levelers, seed-cum-fertilizer drills have also been accepted by the farmers but on limited scale. Major adoption of agricultural machinery in addition to irrigation equipment and tractor, was thresher for wheat crop. Due to various applications of paddy straw, preference has been limited for paddy threshers. Self propelled / tractor operated combines, reaper harvester, potato and groundnut mechanization machinery are also commercially available and accepted by the farmers in states where tractors were introduced. Now combine harvesters are commonly used in different parts of the country, on custom hire basis, for wheat, soybean and paddy harvesting.

Tillage and planting machinery: The traditional animal drawn country plough has low output (30-40 h/ha). Tractor drawn MB plough, harrows, cultivators and rotavator are better machinery used by the farmers. There is need for high capacity machines for custom hire services. For precise application of seed and fertilizer, mechanically metered seed drill and seed-cum- fertilizer drill operated by animal and tractor

have been developed and are being manufactured to suit specific crops and regions. Zero till drill and strip till drill have also been developed to reduce energy inputs in crop Production. CIAE has developed farm equipment like inclined plate planter and pneumatic planter for precision sowing.

Interculture and plant protection equipment: Use of long handle wheel hoe and peg type weeders are being accepted as they reduce drudgery and weeding time to 25-110 hours from 300-700 hours in conventional practice. Animal drawn weeder and cultivator are also used for control of weeds. Self propelled and power operated weeders are being increasingly accepted on limited scale. Different designs of low cost hand operated sprayers and dusters are available for application of plant protection chemicals. Low volume and ultra-low volume (ULV) sprayers, which require comparatively smaller quantity of water, are also in use.

Irrigation and drainage equipment: Diesel and electric pump sets are common. The shift from conventional flood irrigation to sprinkler, micro sprinkler or drip irrigation systems is apparently visible indicating the importance of water use efficiency for covering more area under irrigation. The Government support in the form of subsidy is serving as a catalyst to compensate for the high initial cost of the system.

Importance of drainage for achieveing improved productivity is being realized by the farmers and progressive farmers are going for subsurface drainage, which is high initial cost technology. The low-cost mole drainage technology and equipment has been developed for vertisols. The mole drain laying cost is about 70 US$ /ha (3500 INR) and the same is recovered in one crop season. The farmers are getting attracted in favour of this technology. However, it is just a beginning of adoption of the technology. In years to come, it is expected to be common feature among the farmers. Efforts are on to popularize this technology through demonstrations and awareness programmes.

Harvesting and threshing: Sickle is the major low cost traditional tool for harvesting. Self-sharpening serrated sickle is finding adoption. CIAE. Walk behind and self-propelled reaper harvesters, which facilitate quick harvesting, is getting acceptance. Traditional threshing by animal treading has been almost fully replaced by power threshers operated by 5-15 hp engine or electric motor. Pedal operated paddy threshers reduce drudgery and have become popular in India. Whole paddy straw is obtained by using rasp bar type axial flow thresher. Combine harvesters are being used for harvesting wheat, paddy, soybean and gram in few states.

Agricultural mechanization scenario and farm power: Over, the years, promotion of agricultural mechanization has been directed towards the promotion of eco-friendly and selective agricultural implements and machines with the aims of optimal utilization of the available sources of human, animal and mechanical/electrical power, removing the drudgery associated with various agricultural operations. Farmers have also been provided financial assistance for owning a wide range of agricultural equipment viz. tractors, power tillers, bullock/tractor drawn implements, reapers, threshers, irrigation equipment, hand tools, etc. Further, new equipment such as precision planter, zero-till drill, seed cum fertilizer drill, raised bed planter, improved weeders, plant protection equipment, harvesting and threshing machines, drip, micro sprinkler and sprinkler irrigation equipment have been made available to the farmers. As a result of the joint efforts made by the Government and the private sector, the level of mechanization has been increasing steadily over the years.

Human power: There are a total of 342 million economically active workers of which 224 m (66%) are agricultural workers. These agricultural workers possess energy equivalent to 15.7 million kW and are engaged in various farm activities. In hills, the human power is also utilized in crop production, animal husbandry and fisheries sector.

Draught animal power: Draught animals continue to provide major tractive power for field operations in Indian agriculture. The population of draft animals is estimated to be 64 million. Draught animal power use has been limited to about 400 - 600 working hours/year). They are used for seedbed preparation, sowing, interculture, irrigation, threshing and transport. Due to introduction of mechanical power to ensure timeliness in field operation, there has been some reduction in use of draft animals.

Electro-mechanical power: With an estimated total tractor population of 2.8 million, the country has a potential to cover about 22% of the cultivated land (with 15-16 ha command area/tractor). The power tiller population is estimated as 110000 and that of engines and motors as 20.74 million.

The contribution of different power sources to the total power changed with time (Table 8). The share of agricultural workers continuously declined since 1981 and expected to be only 5.09 per cent by 2011-12 and that of draught animal power from 27.23 per cent to 6.37 per cent in same period. The increase in power has been mainly through introduction of tractors, whose contribution has increased from 7.5 per cent in 1971 to 51.08 per cent in 2011-12.

Table 8 Contribution of different power sources in India

Year	Agril worker (%)	Draught Animal (%)	Tractor (%)	Stationary Engine, (%)	Total Power, KW/ha
1981-82	10.92	27.23	19.95	41.57	0.471
2005-06	5.77	8.02	46.70	41.12	1.502
2011-12*	5.09	6.37	51.08	37.46	1.910

* Estimated

Farm machinery use and availability: Often, farm mechanization has been coupled with use of prime movers, tractor and power tillers (Table 9), rather than adoption and availability of farm machinery, which perform the specific task. Over the years based upon the requirements of the farmers of different regions, following different set of cropping patterns, ICAR institutes and state agricultural universities have developed number of farm machines. Manufacturers have introduced few imported designs. Although utilization of farm power in the form of tractor/power tiller has increased manifold but utilization of farm machines for specific purposes remained low. The rate of growth, in animal operated machinery, has remained low as compared to tractor or power operated machinery. State wise analysis of the farm machinery utilization revealed that few states were using mechanical power source while others still uses the animate sources and implements operated by them. Main reasons are: Low purchasing power and fragmented land holding of farmers, low annual use of specific machinery, lack of awareness among farmers especially in hilly, backward and tribal areas and proper sell outlets and maintenance facility in nearby areas. Often buyer has to travel long distances for procurement, repair and maintenance. Quality and reliability of farm machinery being manufactured and supplied by various agencies and scale of manufacturers are yet to gain confidence of common farmer.

Agro-Processing and Agro Industries Scenario

India's food processing mainly involves primary processing which accounts for 80% of the value. As much as 42% of the food industry is in the organized sector and 33% in the small scale, tiny and cottage sectors. The value addition to agricultural commodities is less than 10%. Food habits in India are traditional in nature and varied across the country. Busier schedules and a growing number of workingwomen have collectively led to an increase in the demand for ready-to-eat traditional and or newer foods. As a segment of the food industry, traditional foods are the largest, both in terms of quantity and value. Most of the operations are manual, even in relatively large-scale units, causing variation in quality. The present level

of post-production losses is: 5-15% in durables, 20-30% in semi-perishables and 30-40% in perishables. About 50% of these could be prevented using appropriate post-harvest approaches.

Table 9. Level of mechanization

Operation	Percentage
Tillage	40.2
Tractor	15.6
Animal	24.7
Sowing with drills and planter	28.9
Tractors	8.3
Animal	20.6
Irrigation	37
Thresher Wheat	47.8
Paddy and others	4.4
Harvesting:	
Reapers	0.56
Combines	0.37
Plant protection	34.2

Source: 1.Proceedings of 20th National Convention of Agricultural Engineers held at PAU, Ludhiana on Jan19-20,2007.

The challenges in processing lie in presenting the product in near natural form with added convenience. The poor segment of population needs to be provided with good quality food at a price affordable by them. Traditionally, agro-processing has been the source of income generation in rural areas. It gradually reduced due to establishment of high capacity processing industry by organised sector. However, to check migration to cities, now the processing of agro-produce in production catchments is being emphasised for employment generation. The CIAE has addressed these issues and developed suitable equipment for processing of cereals, oilseeds, pulses and vegetables.

Processing of cereals, pulses and oilseeds: All major grains --paddy, wheat, maize, barley and millets like: jowar (great millet), bajra (pearl millet), ragi (finger millet), etc. are produced in the country. Wheat is processed for flour, refined flour, samilona, grits, and whole-wheat flour. There are 360000 wheat milling units consisting of burr mills. Roller flourmills process over 50 % of wheat production with a milling capacity of 8-10 million tones each.

Modern rice mills process 65 per cent of paddy production and rest by huller / Sheller mills. The recovery of whole grains in a traditional rice mill using steel hullers for dehusking is around 52-54% whereas in modern rice mills - rubber roll shellers for dehusking operation is around 62-64% in raw and 66-68% in parboiled paddy. The conversion ratio (i.e. recovery % of various final product and byproduct for every 100 kg feed of raw paddy) for these improved rice mills are: milled rice: 62-68%, rice bran: 4-5%, rice husk: 25% and germ wastages : 2%-8% . Thus, need to establish small capacity (150 kg /h) modern rice mills, available in the market, in villages for employment generation.

Dal (split pulse) milling is the 3rd largest processing industry in India after rice and wheat milling Pulses meet 15-30% of protein requirement. *Dal* recovery potential is 83-85%, but at present, it is 68-70% in conventional mills and 72-78 % in modern *dal* mills. The mills are processing more than 10.5 million tonnes of dal. By-products are generally used as cattle feed.

Oil extraction used to be a cottage level activity in the rural areas using animal power in rotary mode. Now mechanical oil expellers, oil mills, 725 solvent extraction plants, 300 oil refineries and over 175 hydrogenated fat units produce about 6.85 million tonnes of edible oils and 3.61 tonnes of non-edible oils. The capacity utilization generally ranges from 10% to around 30% in case of the organized sector. Apart from oilseeds, the byproducts obtained during the processing operation viz. deoiled cake, oil meals and other minor oil products are also of high economic value. India is one of the leading oil meal exporters in the world. Export of soy meal alone gets FOREX of about 800 million US$ (40000 million INR). Small capacity oil expellers are available for use in rural areas for promoting agribusiness. The residual oil content in the oilcakes is between 6-8%. Thus,, the cake obtained need to be solvent extracted for enhancing availability of edible oil for food uses.

Soybean packed with 40% good quality protein, 20% oil and other nutrients has a great potential to combat Protein-calorie malnutrition at an affordable cost. India is now the fifth largest producer of soybean at a global level with more than 10.0 million tonnes production. Soy foods are nutritious, economical and provide many health benefits. Use of 10-20% of soybean along with cereals gives maximum nutritional advantages. However, due to the presence of some ant nutritional factors in soybeans, it requires careful processing to make it fit for human and animal consumption. Soybean Processing and Utilization Centre (SPU) at CIAE, Bhopal has developed a number of process technologies and equipments for soy products. These are being promoted in rural/urban areas for agribusiness and nutrition security and so far over 210 cottage scale units have been established throughout the country.

Fruits and vegetable processing: India produces 126 Mt of fruits and 63 Mt vegetables. Almost all varieties of vegetables are grown in India. It is estimated that only 2% of the total produce is being processed in India. Fruits and vegetable processing industry is being promoted for minimization of post harvest losses.

Processing of commercial crops : Sugarcanes, jute, cotton, tea, coffee and tobacco are major commercial crops grown in India. More than 50 per cent sugarcane is estimated to be processed by sugar mills and the balance by jaggery *(Gur) & Khandsari* industries. Although, the efficiency of jaggery *(Gur) & Khandsari* sector is low compared to sugar mills, but these units provide more employment opportunities to rural work force hence requires further attention.

Rural agro-processing: Decentralized value addition of farm produce helps in better waste management, less transportation, and more employment in rural areas. Primary processing facilities need to be created in rural areas for on farm processing of farm produce to:

a) use available raw materials for processing in the catchment area at reduced cost,
b) reduce cost of processing due to availability of labour, reduced cost of handling, and transport
c) generate more employment for rural people to arrest the migration and reduce social problems in cities (mitigation of congestion in cities),
d) achieve overall development of rural areas with the creation of other infrastructure to serve these units in terms of education, health, communication, etc.,
e) utilize by-products after value addition as animal feed, compost, biogas feed, etc. to reduce pollution load of cities,
f) make better Use of crop residues, processing of by-products and wastes in eco-friendly and economically rewarding fashion, and
g) appropriately pack and market the minimally processed and value added products through food chain.

Renewable Energy

The 20th century has witnessed the phenomenal growth of various industries based on these energy sources and fossil fuel, in particular, has played the most significant role. By now, it has penetrated so deep into the mechanism of human living that man is not prepared to accept the fact that this useful source of energy is not going to last very long. Thus is the compulsion for search alternate sources of energy.

Renewable energy sources -solar, wind, and biomass have potential to be utilized as supplementary energy source. Biomass and animate power meet the major energy needs of the rural sector, as it is available locally. The decentralized production of electricity using biomass is being attempted through the producer gas route, in addition to photovoltaic solar system for lifting water, lighting and energy for household appliances. It is estimated that more than 600 million tonnes of biomass is available from various crop residues and agro-wastes of which about 60 –65 per cent can be used for power generation. Besides about 27 million tonnes municipal waste is also available which has potential to be utilized for energy production.

Energy in Agriculture

Engineers have done immense service, modernizing agriculture and agro-processing. Studies under ICAR reveal that the gains in agriculture have come largely form direct and indirect use of commercial energies, diesel and electricity, fertilizers and chemicals, which are not only expensive but their availability is much wanting in rural areas specially in remote and hilly areas. Petroleum is largest import bill of India. Total Installed capacity in India for electricity generation (2008) in India is 147965.51 MW.

Technology transfer

The CIAE has a Prototype Production Centre equipped with modern machine tools for fabrication of farm equipment for multi location verification, evaluation and supply to needy. The Institute developed 140 farm machines of which 78 have been made available to end-users. The Ministry of Agriculture and Cooperation, Government of India has released 23 machines for popularisation by the provincial governments under centrally sponsored implements subsidy scheme. Institute has strong linkage with State Agro-Industrial Development Corporations and small-scale farm machinery industries for commercialisation of technology.

Technology diffusion is done to farmers, artisans, extension workers, subject matter specialists and manufacturers through vocational training of farmers, crafts persons, rural youths and subject matter specialists. Entrepreneurship development programmes receive special consideration.

Extension wing of Agricultural Ministry alone can't do this work as engineering interventions and output need special inputs to make it available to end user. Approach for National level Commercialization of already developed effective technologies / equipment is:

a) Networking of R & D Institutes, manufacturers and farmers
b) Interface with ministries
c) Participation of Farmers / end users
d) Registration of manufacturers

The following approaches are considered as other means of effective technology transfer:

Service support in agriculture: Unlike other advanced countries, India cannot afford to displace large percentage of rural population from agriculture to other sectors for the want of employment. We have therefore, to generate more jobs in rural areas. Scope of entrepreneurship development for employment and income generation on agricultural mechanization and renewable energy through Agri-business is of high order. This include: repair and maintenance support for farmers, custom hiring services, setting up of agro-waste/biomass based enterprises for charring, briquetting, improved sigri, solar café, etc. Repair and

maintenance of agril. machinery, irrigation, biogas plant, agro processing equipment, etc. can lead to timely service inputs to save crop and resources and generate employment for local youth thereby checking migration to cities.

Custom hire and Service centers for machinery: One of the major constraints of increasing agricultural production and productivity is the inadequacy of farm power and machinery with the farmers. The average farm power availability needs to be increased from the current 1.43 kW/ha to at least 2 kW/ha to assure timeliness and quality in field operations, undertake heavy field operations like sub soiling, chiseling, deep ploughing, summer ploughing, etc. All these agricultural operations are possible only when adequate agricultural mechanization infrastructure is created. Even farmers with small holdings utilize selected improved farm equipment through custom hiring. Each farmer can't purchase the machinery set-up of his requirement. Therefore, custom-hiring facility can be of significance to both unemployed youth and the farmers. Establishment of such facilities has potential for adoption of mechanization systems. This can be true for processing activities also. Repair and maintenance service providers for agricultural machinery are a need and developing countries may adopt that system by training the upcoming entrepreneurs.

The approach identified for employment/entrepreneurship development cover:

- Setting up of Agro-processing enterprises in the rural areas and motivate the farmers to adopt modern techniques.
- Service, repair and maintenance facilities for agricultural machinery.
- Agro-Service Centres establishment
- Establishing agri-implement bank by entrepreneurs to provide the machinery on custom hire basis to farmers when needed.

Skill development training and employment generation: Entrepreneurship development in service sector in agriculture and allied sector has immense potential through engineering interventions. One such approach is skill development training in manufacture, repair, maintenance and related service support in farm machinery, irrigation, processing, energy equipment repair, maintenance and for primary processing of food grains, fruits and vegetables, etc. This is the key approach targeted at ensuring hand and mind engagement security to get productive output. Training programmes are organized regularly to empower unemployed youth, farmers, farmwomen and upcoming entrepreneurs. Some of the technologies identified are production agriculture, agribusiness in improved farm implements, setting up of household/cottage and small scale food processing and soy processing unit. Soy based technologies include full fat soy flour, soy fortified biscuits and soy *paneer* (TOFU). These are simple soy food products for use with cereals and food legumes. Adoption of these technologies provides direct employment to 6-8 persons per unit, higher income to farmers, higher value for the products and minimizes losses. The initial investment to enterprise varies from 4000 – 20000 US$ (0.2 – 1 million INR).

Income generation opportunities for women: Women constitute about 45% agriculture work force in India. In addition to their daily household activities, they contribute 50–75% of the total labour required for various production and post-production agricultural operations in the developing countries. It causes lot of drudgery to them and thus low-productivity. To empower, **t**hey need to be provided with: i) Women friendly agricultural tools and equipment, ii) opportunities for gainful engagement throughout the year to supplement their income with reduced drudgery - agro-processing related activities have proved to be of significance through our interventions.

Information technology in agriculture for information dissemination: So far, we are adopting the traditional systems to disseminate the information to the farmers. In this system, there is a plenty of time gap in reaching the information to the farmers. The information needs to reach at right time. Farmers need information to their situation specific requirements in agriculture.

The Government of India has also realized the importance of the Information Technology. The linking of villages with wired network has come true in India. Some of the examples are (1) Warna Wired Villages (2) M.S. Swaminathan Info Villages etc. The info villages are networked in hybrid form of wired and wireless technologies for communications. They are able to provide information on agriculture technologies, weather, market, etc.

Promotion of agricultural mechanization through training, testing and demonstration: As a result of different programmes implemented by the Government, over the years, the total estimated farm power availability increased from 0.295 kw/ha in 1971-72 to 1.43 kW/ha in 2004-05. For reducing the cost of operation, increasing productivity, irrigation efficiency, etc., new equipment such as zero-till seed cum fertilizer drill, raised bed planters, reapers, rotavators and drip/sprinkler irrigation equipments apart from gender friendly equipments have been promoted through various schemes and found useful (Table 10).

Table 10. Production economics and operational energy of direct drilled wheat after harvest of paddy

Particulars	Zero till drilled	Strip till drilled	Roto till drilled	Conventional sown
Grain yield, t/ha	4.84	4.62	4.78	4.60
Cost of production, Rs/ha	8635	9114	9315	10710
Benefit-cost ratio	3.64	3.29	3.34	2.79
Operational energy, MJ/ha	8114	8712	8444	9516

Sale price of wheat (HI-8498), Rs/kg = 6.50 (2003-04)
Source: Annual Report 2003-04, CIAE Bhopal

Joint efforts of the Government, Indian Council of Agricultural Research (ICAR) and the private sector has resulted in steady increase in the level of mechanization over the years. This is evident from the sale of tractors and power tillers, taken as indicator of the adoption of the mechanized means of farming, over the years (Table-11).

Table 11. Status of farm power sources in India (Numbers in million)

Year	kW/h	Agril Workers		Draft Animals		Tractors		Power Tillers		Diesel Engines		Electric Motors	
		No.	kW	No.	kW	No.	kW	No.	kW)		kW	No.	kW
1960-61	0.28	116.0	5.8	80.4	30.6	0.04	1.00	0	0	0.23	1.39	0.20	0.74
1970-71	0.40	124.2	6.2	82.6	31.4	0.17	4.38	0.10	0.05	1.70	9.5	1.60	5.92
1980-81	0.55	149.3	7.5	73.4	27.8	0.53	13.86	0.02	0.09	2.88	16.1	3.35	12.39
1990-91	0.87	183.5	9.2	70.9	26.9	1.19	31.11	0.03	0.18	4.80	26.9	8.07	29.86
1999-00	1.24	211.0	10.6	60.0	22.8	2.36	61.52	0.08	0.43	5.90	33.0	12.85	47.55
2004-05	1.46	227.7	11.4	56.5	21.5	2.81	73.39	0.08	0.44	7.595	42.5	14.467	53.53

Source:1. Proceedings of tractor & farm machinery manufacturers' meeting, organized at CIAE Bhopal during November 16-17, 2007. pp 81

Demonstration of new farm equipment / technologies, at farmers field to acquaint them about their use and utility, has been a component of the scheme 'Promotion & Strengthening of Agricultural Mechanisation through Training, Testing & Demonstration' during the X Plan and continued in XI Plan. The scheme has been operational through State Govts. and ICAR Institutes. In 2004 –05,

3862 demonstrations were conducted on different equipments covering about 2783 ha. with the field machines and 2795 hours on stationary machines in 12 States. Over 2,99,000 farmers participated in these demonstrations. Special programmes have been developed for less developed areas like North Eastern States

As a result of demonstrations of zero till seed cum fertilizer drill, its adaptability in the Northern States is very encouraging in rice-wheat rotation areas. The other equipment viz. raised bed planter, rotavator, vertical conveyor reaper, multi crop thresher, maize-sheller (power operated), mini-rice-mill, pre-germinated paddy seeder, power weeder, etc. are also being adopted by the farmers, in the areas of their demonstrations.

Assistance in the form of subsidy @ 25% of the cost with permissible ceiling limits, is made available to the farmers for the purchase of various agricultural equipment including hand tools, bullock drawn/power driven implements, sprinkler and drip irrigation equipment, planting, reaping, harvesting and threshing equipment, tractors, power tillers, etc. under the Centrally Sponsored Scheme of Macro Management of Agriculture, etc.

The feedback from the State Governments indicates that 4059 tractors, 8044 power tillers, 113819 hand tools, 48575 bullock drawn implements, 17763 tractor driven implements, 12242 self propelled/power driven equipment, 45424 plant protection equipment, 22685 irrigation equipment and 5582 gender friendly equipment were supplied to the farmers. 454 tractors, 1066 power tillers, 7059 hand tools, 7848 bullock drawn implements, 2043 tractor driven implements, 169 self propelled/power driven equipment, 8834 plant protection equipment, 1315 irrigation equipment and 3006 gender friendly equipment have been supplied to the farmers in 2005 alone.

To achieve an effective and balanced development of agricultural mechanization in various agro-climatic zones of the country, the scheme was entrusted to ICAR for in depth study at micro level keeping in view of the technological, agro-economical, sociological and other relevant factors for formulating effective and balanced strategies for all round development of agricultural mechanization for each agro-climatic zone of the country.

State Agro Industries Corporations were setup in 17 States to provide access to farmers of the industrial inputs for the use in the agriculture.

Women friendly equipments are also being promoted through Macro Management Scheme. The feed back from some of the State Governments indicates that about 20380 women farmers have been benefited under this scheme during 2004-05.

Challenges in agricultural mechanization: Attention on following is a need.

- Land holding is going down so requirement of efficient but less costly agril. tools and equipment suitable for small farmers will continue to exist – whether owned or on hire.
- Higher economic efficiency of scale of operation may compel farmers for co-operative / contract farming. High capacity but precision equipment are needed for irrigated and dry land conditions. Planters for vegetable seeds and transplanters for vegetable nursery are of significance.
- Plant protection equipment – precision applicators to minimize excess application of pesticide to plants for good environment and soil health.
- The area under upland rice is expected to increase where rainfall is decreasing. Thus a need for implement set-up.
- Commodity specific mechanization package development.

Policy on Farm Mechanization:There is no separate National Policy on Agricultural Mechanization. However, this aspect is covered under the agriculture policy of the National government which promotes agricultural mechanization with the following goals in mind:

- Agricultural mechanization should lead to a sustainable increase in yields and cropping intensity with the objective of meeting the planned growth rate in agricultural production and maintaining it.
- The income of agricultural workers should rise at a satisfactory rate so that the disparity between urban and rural incomes is contained and they get opportunity to lead a dignified life.
- The benefits of agricultural mechanization should apply to all types of farmers including small and marginal ones in different regions of the country, particularly rain fed areas.
- Agricultural mechanization should create a worker friendly environment especially for women workers by lessening hard labour, health hazards and improve safety in production operations.
- Agricultural mechanization should lead to a reduced cost of production agricultural thereby increase the income of farmers and impart a price advantage while competing for export contracts in the international market.

3. Status of Agricultural Machinery Industry

India is the largest producer or tractors in the world. During 1970-90, the compound annual growth in the sale of tractors was more than 8%. During the last 10 years (1991-92-2000-01)), about 2.0 million tractors and 1,17,000 power tillers were sold in the country. The total power availability during the period increased from 0.295 to 1.231 kW/ha. Today, more than 270000 tractors, 18000 power tillers (Table 12) and 1.4 million irrigation pumps are introduced every year. Large number of improved agricultural tools, implements, and machines, indigenously manufactured (Table 13), are available and meeting the need. Vertical conveyor reapers, rice transplanter, pregermianted-paddy seeder, zero-till drill, Strip-till drill, raised bed planter, high clearance self-propelled sprayer, aero blast sprayer, combine harvesters are some of the successful recent introduction. Around 1800 combine harvesters are in use in the country which are mostly operational through custom hire basis.

The power tiller industry has gone through a very rough weather and many units folded up their manufacturing activities. However, during the recent years a few new manufacturing units have also come up. Some of them are assembling units of foreign makes for marketing in India. Proven implements are being released for manufacturing, making power tiller operation more versatile and efficient.

Table 12 Production and sale of tractors and power tillers in India

Year	Production, numbers		Sale, Numbers	
	Tractor	PowerTiller	Tractor	PowerTiller
2006-07	310700***	NA	352835**	24791**
2007-08	345172 [a]	NA	346501 [a]	18375**(Nov07)
2008-09	303300***	NA	NA	NA

Source:* Agricultural engineering today 23(1-2), 1999 pp10-13 a Tractor manufacturers association data NA-Not Available **http://www.indiastat.com accessed on 6.7.2009 ***http://www.indiabudget.nic.in/es2008-09/chapt2009/tab131.pdf accessed on 7.7.2009 b Agricultural mechanization in Asia, Africa and Latin America 2008.

Table 13. Status of farm machinery industries in India

Equipment	Number of manufacturers
Agricultural tractors	13
Power tillers	2
Earth movers	3
Pumps	600
Sprinkler set	35
Drip irrigation system	35
Plant protection equipment	300
Combines	48
Reapers	60
Threshers	6000
Seed drills	2500
Ploughs, cultivators and harrows	5000
Tractors parts and accessories	546
Earth moving machinery and parts	188
Diesel oil engines	200
Rice processing machinery	300
Sugarcane crusher	50
Chaff cutter	50
Dairy and food industries	500
Village craftsmen	1 million

Source:1.http://agricoop.nic.in/Farm%20Mech.%20PDF/05024-09.pdf
Agricultural machinery industry in India pp166 accessed on 15.7.2009

4. Agricultural Machinery and Safety

To develop safe equipment and to pursue measures for minimizing accidents in agriculture, realistic data on these accidents are essential. Therefore, an agricultural accident survey was carried out during 2004-07 in large number of villages in seven states namely *Tamil Nadu, Orissa, Madhya Pradesh, Punjab, Rajasthan, Arunachal Pradesh and West Bengal.* Of the total accidents reported during a period of one year, 30.5% accidents were due to farm machines, 34.0% - hand tools and 35.5% - other sources. Under the farm machinery category about 30.9% of accidents were due to tractors and tractor operated equipment, 22.3% - animal drawn equipment, 14.5% - threshers, 11.9% - electric motor / pump sets, 7.9% - chaff cutters, 5.5% - power tillers, 4.3% - sprayers and 2.7% - other machines. The equipment, which needs immediate attention, is tractors, threshers, electrical motors and pump sets, chaff cutters, power tillers, sprayers and animal drawn equipment. Of the total accidents, 5.5% were fatal whereas 94.5% - nonfatal in nature. The overall incidence rate per year was 334 accidents per 0.1 million workers whereas the fatality rate was 18.3 per 0.1 million workers. Accident minimization programme has been formulated based on the survey.

The following safety gadgets were developed / evaluated to minimize accidents in agricultural activities.

- Safety gadgets for chaff cutters and sugarcane crushers
- Safety cover for pedal operated paddy thresher
- Belt and chain type conveyor feeding system for high capacity thresher
- A tractor trailer with brakes and other safety features
- Lighting system with turning indicators for tractor trailers
- A safety cover for open / tube well

Anthropometric and strength data: Anthropometrical data of 12525 agricultural workers from 12 states (8025 male and 4500 female) on 79 body dimensions useful in farm equipment design were collected. Technology / gadgets developed to enhance comfort and minimize the health hazards for operators during operation of tractors and power tillers include:

- Ant vibration devices (vibration isolators) for tractor and power tiller
- Improved muffler for power tiller for reduced noise level
- Tractor workplace layout for Indian operators based on ergonomical considerations.

Ergonomics and work comfort: Ergonomically improved equipment / workplace offer one or more of the following benefits to the operator:

- Highest labour productivity (output / unit time)
- Better safety and less occupational health hazards
- Lower working heart rate (beats / min), oxygen consumption rate (l/min) and energy expenditure rate (kJ/min)
- Lower cardiac cost (beats / unit output)
- Lower specific energy cost (kJ/unit output)
- Lower muscular discomfort (expressed in terms of overall discomfort rating / body part discomfort score)

Thus, the farm tools and equipment were ergonomically evaluated / refined / developed and recommended for use are: i. Eight-row direct paddy seeder, ii. improved sugarcane harvesting knife, iii. improved cono weeder for paddy, iv. sugarcane striper (detrasher), v. wheel hand hoe, vi. wheeled fertilizer broadcaster, vii. hand operated chaff cutter and viii. pedal operated paddy thresher.

Standards: Total 25 standards on safety aspects have been developed by BIS (Bureau of Indian Standards, New Delhi, India (Source:1. BIS Catalogue,2007.) and are in use. Some standards are made compulsory which are covered under dangerous machinery act of 1983 and related with safety and health hazards.

5. Agricultural Machinery and sustainable environment

Precision Farming: The human, animal and mechanical energy is extensively used in agriculture for production and processing application. Traditional agriculture utilizing natural resources has been symbiotic to the environment conservation. Use of animate energy was supplemented by mechanical and electrical sources and thus created higher environment pollution. Engineering input on land leveling equipment, drainage equipment help in disposal of extra water, provide better crop root zone and minimize water requirement for irrigation. Equipment for efficient irrigation, appropriate use of pesticides, micronutrients and minimizing their excess use to protect soil health and environment is a growing concern. The engineering input with electronic gadgets has a role to deliver the appropriate quantity of input at appropriate location to improve factor productivity and soil health. It is being tried for control of depth of operation, application rate in case of seed drill and chemical applicators, control of clogging of furrow openers, crop losses in harvesting using combine harvester at controlled grain moisture. Use of these gadgets though will involve additional cost on their installation on the equipment but these can contribute in enhancing 20 to 50% production, productivity and help in clean environment development.

Clean Environment: The actual feasibility of use of bio-mass and waste, as against direct burning, will depend upon collection, handling, pretreatment, energy production technology and National and International laws to protect environment. Pesticides of plant origin and integrated pest management technology help in control of pests besides, reduction in environment pollution. Intensive efforts are on in favour of organic manure use and receiving due attention of farmers.

Mechanical sources of energy emit considerable carbon and nitrogen oxides (Table 14). Due to use of combine harvesters some of the farmers have resorted to burning of crop residues, which produce pollutants like nitrogen oxides and sulphur oxide, Carbon dioxide and Carbon mono - oxide. Environment pollution by tractor and powered machinery through noise and exhaust emissions, surface erosion, pollution due to use of herbicide and pesticide has increased.

Table 14. Extent of pollutants for each Mega Joule of energy produced

Fossil Fuel Emission Levels - kilograms per Mega Joules of Energy Input			
Pollutant	**Natural Gas**	**Oil**	**Coal**
Carbon Dioxide	49.9	69.95	88.72
Carbon Monoxide	0.017	0.014	0.088
Nitrogen Oxides	0.039	0.19	0.195
Sulphur Dioxide	4.265×10^{-4}	0.478	1.105
Particulates	2.98×10^{-4}	0.036	1.17
Mercury	0.000	2.98×10^{-6}	6.82×10^{-6}

Source: EIA-Natural Gas Issues and Trends, 1998, http://www.naturalgas.org/ environment/naturalgas.asp accessed on 20.08.2007

Thermal conversion efficiency of open fire is usually 5 per cent, domestic chulha-12 per cent, smokeless chulha-20 percent and improved cook stove 20-35 per cent. Improved stove and furnaces, charcoal briquettes, fluidized bed combustion with optimum air / oxygen can improve the thermal efficiency besides cleaner environment and therefore being promoted to meet the requirement effectively (Table 15 & 16). It is estimated that 35-40% of bio-mass is utilized for animal feed and the remaining as energy source through direct combustion either for cooking food or for processing of agro-produce which leads to pollute the environment (Table 17), if not used with improved gadgets.

Presently there are about 12 million electric motors and 6 million diesel engine pump sets for lifting water from various sources. These consume about 90 billion kWh of electricity and 3.6 billion litre of diesel annually. Field studies revealed that most of the agricultural pump sets selected and installed are operated at much lower efficiency and create environmental hazard. Awareness of farmers in selection of appropriate pump, its proper installation, selection of proper prime mover and couplings and regular maintenance is thus a priority.

Human, draught animal, tractor, power tiller, electric motor and diesel engine are the major sources of farm power for agricultural operations. Despite smallholdings in the country, selective use of machines for tillage, sowing, plant protection, and threshing operations is showing considerable growth.

Table 15. Rural energy needs

Home management and rural industries	: 66 - 80%
Agricultural production	:16 - 25%
Post harvest activities	: 2 - 4%
Animal husbandry and dairying	: 2 - 5%

Table 16. Operational energy use pattern in agriculture

Energy, MJ ha^{-1}	1970-71	1980-81	1990-91	1996-97	2000-01*	Growth,%
Diesel	23	148	288	480	550	12.4
Electrical energy	322	1002	3233	5308	7720	11.4
Animal energy	1606	1404	1101	980	907	-1.88
Human energy	1331	1401	1409	1525	1607	0.52
Total energy	3282	3955	6031	8773	10784	3.85

*Estimated Capacity: Diesel, 63.27 MJ/kg; electricity, 11.93 MJ/kWh Bullocks pair, 10.10 MJ; Human, 1.84 MJ (male , 70% and female, 30%). Note: 40% of the total diesel used in rural sector assumed for crop production and remaining for transport and other agro-industrial activities.

Table 17. Gas production from agricultural residues

Residues	Gas production m^3/kg dry matter	% methane
Dung	0.33 - 0.37	60
Poultry manure	0.42 - 0.45	65
Night soil	0.38 - 0.42	65
Dry leaf powder	0.45	44
Sugarcane trash	0.75	45
Maize straw	0.81	46
Activated sludge	0.62	44
Straw powder	0.93	46

Conservation tillage: Conventional agriculture recommends extensive soil tillage and burning of crop residues. Such practices lead to soil degradation through loss of organic matter, soil erosion and compaction. Conservation agriculture is a range of soil management practices that minimize effects on composition, structure and natural biodiversity and reduce erosion and degradation. Largely, the conservation agriculture practices include (i) direct sowing / no – tillage, reduced tillage / minimum tillage, (ii) surface – incorporation of crop residues, and (iii) establishment of cover crops in both annual and perennial crops. As per FAO, the Conservation agriculture is based on enhancing natural biological processes above and below the soil surface. These go beyond zero – tillage and provide a range of technology and management options. Conservation agriculture practices are applicable to virtually all the crops.

Energy can be conserved by less manipulation of soil for plant growth using zero- till drill, strip till drill, bed forming technique and less application of chemicals for weeds and management of pests. Upland paddy cultivation through seed drills - less puddling, as a result better soil structure and less gas emission compared to flooded paddy field. In conservation tillage the soil surface is disturbed least and thus, significant amount of residue remains on the surface which helps in reducing run off, sediment loss and loss of nutrients. The seed is directly drilled through the layer of residues. In no-till farming, soil preparation and planting are done in single operation, in reduced till farming there is limited preparation with disc, rotavator or chisel plough. Water harvesting, soil conservation and efficient irrigation techniques make the clean farming easy and improve the ecology and environment. Community participation is very often necessary in such cases. Mulch and cover crops also improve soil, water and nutrient conservation.

The aspect of conservation agriculture is receiving due attention in Indian agriculture.

6. Agricultural machinery standards and testing

The manufacture of agricultural machinery in India is varied in nature and starts from village artisans, tiny units, cottage to small scale industries, organized tractor and agricultural machinery manufacturers including energy and processing machinery industry. Standardization and quality control measures are inadequate except in the organized sector like tractor manufacture. Even in tractors noise and vibration continue to be a problem.

Though, the Bureau of Indian Standards (BIS), New Delhi India helps in good quality manufacture and marketing of agricultural machinery, it is not a easy task particularly keeping in view the wide range of manufacturers and adoption of the standards being voluntary. The BIS prepares specifications for agricultural machinery, etc. and stipulates test codes. 106 BIS Standards on Agri. Machinery and its testing are available (Source:1. http://www.dacnet.nic.in /nrfmtti /Testing / Standards.html accessed on 18.7.2009). The testing is done at approved facilities and eight such

laboratories referred by BIS are functional in different parts of the country. (Source: http://www.bis.org.in/lab/osladd1.htm accessed on 20.8.2009). Agricultural machinery financed under government schemes is required to be tested and quality certified. The Ministry of Agriculture is responsible for monitoring the Act. Other than the BIS, the government has also set up four farm machinery testing centres for the promotion of quality farm machinery.

- Central Farm Machinery Training and Testing Institute, Budni (*Madhya Pradesh*)
- Northern Region Farm Machinery Training and Testing Institute, Hissar (*Haryana*)
- Southern Region Farm Machinery Training and Testing Institute, Garladinne, Distt. Anantpur, (*Andhra Pradesh*).
- Eastern Region Farm Machinery Training and Testing Institute, Biswanath Charlialli, Distt. Sonitpur, (*Assam*).

Testing of tractors and power tillers at CFMTTI Budni is obligatory activity for the manufacturer prior to introducing the product in market. Institute at *Hissar* conducts tests on selfpropelled combine harvesters, irrigation pumps, plant protection equipment, agricultural implements and other machines. The Institute at Biswanath Chariali (*Assam*) tests only the bullock drawn implements, manually operated equipment and small hand tools. The Institute at Garladinne (*Andhra Pradesh*) tests various agricultural implements and components.

Apart from conducting testing and performance evaluation of various agricultural implements and machines, these Centres are required to and have been imparting training to the farmers, technicians, nominees of Government, retired defence personnel, etc. in selection, operation, maintenance, energy conservation and management of agricultural equipments. To supplement the efforts of Farm Machinery Training AND Testing Institutes in human resource development, outsourcing of the training through the State Agricultural Universities, Agricultural Engineering Colleges, etc. has been approved during current plan. Similarly, the Government Institutions are being approved to facilitate testing of agricultural equipment in time.

7. Regional Agricultural Machinery testing network

The concept of ANTAM (Asia-Pacific Network for Testing Agricultural Machinery) has been mooted on the lines of ENTAM (European Network for Testing of Agricultural Machines) to strengthen the testing acivity and avoid duplication of inputs. ENTAM appears to be on more sound footing mainly because of cohesiveness in understanding and harmonization of standards within the member countries. The ANTAM shall succeed in its objective, only if the mutually agreeable test codes / standards are developed and enforced for testing of agricultural equipment / machinery. Then only, the validity of the test reports will be assured to facilitate technological movement and acceptance in member countries. Therefore, the basic issue of harmonization of the standards on the basis of common interest and considerations is a need.

8. APCAEM Programmes in India

The following programmes are being pursued at the Institute level. However, it is felt that an activity based on UNAPCAEM funding shall be of significance for rigorous inputs and targeted output.

Agricultural Mechanization

- Adoption of Chinese design of Tractor mounted Zero Till Drill – As decided in earlier meeting, the Chinese design equipment be made available in exchange of Indian zero till drill. Both the units be tested and the best one be advocated for adoption
- Promotion of conservation agriculture
- Database on Testing Institutes in the country (standards) – as input for Asia Pacific Network of Testing of Agricultural Machinery (ANTAM)

Energy in Agriculture

- Energetics of the process for alcohol production from agro residues.

Agro-Soybean Processing

Agro-Soybean enterprise development

9. Recommendations

The following policy inputs are put forth for the consideration of Technical Committee of UNAPCAEM.

- APCAEM needs to reposition itself as a focal point for Agricultural Engineering Technology development and dissemination in the area of agricultural mechanization of production and post production agriculture for food and nutrition security in the Asia Pacific region in changing scenario of global warming and climate change.
- The APCAEM together with its member countries should consider establishment of ANATE (Asia Pacific Network for Agricultural Technology exchange) in addition to ANTAM. Such an arrangement should be based on nominal technology fee for member countries. The document consisting of list of technologies available and their usefulness / utility be developed by each country and made available to different countries through ANATE headed by an identified official, responsible for co-ordination of the activity. Such an arrangement will facilitate ease of adoption of available technology and avoid duplication of research inputs thereby making available the manpower for research on demanding priority areas.
- Inputs in Agro enterprise development in agricultural mechanization service provider and processor of farm produce for income and employment generation, on priority, to enhance purchasing power of the poor including women.

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Note: Other references based on web portal sources are indicated separately in the manuscript.