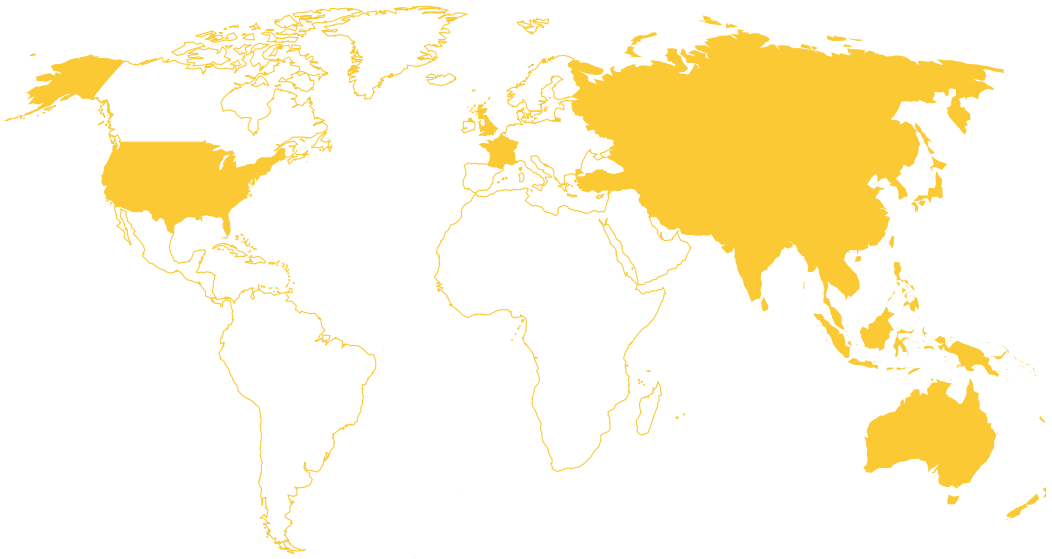
Agricultural Mechanization and Testing of Agricultural Machinery in the Asia-Pacific Region

UNITED NATIONS ESCAP
Economic and Social Commission for Asia and the Pacific
CSAM

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

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



The shaded areas of the map indicate ESCAP members and associate members

Agricultural Mechanization and Testing of Agricultural Machinery in the Asia-Pacific Region

Centre for Sustainable Agricultural Mechanization

United Nations Economic and Social Commission for Asia and the Pacific

ACKNOWLEDGMENTS

This report is published under the overall guidance of ZHAO Bing, Head of the Centre for Sustainable Agricultural Mechanization (CSAM) of the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP). It was prepared by a core team led by AI Yuxin, Senior Expert of CSAM, who authored the Editorial and edited the publication. Main contributors to the substantive chapters are Dr. Gajendra Singh, Dr. Chan Chee Wan and Ms. HAN Xue respectively, consultants contracted by CSAM. The report also benefited from the presentations made by participants at meetings organized by CSAM. Special thanks go to Ms. Camilla Stelitano, Programme Specialist, who did the initial editing of the case study, and Mr. WEI Zhen, IT Specialist, who provided the layout design.

Cover Photograph: courtesy of Mr. Humayun Kabir, Bangladesh

EDITORIAL

Agriculture remains the backbone of national economy in most developing countries in the Asia-Pacific region. Agriculture is not only the producer of food and but also employer of approximately 60% of the working population in this region, according to ESCAP's survey in 2013. However, achieving and ensuring sustained food security in the region remains a challenge. In recent years, countries across the region start embracing agricultural mechanization to increase labor and land productivity in order to meet the growing demand for food. Sustainable agricultural mechanization plays an increasingly important role in improving efficiency in the agricultural systems, filling the rural labour gaps and enhancing farmers' income through rural business/enterprise development.

At present, there is a varying level of agricultural mechanization across the region. Most developing countries in the region lack appropriate technologies, knowledge, infrastructure and qualified human resources to promote farm mechanization. Inadequate government support, underinvestment in R&D, absence of holistic approach and coherent institutional framework are also contributing factors.

At the same time, increased demand for agricultural mechanization results in booming trade of agricultural machinery in the region. According to the World Bank estimate in 2010, over the past two decades, the Asia-Pacific region has emerged as the largest market in the world in terms of sales of agricultural machinery, implements and equipment. In 2015, it is projected to have sales of US$ 49 billion as compared to US$ 27 billion in North America and US$ 20.5 billion in Western Europe.

In the mechanization process, standard testing to ensure safety, technical reliability and environmental sustainability of agricultural machinery is crucial. The on-going efforts made by governments to address the mechanization needs of farmers necessitate a region-wide mechanism to standardize and harmonize testing codes of agricultural machinery for the benefits of farmers, food production, environment and cross-border trade. The Asian and Pacific Network for Testing of Agricultural Machinery (ANTAM) initiated by CSAM is aimed to promote sustainable agriculture through region-wide standard-setting to address safety, efficiency and environmental aspects of agricultural mechanization in the region.

The newly adopted UN sustainable development goals (SDGs) call for food security through sustainable agriculture. Sustainable agricultural mechanization and testing are integral parts of sustainable agriculture.

Contents

I. AGRICULTURAL MECHANIZATION SITUATION IN ASIA AND THE PACIFIC

II. AGRICULTURAL MACHINERY TESTING IN THE ASIA-PACIFIC REGION

III. A CASE STUDY ON TESTING & APPRAISAL SYSTEM OF AGRICULTURAL MACHINERY IN CHINA

I. Agricultural Mechanization Situation in Asia and the Pacific

Contributed by Dr. Gajendra Singh

1. INTRODUCTION

1.1 FOOD SECURITY - A MAJOR CHALLENGE IN MANY COUNTRIES

At present the world is facing multiple challenges of feeding growing populations, alleviating poverty, protecting the environment, and responding to climate change. If the population growth is not checked, it may perpetuate hunger and malnutrition and reduce economic growth. During the period 2010 to 2012, thirteen percent of the population of Asia and the Pacific experienced severe forms of hunger and malnutrition. However, while this proportion has fallen from 22 per cent during the period 1990 to 1992, still as of 2012, about two thirds of the world's undernourished people lived in the Asia and Pacific region (OECD-FAO, 2013). According to FAO (2014) about 805 million people of 7.3 billion people in the world (one in every nine) were suffering from chronic undernourishment in 2012-14 and 791 million lived in developing countries. The world is facing perhaps the greatest challenge of how to feed two billion more people by 2050. This, combined with increasing incomes in the developing world and growing needs for energy, is likely to lead to increased demand for agricultural products at an unprecedented rate. The global demand for food is expected to increase by 60 per cent by 2050 (OECD-FAO, 2012).

The green revolution which occurred in the region in the 1960s and the 1970s focused mainly on farm production aspects, and the post-harvest sector was considered after bumper harvests began to choke the post production infrastructure leading to massive losses. It was only in the early 1980s when there was a concerted effort, initially focused on storage, to tackle the post-harvest constraints. Post-production systems will have to be strengthened to ensure food security and also to enhance the growing export opportunities for countries of the region with surplus production capacity (Mrema and Rolle, 2003).

Asia has the largest land area in the world, comprising about 45 billion ha (30 per cent) of the global land area with more than 50% of the world population and with only 36% (504 million ha) of the world's arable land. Agriculture provides livelihood and is a culture. Cereals, fruits and vegetables and livestock production continue to be the main activity, and rice and wheat remain the staple food crops in Asia. Over 90 percent of the world's rice supply comes from Asia. Due to increased incomes, food habits are changing and the agricultural production systems are changing to meet those demands. During 1970s, cereals constituted 40% of agricultural production in monetary terms and by 2010 contribution of cereals reduced to 25%. During the same period the share of fruits and vegetables and livestock production increased from 18% and 15% respectively in 1970 to 27% and 28% respectively by 2010 shown in Figure 1.1 (Briones and Felipe, 2013).

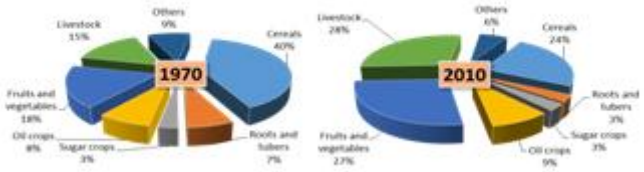


Figure 1.1 Percent Composition of Agricultural Output (constant $) for Asian Countries in 1970 and 2010

According to the World Bank (2014) projections (Table 1.1), the population of South Asia will continue to grow through 2050 where about half of the world's undernourished population lives at present. Agriculture is the most effective route to reduce poverty in many of the poorest parts of the world. One per cent growth in the agricultural economy results in a 6 per cent increase in spending by the poorest 10 per cent of the population. Far less income filters down to the poor from the growth of other sectors of the economy (World Bank, 2008).

Table 1.1 Projected Population (Billion People)

Region	2020	2030	2040	2050
East Asia & Pacific (Developing)	2.1	2.18	2.2	2.17
South Asia	1.81	1.99	2.13	2.21
World	7.67	8.37	8.97	9.47

Source: World Bank, 2014

1.2 DECREASING SHARE OF AGRICULTURAL LABOR AND INCREASING URBANIZATION

The percentage share of agriculture in the total work force has been decreasing in all countries. The decline in absolute number of workers in agriculture sector is related to development of industry and service sectors of a country. The absolute number of workers in agriculture sector started to decline in Japan in 1955 and in Republic of Korea in 1977 (Kienzle et al, 2013). By now the absolute number of workers in agriculture sector is decreasing in most of the countries.

Urbanization is driven by three factors: natural population growth, rural to urban migration and reclassification of rural areas into urban areas. In 2012, 1.96 billion (46%) people of the Asia-Pacific region lived in urban areas. By 2020 urban population is expected to reach 50% (UNESCAP, 2014). Benefits of living in urban areas are effective delivery of critical services such as transport, health and education as well as higher wages. This is making less labor available for farming as more people, especially the young, move to cities to look for jobs outside of the agricultural sector. Shortage of labor and rising rural wages are forcing farmers in Asia to adopt labor-saving technologies, i.e. farm mechanization. Also with increasing feminization of agriculture due to the propensity of more men migrating to urban areas than women, there is an increasing demand for labor saving technologies as well as gender specific interventions in farm mechanization.

1.3 DECREASING SHARE OF AGRICULTURAL SECTOR IN GDP FASTER THAN DECREASE IN AGRICULTURAL LABOR FORCE

According to the World Bank (2013), worldwide during 2012 agriculture sector employed 36% of workforce and its contribution to world GDP was only 3%. While services and industry sectors employed 41% and 20% respectively, and their contributions to world GDP were 70% and 27%, respectively. The share of agriculture sector in GDP is extremely low compared to labor force employed in these sectors.

During 2012 contributions of three sectors, namely, agriculture, industry (including manufacturing) and services are given in Table 1.2.

Table 1.2 Share of Agriculture, Industry (including manufacturing) and Services Sectors in GDP

	East Asia & Pacific (Developing)	South Asia	World
GNI per Capita ($, 2013)	5,536	1,474	10,584
Agriculture GDP (%)	11	18	3
Services GDP (%)	45	56	70
Industry GDP (%)	44	26	27
Manufacturing GDP (%)	30	14	16

Source: World Bank (2014)

It is clear from Table 1.2 that contribution of agriculture sector in overall world economy is extremely low (3%). Even for developing countries in East Asia and the Pacific, the contribution of agriculture sector in economy is very low (11%), and it is 18% for South Asia while agriculture sector employs about one third of the workers in East Asia and the Pacific, and about half of the workers in South Asia (Table 1.3). Due to very low income of farm workers, many of them are migrating to urban areas. This has resulted in shortage of labor and rising rural wages contributing to an increase in mechanization. When the agriculture is highly mechanized the difference in GDP per person in agriculture and other sectors becomes negligible, for example, Republic of Korea, Japan and USA (Table 1.3).

Table 1.3 GDP, Employment and Value Added per Person in Agriculture, Industry and Service Sectors of Selected Countries

Country	Percent GDP			Percent Employment			Value Added/ Person, $	
	Agriculture	Industry	Services	Agriculture	Industry	Services	All workers	Agriculture
Bangladesh	17	29	54	39	21	40	829	505
Cambodia	36	24	40	49	20	31	1008	524
China	10	44	46	34	30	36	6807	785
India	18	25	57	50	21	29	1504	697
Indonesia	14	46	40	35	20	45	3500	1018
Korea	2	39	59	6	24	70	25977	27097
Malaysia	9	41	50	13	28	59	10514	9687

Nepal	35	16	49	67	11	22	694	265
Pakistan	25	22	53	44	22	34	1300	1080
Philippines	12	31	57	31	16	53	2765	1129
Sri Lanka	11	32	57	32	26	42	3280	1041
Thailand	12	43	45	42	20	38	5780	1160
Vietnam	18	38	44	47	21	32	1911	476
Japan	1	26	73	5*	25	70	40000	46000
U.S.A.	1	20	79	1	17	74	50000	50000

**Japan has a very large number of hobby (weekend) farmers who have regular job outside agriculture. Source: World Bank (2014)*

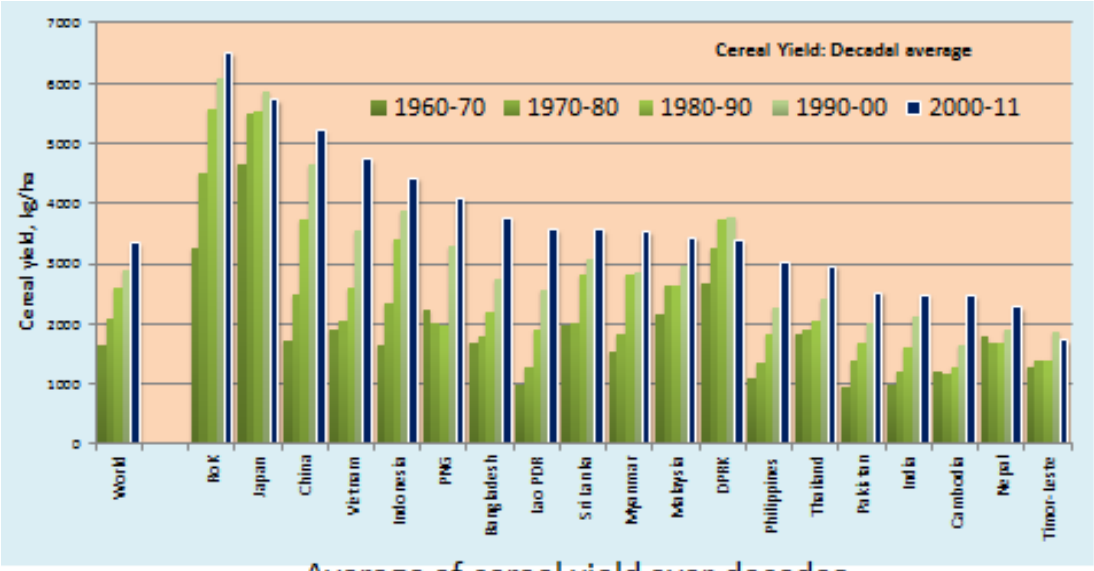
The agriculture sector in developing countries in the Asia-Pacific region employs more people than in other sectors including industry and services (Table 1.3). Contribution of agriculture to GDP is much smaller and thus average annual earnings of farm workers are much lower compared to workers in other sectors. For example, in India, agriculture employs about 50% labor force and its contribution to GDP is about 14% only. Thus the average annual earnings of non-agricultural workers are about 6 times that of agricultural workers in India. Similarly, the average annual earnings of non-agricultural workers are about 4.5 times in China, about 3.3 times in the Philippines and about 5.3 times in Thailand compared to those of agricultural workers. The computation of ratios of average annual income (GDP/Worker) of non-agricultural workers to those of agricultural workers for selected countries, India, China, the Philippines and Thailand is given in Table 1.4.

Table 1.4 Ratio of Incomes of Non-Agricultural Worker and Agricultural Worker for Selected Countries

	Agriculture			Non-Agriculture			Non-Agri/Agri
Country	Workers	GDP	GDP/ W	Workers	GDP	GDP/W	GDP Ratio
India	50	14	0.28	50	86	1.72	1.72/0.28=6.1
China	34	10	0.29	66	90	1.36	1.36/0.29=4.7
Philippines	31	12	0.387	69	88	1.273	1.27/0.387=3.3
Thailand	42	12	0.286	58	88	1.52	1.52/0.286=5.3

1.4 INCREASE IN LAND AND LABOR PRODUCTIVITY

As shown in Figure 1.2, the cereal yields in most countries have increased very significantly. The cereal yields (Table 1.5) in many countries in the region are higher than average yield of cereals in the world while cereal yields in other countries are lower than average yield of cereals in the world (FAOSTAT and World Bank, 2013). The output per worker in agriculture sector rose by 2.2% per annum during 1980-2010.



Average of cereal yield over decades

(Source: Soni (2014) calculation based on data from FAOSTAT and World Bank, 2013)

Cereal yield, *measured as kilograms per hectare of harvested area includes:wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat and mixed grains. Production data on cereals relate to crops harvestedfor dry grain only.*

Table 1.5 Cereal Yields in Countries of Asia and the Pacific Region (2011)

Country	Yield (Kg/ha)	Country	Yield (Kg/ha)	Country	Yield (Kg/ha)
Bangladesh	4191	Indonesia	4886	Malaysia	3920
Cambodia	2925	Japan	4911	Pakistan	2718
China	5706	Korea	7038	Philippines	3341
India	2883	Lao PDR	4045	Thailand	3065
Vietnam	5383	Myanmar	3880	World	3708

Source: World Bank (2013)

Approximately 80 percent of water in the region is used for agriculture. With the rapidly increasing demand for water by industrial and municipal users, competition for water is becoming increasingly fierce. Global climate change has potential grave consequences for food production, and consequently for global food security. Agricultural production systems in most Asian developing countries are highly vulnerable to risks of climate change and have little capacity to cope with its impact. Water shortages, low water quality, increasing temperatures, rise in sea-level, floods and more intense tropical cyclones are real risks that will lead to the deterioration of farming environments in many areas of the region. These trends require the development and implementation of sustainable cropping systems which include innovative crop management practices and efficient post-production systems that are resilient to climate change to minimize risks.

Sustainable intensification of crop and livestock production must not only reduce the impact of climate change on the production system but must also mitigate the factors that cause climate change, by reducing emissions and

by contributing to carbon sequestration in soils. Agricultural mechanization using efficient machines improves the utilization efficiency of inputs like fertilizers and agro-chemicals and reduces negative impact on environment. Similarly use of micro-irrigation techniques, not only improves water use efficiency significantly but also reduces deep percolation of water with which fertilizers like nitrates leach and pollute ground water. Application of fertilizer with drip irrigation (fertigation) improves fertilizer use efficiency and thus reduces amount of fertilizer needed to be applied, again reducing the negative chemical impact on the environment. The use of conservation tillage and minimum tillage methods improves soil health, reduces soil erosion and cost. Thus appropriate and sustainable agricultural mechanization plays a major role in making agriculture sustainable. Meanwhile, agricultural mechanization reduces the drudgery in performing agricultural tasks by farm workers, overcomes time and labor bottlenecks thus enabling performance of tasks within optimum time period. Sustainable agricultural mechanization through adoption of socially, economically and environmentally viable approaches and strategies that address both the efficiency of food production and protection of the fragile agro-ecological systems is gaining importance.

1.5 HISTORY OF MECHANIZATION IN ASIA

Until 1950s traditional methods of using animate (human and animal) power were used in all crop production operations throughout Asia. However, three regions of Asia, namely, northeast, south and southeast experienced somewhat different development in agricultural mechanization (Kienzle et al, 2013). In the northeast, Japan was the first to mechanize as a result of rapid industrialization immediately after the Second World War. The Republic of Korea followed due to its own industrialization and access to technologies from Japan. The two-wheel tractors or power tillers developed in Japan became the mainstay of agriculture in these countries which are being replaced by four-wheel tractors. China, during 1953-57 acquired about 5,000 tractors of 15 hp each from the former USSR. The first tractor factory was also constructed with assistance from the USSR, and in 1976 mechanization started to expand rapidly (Wang, 2013).

In South Asia, the first tractor to India was brought in 1914. In the 1930's, pump-sets were introduced. In the 1940's, high horse power crawler tractors were imported under the aegis of Central Tractor Organization mainly for land development and to eradicate obnoxious weed *kans* grass. There were only about 8,000 tractors in 1950. Manufacturing of irrigation pump-sets started in the late 1950's and tractor manufacturing started in 1961. Among the Southeast Asian countries, Thailand made considerable progress in the 1980's by introducing locally made two-wheel tractors, stationary threshers and low lift water pumps, also mostly powered by two-wheel tractor engines. Before that Thailand was mainly using four-wheel imported tractors assembled locally, assembly of which was discontinued later. Malaysia introduced large four-wheel tractors and combines in the 1970's and 1980's under Muda Agricultural Development Authority (MADA).

In a seminal paper Binswanger (1978) concluded: "*....The tractor surveys fail to provide evidence that tractors are responsible for substantial increases in intensity, yields, timeliness, and gross returns on farms in India, Pakistan, and Nepal. At best, such benefits may exist but are so small that they cannot be detected and statistically supported, even with very massive survey research efforts. Indeed, the fairly consistent picture emerging from the surveys largely supports the view that tractors are substitutes for labor and bullock power, and thus implies that, at existing and constant wages and bullock costs, tractors fail to be a strong engine of growth. In view of this finding, many of the benefit-cost studies reported may have overestimated the benefits, both social and private which arise out of the agricultural uses of tractors. Except in situations where area effects are possible—or by renting or buying from others—private returns to tractors from agricultural operations must be close to zero, or even negative at current fuel prices...*"

In another paper Binswanger (1986) stated, "*....In general, mechanization will contribute little to growth in countries without a land frontier and with densely populated farmland — such as Bangladesh, most of India, and China. Given the fact that a high proportion of the work forces in these countries are still engaged in farming, even very rapid growth in the rest of the economy will not lead to rapid wage increases. Labor scarcity cannot be expected to arise from non-agricultural growth in the near future as a driving force for mechanization....*"

In a major ILO commissioned study Raj (1973) reported similar findings. Such findings created doubts about the agricultural development model based on the use of motorized agricultural mechanization inputs and led to reduced support for mechanization by governments in many developing countries and also by international development organizations.

However, Singh and Chancellor (1975), based on a year-long survey, found that agricultural output for categories of farms was related to energy inputs, irrespective of ownership of farm power sources (owned or rented) and the size of land holding had no effect on yield. Farmers with better management (i.e. timely operations, like sowing, irrigation, weeding, fertilizer and pesticide application; and proper amounts and right techniques of application) had higher yields than those with poor management.

Further, Singh (2001) reported that the economics of ownership of most tractors in India had been justified by custom hiring for on-farm work as well as for off-farm transport and construction activities. The use of tractors in transport activities accounted for about 60% of average annual use of 600 hours. Many small farmers also started purchasing tractors due to the opportunity of custom hiring. Similarly, the ownership of many other farm machines and equipment, like pumps for tube-wells, seed-drills and planters became economically viable due to renting out to other farmers. However, ownership of large threshers, laser land levelers and combine harvesters is mainly justified by custom work.

1.6 SEQUENCE OF MECHANIZATION

Use of labor in agriculture is not uniform throughout the year. Use of equipment is also seasonal. Need for mechanization initially arises mainly due to:

a) Shortage of labor during peak periods;

b) Unreliability of available labor;

c) Inability of animate power sources (human and draft animals) to complete operations within optimum period resulting in losses in yield or produce;

d) Unwillingness to work in agriculture due to: drudgery, harsh climate/environment, long working hours, farmer-worker relationship, limited days of work in a year and low annual income.

The growth of the mechanization in Asia and the Pacific is following a same general pattern found worldwide as given in Table 1.6. Farm operations requiring high power inputs and low control are mechanized first (tillage, transport, water pumping, milling, threshing, etc.).

Table 1.6 Sequence of Mechanization of Different Operations

Sequence	Operation		
Type of Operation	I Low skill High power	II Medium skill Varying Power	III High Skill Varying Power
Stationary	Grinding, milling, crushing, water pumping, threshing	Grinding by size, cleaning	Grinding by quality
Mobile	Land preparation, Transport	Seeding of grain, Harvesting of grain	Transplanting, Harvesting of cotton, Sugarcane, Fruits and Vegetables

Farm operations requiring medium levels of control and varying levels of power are mechanized next (seeding, spraying, intercultural operations, etc.). Farm operations requiring high degree of control and varying levels of power inputs are mechanized last (transplanting, planting of vegetables, harvesting of fruits and vegetables, etc.). This happens so because any work, which is power intensive, can be done faster mechanically and at a lower cost. Whereas converting human knowledge into machine knowledge is difficult and costly.

2. PRESENT STATUS OF AGRICULTURAL MECHANIZATION IN THE ASIA-PACIFIC COUNTRIES

2.1 MAIN POWER SOURCE - EQUIPMENT SYSTEMS USED IN OPERATIONS

At present, countries across the region differ widely with respect to how they make use of following main sources of farm power in performing various on- farm and off-farm operations.

1. Human labor
2. Animal power
3. Engine (petrol/diesel)
4. Electric motor
5. Two-wheel, single axle tractor (2WT)
6. Four-wheel, two-axle tractor (4WT)
7. Self propelled machines

Human labor

Manual labor is predominantly used in many countries for broadcasting of seeds and fertilizers; sowing; transplanting of rice and vegetable seedlings; spraying using knapsack sprayers; weeding, inter-culture, ridging, leveling and bund-making using hand tools; reaping of crops using sickles; plucking of fruits; plucking and harvesting of vegetables; bundling of harvested crops including fodder crops, transportation of inputs (seeds, fertilizer, etc.) to field and harvested crops to threshing floors; threshing of crops by beating (including against a log); transportation of produce to drying floor and homestead; bagging and loading on transport vehicle.

Human operator is needed to operate all animal powered implements and mechanically (including electrically) powered implements and equipment.

Animal power

In many countries animal draught power is still being used for tillage, sowing, inter-culture, irrigation (water lifting), threshing (trampling), and transport operations.

Engine (petrol/diesel)

Most of the engines are diesel engines and are used to power stationery machines like water pumps, threshers, winnowers, cleaners, graders and processing machines.

Electric motor

Electric motors are used to power stationery machines like water pumps, threshers, winnowers, cleaners, graders and processing machines.

Two-wheel, single axle tractor (2WT)

Two-wheel, single axle tractors are mainly used for tillage and transport operations. A 2WT equipped with a rotary tiller is commonly known as Power Tiller. With a belt and pulley mechanism engines of these 2WTs are also used to power stationery machines like water pumps and threshers.

Four-wheel, two axle tractor (4WT)

Four-wheel, two-axle tractors are mainly used to power equipment for tillage, sowing/planting, inter-culture, weeding, ridging, bund-making, leveling, spraying, reaping and harvesting, and transport operations. Using PTO shaft (with a belt and pulley mechanism) these 4TWs are also used to power stationery machines like water pumps, threshers and other machines.

Self-propelled machines

The most common self-propelled machine in use in the region is combine harvesters for grain crops, mainly wheat and rice. Other self-propelled machines which are gaining popularity mainly by custom-hire operators are rice transplanters and sugarcane harvesters. Corn (maize) pickers, forage harvesters and cotton pickers are also being introduced by custom-hire operators.

2.2 AVAILABILITY OF POWER SOURCES

The land and water resources in Asia and the Pacific are already fully exploited. With only significant inputs of energy we can improve the use of these resources to increase food production. Agricultural mechanization plays a pivotal role as machines make it possible to apply and use inputs like seeds, fertilizers and chemicals and water at appropriate place and time in desired quantities in an efficient way.

The experience of the region shows that mechanization of processing and pumping has tended to precede the mechanization of crop care and harvesting operations. The use of irrigation pumps has increased exponentially in the region: in India the use of pumps grew from 6 million in 1980, to 28 million in 2010. In Bangladesh, the use of pumps grew from 0.3 million in 1996 to 1.3 million in 2010; while in Cambodia, it increased from 0.06 million in 2001 to 0.17 million in 2010. In certain areas, excessive use of pumps has also led to

the overdrawing of groundwater, and as a result, countries in the Asia-Pacific region have recently been facing depleted water tables. Japan, Russia and Korea have already mechanized most of the operations. Malaysia, Thailand, China, India, Pakistan, Sri Lanka, Bangladesh, Vietnam have mechanized land preparation and transportation operations using 4WTs and 2WTs, and milling, water pumping and threshing using stationery engines and electric motors. In Thailand, Indonesia, Vietnam, Cambodia, the Philippines, Bangladesh and Nepal, 2WTs (in stationery mode) are also used to power irrigation pumps. Harvesting combines are being used extensively in Malaysia and gaining popularity in Thailand, China, India and Pakistan. Combines are also being used to limited extent in the Philippines, Cambodia, Bangladesh and Nepal.

The use of animal draft power has declined significantly in all countries since the 1990s. In India, the number of draft animals in use declined from over 85 million in 1975 to about 50 million in 2010, and is projected to decline to 18 million by 2030 (Singh, 2013). Of the total power 2.0 kW/ha available during 2013, the share of animal draught power was only 5% compared to 46% share from tractors and 27% share from electric motors. In Bangladesh, the cyclones of the 1980s killed most of the draft animals and these were replaced by 2WTs. Similarly in China, it is projected that draft animals will be completely replaced by 2025 (Renpu, 2014). The animal draft power is still being used to varying extents mainly for land preparation and transport operations in all countries except Japan and Korea. The use of animal draft power is still quite common in Nepal, Cambodia, Indonesia, the Philippines, India, Bangladesh, Vietnam, Pakistan, Fiji, Papua New Guinea and Thailand. With the exception of Japan, Russia and Korea, rice transplanting, seed broadcasting, transplanting of vegetable seedlings, weeding and inter-culture, spraying (with knapsack sprayer) fertilizing, reaping of crops, picking of fruits, harvesting of vegetables, winnowing, cleaning, grading and sorting are mostly done manually.

Table 2.1 Number of 4W Tractors, 2W Tractors, Irrigation Pumps and Combine Harvesters and Power Available in Selected Countries

Country	4W Tractors (000's)		2W Tractors (000's)		Irrigation pumps (000's)		Combine harvesters (Units)		Power kW/ha	
	1990	2013	1990	2013	1990	2013	1990	2013	1990	2013
Bangladesh	5	60	10	700	220	1729	N/A	130	0.3	1.83
Cambodia	0.3	9.5	0.5	152	1.0	256	N/A	4580	N/A	1.32
China	814	5270	6981	17523	7255	22068	39588	1421000	2.0	5.7
India	1200	5430	31	440	12900	28000	4500	38000	0.75	2.02
Indonesia	4	2.8	17	71	N/A	N/A	N/A	N/A	0.3	N/A
Rep. Korea	31	278	739	640	326	350	32900	78854	N/A	10.6
Malaysia	2.5	8	2.1	35	70	N/A	44	1700	0.24	0.2
Nepal	6	30	1	12	23	550	N/A	N/A	0.22	N/A
Pakistan	231	573	5	2	288	1050	1300	9000	0.75	1.1
Philippines	6	N/A	32	N/A	107	N/A	N/A	N/A	0.39	N/A
Russia	1366	260	N/A	N/A	79.4	5.2	407800	67900	2.67	1.48
Sri Lanka	15	1.5	24	2.8	52	N/A	N/A	1099	0.43	N/A
Thailand	45	334	583	1750	851	2320	2250	15000	0.89	2.5

Vietnam	5.2	170	20	380	168	2170	0	20000	0.61	1.7

Source: 1. RNAM reports; 2. Data provided by national participants to CSAM meetings during 2014. N/A: Not Available

2.3 LOCAL PRODUCTION AND IMPORTS OF FARM MACHINERY

The Asia-Pacific region has emerged as the largest market in the world in terms of agricultural machinery sales, and is projected to have sales of about USD 50 billion in 2015 (World Bank, 2010). In 2012, globally the output value of agricultural machinery industry was about US$120 billion of which China accounted for about US$50 billion and India about US$ 15 billion.

The 4-wheel tractors (two axles) are mainly produced in China, India, Japan, Korea and Pakistan. Other countries in the region import tractors from countries within the region as well as from countries outside the region. The 2-wheel tractors (single axle) or power tillers are mainly produced in China, India, Japan, Korea, Thailand, Philippines, Indonesia, and Vietnam. Other counties in the region like Bangladesh, Nepal, Sri Lanka, Cambodia, and Laos import 2-wheel tractors mainly from China. Laos and Cambodia also import 2-wheel tractors (power tillers) from Thailand. Mainly Japan, China, Korea and India are producing combine harvesters in large numbers. Thailand also produces locally made track type combines mainly to harvest rice from wet fields. Other countries in the region import combines from these countries in the region as well as from the countries outside the region.

Most counties in the region are producing engines (petrol/diesel) and electric motors with the exception of Laos, Cambodia, Nepal, Fiji and PNG. Similarly, most of the countries are producing implements and equipment powered by 4-wheel and 2-wheel tractors and water pumps and threshers. However, some countries still rely on imports from China, India, Thailand, Japan, Korea and some countries outside the region.

In 2012, China had 2040 large-scale agricultural machinery manufacturers having a gross industrial output value of RMB 338.2 billion Yuan, and the total amount of agricultural machinery import and export of China reached USD 11.255 billion. The power of agricultural machinery in 2013 in China totaled about 1.039 billion kilowatts, with the population of large- and medium-sized tractors and combine harvesters reaching 5.2702 million and 1.4210 million, respectively.

2.4 LEVEL OF MECHANIZATION FOR DIFFERENT OPERATIONS

The level of mechanization for different operations varies significantly from crop to crop, and in big countries it varies from region to region in the same country. The level of mechanization for different operations also varies significantly for the same crop.

In 2013 in China, the national comprehensive mechanization level, comprising of crop tillage, planting and harvesting reached 59.5%; with tillage at 76.0%, planting at 48.8% and harvesting at 48.1% (Table 2.2).

Among crops, wheat had the highest level of comprehensive mechanization at 93.7%, followed by rice at 73.1% and maize at 59.5%. For tillage, tractor plowing for wheat was 98.9%, for rice it was 95.1% and for maize it was 76.0%. The level of mechanical sowing for wheat was 86.7%, for rice only 31.7% and for maize it was 84.1%. Similarly, the level of mechanical harvesting for wheat crop was 93.8%, for rice 80.9% and for maize it was only 51.6%. Even for the same crop and the same operation, the level of mechanization varies in different parts of China.

Table 2.2 Mechanization Level for Main Crops and Their Operations in China in 2013

Items	Comprehensive mechanization level (%)	Tractor plowing (%)	Mechanical sowing (%)	Mechanical harvesting (%)
Crops	59.48	76.00	48.78	48.15
Wheat	93.71	98.90	86.69	93.82
Rice	73.14	95.09	36.10	80.91
Corn	79.76	97.67	84.08	51.57

Source: Department of Agricultural Mechanization, Ministry of Agriculture, China

Based on the data and information provided by member countries Table 2.3 gives various operations done using different sources of power.

Table 2.3 Present Status of Agricultural Mechanization in Asia-Pacific Countries

Country	Human Labor	Animal Power	Engine (Petrol/ Diesel)	Elect. Motor	2-Wheel 1-Axle Tractor	4-Wheel 2-Axle Tractor	Self Propelled Machine
Bangladesh	BD: 100%, DT: 90% WD: 95%, TPR: 99% BCS+TPR: 99% SPK: 100% FR: 95%, HR: 95% CL: 90%, DR: 99%	LP: 20% LL: 20% PL: 20% TH: 30% TR: 20%	IRE: 90%; WD: 5% TH: 70 % CL: 10% CS: 95% DR: 1%	IRM: 10%	DT: 10% LP:60% LL: 60% TR: 56%	LP: 20 % TR: 20% HRR(pto): 4%	HRC: 1%
Cambodia	BCS+TPR: 99% WD: 90%; FR: 100% SPK: 70% HR: 35%; DR: 90%	LP: 20% LL: 20% TR: 20%	WD: 10 %; SPP: 30%; TH: 35 % PR: 100 % DR: 10%		LL: 70% LP: 35% TR: 50%	LL: 10% LP: 45% TR: 40%	HRC: 65%
China **60% mech. for LP, CE & HR**	CE: 51% HR: 52%	LP:24%	IRE:41%	IRM: 55%	LPW: 95% (Rice) LP: 76% All Crops CE: 49%All Crops		HRC: 93% Wh HRC: 81% Rice HRC: 52% Corn
India **40-45% mech. for LP, CE & HR**	BD: 20%; BCS: 20% (Rice) TPR: 60-70%: SP: 10%; SPK: 85% HR: 35-40% TR: 10%	LP: 20 % SW: 20% TH: 10% TR: 30%	IR: 35-40% TH: 15% SPP: 5%	IR: 45-50% TH: 10%	L P: 20% SW: 10% WD: 10% TH: 5%	LP: 60 % SW: 50% WD: 30% HRR: 20% TH: 20% TR: 60%	HRC: 35-50%

Rep. Korea 94% Mech.(Rice) 64% Mech. For Other Crops					For Rice: LL: 99%; LP: 99%; LPD: 99%; SPP: 96%		HRC: 99% (Rice)
Malaysia	BD: 50%; BCS: 90% (Rice) WD: 70%; SPK: 10%	N/A	IR: 80% BC: 80% SPP: 90%	IR: 20%	LL: 10% LP: 10%	LL: 90% LP: 90% TPR: 10% BD: 50%	HRC: 100% Rice
Nepal: Mech: 23%, Animal: 41%, Human: 36%	LP: 5%; SW: 100% FR:100%; WD: 100% HR:95%; CL: 100% TPR: 100%; TR: 50%	LP: 30% TH: 10% TR: 25%	N/A	N/A	LP: 65% TH: 90% TR: 25%		
Pakistan	DT: 10%; BD: 50% BCS: 70%; TPR: 80% WD: 40%; SPK: 50% BCF: 75%; CR: 15% HR: 30%; CL: 15% CS: 5%; DR: 80% DT: 30%; GM: 60% LP: 5%; SPK: 50% THR: 20%;	BD: 10% WD: 5% DT: 5% IR: 5% LL: 20% LP: 20% THR: 10% THW: 5% TR: 10%	IRE: 60% SPP: 10% WD: 5% CL: 5% CR: 10% CS: 10% GM: 5% PR: 30% THW: 5%	IRM: 35% CL: 80% CR: 75% CS: 5% DR: 20% GM: 5% PR: 60% THW: 5%	For 4W Tractors only LL: 80%; BD: 40%; DT:65%; GM: 30%; LP: 75%; SPP: 50% BCF: 25%; BCF: 30%; WD: 50% IR: 5%; CS: 80%; HRR: 30% THW: 85%; THR: 70% TR: 85%; TR: 5% (2W Tractor)		HRC: 40%
Philippines	BD: 100%; DT:100% CE: 95%; BCF: 95% SPK: 97%; WD: 95% HR: 85%; CS: 30% TPR: 95%	LL: 20% Rice LP: 20% Rice LL: 50% Corn LP: 50% Corn	IRE+IRM: 95% TH: 93% CS: 70% DR: 98%		LL: 80% Rice LP: 80% Rice WD: 5% LL: 20% Corn LP: 15% Corn HRR: 5%	LL: 30% LP: 35% Corn SPP: 3% HRR: 5%	HRC: 4% Rice
Russia	Mainly in Green Houses	Rarely used	IR: 10%	IR: 80% DR: 100%	Mainly in Green Houses	GM: 80% LP: 100% CE: 100% DT: 10% SPP: 65% IR: 10% HRR: 65% TR: 20%	GM: 20% DT: 90% HRC: 100% SPP: 35% TR: 80%
Sri Lanka:	BD: 100%; DT:100% CE: 100% BCF: 80%; SPK: 80% HR: 15% Rice HR: 100% Maize	LL: 2% LP: 2%	IR: 60% SPP: 20% WD: 10%	IR: 30% PR: % SP: %	LL: 70% LP: 70% IR: 10 % HR: 10 %	LL: 28% LP: 28% HR:5 % CS(pto): 75%	HRC: 70% Rice RP: 10%
Thailand	CE: 10%; WD: 80%; TPR: 20%; BC: 80% SPK: 30%; CC: 50%	Rarely used	IR: 40% TH: 50% PR: 5% SPP: 40%	IR: 10% PR: 95%	LPW: 80% LPD: 10% CE 20:% CC: 10% IR: 50%	LPW: 20 % LPD: 90% TH: 30% CE: 70% CC: 20%	HRC: 90% Rice HRC: 10% Corn HRC: 30

	FR: 50%				SPP: 20%	FR: 50% SPP: 10%	Sugarcane
Vietnam	BD: 20%; WD: 90% DT: 60%; SPK: 90% SPK: 60%; HR: 50%	LP: 10%	IR:20% SPP: 30% PR: 10%	IR: 70% PR: 90%	BD: 80% (2WT+4WT) SP: 10% (2WT+4WT)		
			TH: 100% (Engines+ Electric Motors)		LP: 63% DT: 20% HR: 10%	LP: 27% DT: 30% SPP: 10 %	

Source: Data provided by country representatives to CSAM

Key to Abbreviations

BC	Broadcasting	BCS	Broadcasting Seed
BCF	Broadcasting Fertilizer (Dust & Granules)	BD	Bund Making
CC	Crop Care	CE	Crop Establishment
CL	Cleaning (Winnowing)	CR	Crushing
CS	Corn (Maize) Shelling	DR	Drying
DT	Ditch Making	FR	Fertilizing
GM	Grass Mowing	HR	Harvesting
HRC	Harvesting (Combine)	HRR	Harvesting (Reaper)
IR	Irrigation	IRE	Irrigation (Engine)
IRM	Irrigation (Electric Motor)	LL	Land Leveling
LP	Land Preparation	LPD	Land Preparation (Dry)
LPW	Land Preparation (Wet)	PL	Planting
PR	Processing (Milling)	SP	Spraying
SPK	Spraying (Knapsack, Manual)	SPP	Spraying (Power)
SW	Sowing	TH	Threshing
THW	Threshing Wheat (Barley)	THR	Threshing Rice
TP	Transplanting	TPR	Transplanting Rice
TR	Transport	WD	Weeding
N/A	Not Available		

2.5 COMMON CUSTOM HIRE SERVICES

Initially the ownership of machinery was with big farms/farmers, and they provided very little custom hire services. With shortage of labor, many medium farmers owned machines for their own work and custom hired these machines to other farmers. Now in most countries, custom hire services are being provided by the entrepreneurs, both farmers and non-farmers. The size

of machines owned by service providers is relatively larger compared to those owned by farmers for their own work. Many enterprises providing custom hire services own multiple sets of various machines, and some enterprises provide services at far away distances from their home base. In China, Combine Service Enterprises (CSEs) in 2011 were operating in 12 provinces (Yang et al, 2013). They shifted from Chinese Futian combines to more reliable Japanese Kubota combines. CSEs have evolved in small co-operatives of 5-10 CSEs for maintenance and coordination. Combines are up to 8 months away from home. In India, combine services providers travel up to 600 km over a period of 2 months to harvest mainly wheat crop. Under a Sub-Mission on Agricultural Mechanization, the Government of India is promoting "Custom Hiring Centers including hubs for hi-tech & high value farm equipment" to offset the adverse economies of scale arising due to small landholding and high cost of individual ownership (MOA, 2014).

Common custom hire services provided by farmers, entrepreneurs and service enterprises to farmers not owning some equipment are as below:

Transportation: 4WT and 2WT trailer: all countries; Animal cart: Nepal, Cambodia, Laos

Milling: Engine and motor: all countries

Water pumping: Engine, motor, 2WT pump: most countries

Threshing (Wheat): 4WT thresher: India, China, Pakistan, Nepal

Threshing (Rice): 4WT and 2WT thresher: most countries; Diesel engines: Thailand

Harvesting (Wheat): Combine harvester: China, India, Pakistan

Harvesting (Rice): Combine harvester: China, Malaysia, India, Thailand, Sri Lanka

Tillage (Dry): 4WT: most countries

Tillage (Wet): 2WT: most countries

Land leveling: 4WT laser leveler: India, Pakistan, Cambodia

Seeding: 4WT seed drill: China, India, Pakistan, Thailand

Transplanting (Rice): China, India

Maize shelling: India, Bangladesh, Philippines

Harvesting (Sugarcane): Thailand, India

3. CHALLENGES

3.1 SMALL LAND HOLDINGS

About 90% of the world's more than 500 million small farms (<2ha) are in the Asia-Pacific region. The average size of land holdings in Asia is only about 1 ha. Average size of holdings for the countries in the Asia-Pacific region are: Bangladesh: 0.5 ha; China: 0.54 ha; India: 1.2 ha; and Nepal: 0.7 ha. In most countries, even these small holdings are made up of a number of small plots scattered in different locations. Many of these plots have limited access to relatively large size farm machines like combine harvesters and even tractors. Due to small size of land holdings, majority of the farmers have low investment capacity and cannot afford to buy even small machines like 2-wheel tractors or power tillers. Due to shortage of labour, such farmers rent equipment on hire from service providers. Consolidating the holding of a farmer at one or two places will increase the size of operational plot. It will be easier to use a relatively big equipment at reduces cost of operation.

3.2 LIMITED MANUFACTURING CAPACITY

Due to increased incomes, food habits are changing and the agricultural production systems are changing to meet those demands. During the 1970s, cereals constituted 40% of agricultural production in monetary terms and by 2010 contribution of cereals reduced to 25%. During the same period the share of fruits and vegetables and livestock production increased from 18% and 15%, respectively in 1970 to 27% and 28%, respectively by 2010. As income from growing grain crops is very limited for their survival and sustainability, small holder farmers are diversifying into labor intensive, but more profitable activities like production of fruits and vegetables, fish and livestock. The produce being perishable (milk, meat, fruits, vegetables, fish, etc.) makes these farm activities highly risky. So far there has been very limited mechanization of production and post-production activities related to production of fruits and vegetables and livestock and fish. There is a need to provide mechanization services for production and post-production activities, and reliable post harvest handling, processing and marketing infrastructure and services to ensure reasonable returns to farmers.

Only a few countries in Asia and the Pacific like Japan, China, India and Korea have well developed industry for the manufacture of agricultural equipment, and these countries are also exporters of equipment. Pakistan, Thailand, Vietnam and Indonesia also have agricultural equipment manufacturing industries. However, these countries import certain critical components from other countries. Countries like Bangladesh, Sri Lanka, and the Philippines import prime movers like tractors, engines and motors and farm implements, and equipment like plows, harrows, seed drills, sprayers, threshers, irrigation pumps and milling machines are produced locally. A few countries like Nepal, Cambodia, Laos, Fiji, PNG and Mongolia have very limited manufacturing industry and import most of their farm equipment.

Although, Malaysia has a well developed industry but due to limited demand it imports most of the farm equipment.

Manufacturers who are exporting their products to developed countries maintain high quality of products. However, keeping the limited purchasing power of farmers in mind, many of the equipment manufacturers produce products of relatively poor quality to keep the cost low. Poor quality equipment do produce poor quality work, due to improper match between power source (engine size) and the equipment size and use of such equipment may result in injuries and fatal accidents.

3.3 SHORTAGE OF POWER AND FUEL

Most countries in the region face shortage of power due to which there are frequent shut downs. Many days the industrial workers sit idle for long hours in factories for non availability of power. This reduces productivity of workers and increases the cost of manufactured items. Many times, interrupted power supply also affects the quality of product. Small- and medium-sized enterprises (SMEs) cannot afford to put up a power generation plant. However, some big industries have put up power generation plants using fossil fuels, but many of these industries face shortage of fuel. Due to expensive fuel, the electricity generated is also more expensive which in turn increases the cost of items manufactured. Shortage of power also affects the crops as certain operations like irrigation if not done at the most appropriate time would result in reduced yields. As petroleum fuel is mainly available in cities and towns and on main roads, the owners of farm machines have to travel quite a distance to get it which also adds to cost. Many times fuel is also in short supply or not available for a period of time. Reliable supply of electricity to industries is essential to produce quality products at reasonable cost.

3.4 NEED FOR INSTITUTIONAL FRAMEWORK AT REGIONAL LEVEL

The Asia-Pacific region is emerging as a leading global player in the manufacture and use of mechanization inputs. The challenge is how to incentivize manufacturers to R&D and produce quality machinery at affordable cost. Like in North America and Europe, the academic and research institutions should work in close collaboration with the private sector. South-South collaboration in R&D to achieve economies of scale through regulatory framework for patenting and licensing of technologies at regional level should be encouraged. A large manufacturing base in the region and trade in mechanization technologies requires a regional mechanism for standards and testing of these technologies. The Asian and Pacific Network for Testing of Agricultural Machinery (ANTAM) offers this opportunity by supporting establishment of testing centers and harmonization of testing protocols across the region to facilitate trade in mechanization technologies regionally and globally.

4. POLICIES AND INSTITUTIONS

4.1 CURRENT POLICIES

Policy support is critical to agricultural mechanization. Major change in current practices will be required, not only in agricultural but industrial and trade policies which will require close coordination among various ministries of the governments (Ministries of Agriculture, Trade and Industry, Finance and Planning). Public sector initiatives are usually multi-sectoral, but poorly coordinated.

Some countries have policies and programs to support mechanization while a few countries have no specific policy related to agricultural mechanization. China has enacted a Law on Promotion of Agricultural Mechanization with a view to encourage and support peasants and agricultural and operation organizations to use advanced and applicable agricultural machines, to promote mechanization of agriculture and develop modern agriculture. India has launched a Sub-Mission on Agricultural Mechanization (SMAM) to promote farm mechanization and empower small and marginal farmers with knowledge, better access and expanded opportunities in farm mechanization. Malaysia has adopted the National Agro-food Policy (NAP) 2011-2020 and the National Farm Mechanization and Automation Plan (NFMAP) to determine the direction, setting the targets for the adoption of mechanization and automation technology in agriculture. In Indonesia, the appropriate strategy established for promoting agricultural mechanization development is based on selective, progressive and participatory approach. Agricultural Mechanization Promotion Policy of Nepal adopted in 2014 is based on demand and was developed during rigorous consultation with all stakeholders at all levels. Cambodia developed Strategic Plan for Agricultural Mechanization in 2011 to enable farmers' access to mechanization and required skill development. The Republic of Korea enacted a specific law in 1978 to promote agricultural mechanization (Agricultural Machinery Promotion Law). The law contains almost all details for agricultural machinery. The core of the law on testing of agricultural machinery state that some particular machines (44 types) must be tested by the national testing code in order to be sold and used in the country. The Philippines has recently enacted the Agricultural and Fishery Mechanization Law, Republic Act 10601, which defines the roles of the Agriculture and Fishery Mechanization Council (AFMeC), the DA Agricultural and Fishery Engineering Groups, and the Bureau of Agricultural and Fisheries Engineering (BAFE). The Russian Government issued a decree in 2012 about approval of rules for granting subsidies to producers of agricultural machinery. Subsidies are provided to the manufacturers in the amount of 15 percent of the price of agricultural machinery. In 2008, the Vietnamese government passed a resolution pertaining to agricultural mechanization by 2020: building the agriculture sector towards modernization and industrialization and development of services in rural areas, and enhancing research, transfer

and application of science, technology, human resource training, making breakthrough to agricultural mechanization and rural industrialization.

At present Bangladesh, Pakistan, Sri Lanka, Thailand and Papua New Guinea have no policy on agricultural mechanization.

4.2 SUBSIDIES, CREDIT AND TAXATION

Subsidies, credit, taxation, import duties, tax on industry or support to industry vary from country to country. China supports the development of major technical equipment by exempting from customs duties and import VAT. China provides significant subsidy for the purchase of agricultural machinery. During 2004 to 2013, the Central government allocated a sum of RMB 96.4 billion (US$ 12 billion) to agricultural machinery purchase subsidy. For a more than 100 horsepower tractor, or a high-performance green fodder harvester, or a large no-till planter and a large combine harvester, subsidies could be up to RMB 150,000 (US$ 18,000); for a more than 200 horsepower tractor and a sugarcane harvester, it could be up to RMB 200,000 (US$ 24,000), and for a large cotton picking machine, it could be up to RMB 300,000 (US$ 36,000). The Government of India under Sub-Mission on Agricultural Mechanization (SMAM) provides subsidy of 25-40% to small and marginal farmers for the procurement of farm machines. To establish a High-Tech Productive Equipment Hub for Custom Hiring, the Government provides an assistance of 40% of the project cost. To establish Farm Machinery Banks with minimum eight farmers, the Government provides up to 80% financial assistance (with a maximum of Rs 1 million, about US$ 16,000). Bangladesh provides a 25% subsidy for procurement of farm equipment. The Russian Government provides subsidy to the manufacturers in the amount of 15% of the price of agricultural machinery.

Many countries like Pakistan provide incentives to farming communities in terms of credit on low interest rates, and provision of subsidy on agricultural machinery. Many countries like Sri Lanka, Bangladesh, Nepal, Thailand and Cambodia allow duty free imports of farm machinery, but in Papua New Guinea customs apply 10% excise duty across the board for all agricultural tractors.

4.3 RESEARCH AND DEVELOPMENT, EDUCATION AND TRAINING AND EXTENSION

Research and development, education and training in most countries are undertaken by government departments and institutions and universities mainly agricultural universities. Some multinationals and a few big national industries also conduct these activities.

In China, the Department of Agricultural Mechanization of the Ministry of Agriculture looks after all activities related to mechanization. The government supports the scientific research institutions, colleges and universities in scientific and technological research in agricultural mechanization, based on the different conditions of agricultural production

and different needs of peasants. It supports the efforts to combine scientific research and teaching of agricultural machinery with their manufacturing and the promotion of their wide use to ensure that agricultural machinery will be geared to the needs of the technological development of agricultural production. The Chinese Academy of Agricultural Mechanization Sciences (CAAMS) has strong capabilities in agricultural machinery, agro-product processing and packaging industry. China has 75 institutions related to education in agricultural engineering with 7,000 faculty members. The leading institutions include: China Agricultural University (CAU), South China Agricultural University, Zhejiang University, Harbin Institute of Technology, Nanjing University, Tianjin University and others. China has 33 agricultural mechanization extension institutions at or above provincial level.

In India, R&D activities are mainly conducted by the Indian Council of Agricultural Research (ICAR), State Agricultural Universities (37) and central universities and institutions (7). Education and training with regards to machinery are being carried out by four Farm Machinery Testing and Training Institutes FMTTI) established by the Government of India in four different regions of country. Apart from these, 29 farm machinery testing centres have been established in different states, mainly at state agricultural universities. Two main institutes of ICAR dedicated to agricultural engineering research are: Central Institute of Agricultural Engineering (CIAE) and Central Institute for Post-Harvest Engineering and Technology (CIPHET). There are about 45 institutions offering degree programs in agricultural engineering, and majority of these also offer masters degree and about 10 of these offer Ph.D. degree programs. Leading agricultural engineering educational institutes include: Indian Institute of Technology Kharagpur, Tamil Nadu Agricultural University, G B Pant University of Agriculture & Technology Pantnagar, Punjab Agricultural University, M P University of Agriculture & Technology Udaipur, Indian Agricultural Research Institute (IARI) and others.

In Republic of Korea, the government agency Rural Development Administration (RDA) is responsible for all agricultural machinery affairs (domestic or international) with collaboration of the Agricultural Technology Commercialization and Transfer (FACT) on projects. Seoul National University and other universities also contribute to research and development, education and training activities. In Malaysia, the R&D activities are mainly conducted by the Malaysian Agricultural Research and Development Institute (MARDI) and the University Putra Malaysia (UPM), and extension and training activities are mainly undertaken by the Department of Agriculture.

In Bangladesh, farm machinery departments of Bangladesh Agricultural Research Institute (BARI), Bangladesh Rice Research Institute (BRRI) and Bangladesh Agricultural University are major contributors in R&D while the Department of Agricultural Extension (DAE) provides extension services on agricultural machinery to the farmers. In Cambodia, under the Ministry of Agriculture, Forestry and Fisheries (MAFF), three institutions are working on activities related to agricultural mechanization: Department of Agricultural Engineering (DAEng), Cambodian Agricultural Research and Development Institute (CARDI), and Royal University of Agriculture (RUA). The Indonesian Center for Agricultural Engineering Research and Development

(ICAERD), Bogor Agricultural University and Gajdamada University are main institutions involved in R&D activities in Indonesia. In Pakistan, Agricultural & Biological Engineering Institute (ABEI) under Pakistan Agricultural Research Council (PARC), Agricultural Mechanization Research Institute (AMRI), and Agricultural Mechanization Research Cell (AMRC) are solely engaged in farm machinery research and development work. The Centre for Agricultural Machinery Industries and Agricultural Light Engineering Program is engaged in farm mechanization promotion activities in provinces. For the promotion of agricultural mechanization, five universities are awarding degrees in agricultural engineering and four institutes are awarding diploma in farm machinery.

In the Philippines, Agricultural Mechanization Development Program (AMDP) based at the University of the Philippines Los Baños, Agricultural Inter-Agency Committee AMIC, the Philippine Center for Postharvest Development and Mechanization, Agricultural Machinery Testing and Evaluation Center (AMTEC) and Philippine Rice Research Institute, are responsible for agricultural mechanization activities. The University of the Philippines Los Baños, Central Luzon State University, Central Mindanao State University and other universities are providing agricultural engineering education and training and involved in R&D activities. The Bureau of Agricultural and Fisheries Engineering (BAFE) under the Department of Agriculture (DA) is responsible for activities related to mechanization at national level. In Sri Lanka, R&D and training activities are conducted by the Farm Mechanization Research Centre and Institute of Post-Harvest Technology. The University of Peradeniya offers educational programs in agricultural engineering.

In Thailand, R&D and training and extension activities are undertaken by institutes and universities. These include: Agricultural Engineering Research Institute (AERI), Department of Agriculture (DOA); Agricultural Engineering Extension Division (AEED), Department of Agricultural Extension (DOAE); agricultural machinery manufacturers; and departments of agricultural engineering at Kasetsart, Khon Kaen, Chiang Mai and other universities. In Vietnam, R&D and training and extension activities are undertaken by the Vietnam Institute of Agricultural Engineering and Post Harvest Technology (VIEEP).

In Russia, R&D activities are the responsibility of the Russian Research Institute for Certification, Russian Scientific Research Institute of Standardization and Certification in Engineering and the Federal Agency on Technical Regulation and Metrology. Trainings are provided by the educational autonomous non-profit organization "Register of Personnel Certification".

5. NATIONAL DATA REQUIREMENT FOR A REGIONAL DATABASE OF AGRICULTURAL MECHANIZATION IN ASIA AND THE PACIFIC

For sound planning of mechanization it is necessary to have a sound database. The types of data needed are given below.

5.1 GENERAL INFORMATION

Geography- Location, Area, Land Use Classification

Population- Total, Rural and Urban

GDP- Total, Agriculture, Industry and Services, Per Capita Income (GDP)

Labor Force- Total, Agriculture, Industry and Services

Literacy – Urban, Rural

Life Expectancy

5.2 NATURAL RESOURCES

Agro-ecological Zones/Regions

Area under Different Soils Groups/Types

Land Holdings-Number, Percentage and Average under Class Sizes

Area under Different Crops, Yields and Production

Available Water- Rainfall, Ground Water, Rivers, Lakes, Ponds

5.3 AGRICULTURAL INPUTS

Source-wise and Crop-wise Irrigated Area, Drip Irrigation

Consumption of Fertilizers – Crop-wise per ha

Consumption of Pesticides – Crop-wise per ha

Institutional Credit, Subsidies

5.4 POWER SOURCES

Agricultural Workers- Total, Gender-wise. Owner Cultivators and Hired Workers

Draft Animals

4-Wheel Tractors by Size (hp)

Power Tillers by Size (hp)

Diesel and Petrol Engines by Size (hp)

Electric Motors by Size (hp)

5.5 TOOLS, IMPLEMENTS AND MACHINES

Hand Tools

Animal-drawn Implements

Stationary Machines- Pumps and Tube wells, Threshers, Corn Sheller, etc.

Sprayers – Manual and Power-operated

Tractor-drawn Equipment – Ploughs, Harrows, Tillers/Cultivators, Rotary Tillers, Seed-Fertilizer Drills, Weeders, Reapers, Binders, Combines, Laser Leveler, etc.

Power Tiller-drawn Equipment

Self Propelled Machines – Rice Transplanters, Weeders, Reapers, Combine Harvesters, etc.

5.6 POST-HARVEST AND PROCESSING EQUIPMENT

Cleaners, Graders, Dryers

Grain Storage Structures

Cold Storage

Milling Machines for Grains, Pulses

Processing Machines for Fruits and Vegetables

Processing Units/Plants

5.7 RENEWAL ENERGY SOURCES

Agriculture-based Biomass, Biogas

Biofuels- Sugarcane, Jatropha

Solar Energy –Dryers, Photo-voltaic for Pumps, Electricity

Wind Energy – Wind Mills for Water Pumps, Electricity

5.8 LEVEL OF MECHANIZATION

Availability of Custom Hire Services – Operations and Crops

For Major Crops – Degree/Level of Mechanization Operation-wise

Overall Level of Mechanization- kW/ha, Level of Mechanization for Major Operations

5.9 SUPPLY OF EQUIPMENT AND MACHINES

Local Manufacture of Equipment and Machines

Imported Equipment and Machines

Export of Equipment and Machines

5.10 STANDARDS AND TESTING

Education, Training and Extension

Agricultural Engineering-related Institutions (Degree and Diploma)

Skill Training Institutions

Extension Programs

5.11 FUTURE NEEDS OF MECHANIZATION

Operations (Cropwise) Needing Mechanization Now

Operations (Cropwise) Needing Mechanization in Next 5-10 Years

Resources needed - Technology, Human Resource and Finance (Credit/Subsidy)

6. GENERAL FINDINGS AND RECOMMENDATIONS FOR THE ASIA-PACIFIC REGION

The region has made great progress over the past six decades in transforming farm power situation from over 90% from animate sources in 1960s to over 60% from mechanical sources by 2013 in many countries. Four main types of mechanical power sources are becoming popular: i) two wheel-single axle tractors for wet tillage, transportation, water pumping and threshing; ii) four wheel-two axle tractors for dry tillage, transportation, planting and seeding, inter-culture, spraying, harvesting and threshing; iii) electrical motors and diesel engines for irrigation pump sets and many post harvest processing operations; and iv) self propelled machines like combine harvesters for grain harvesting, trans-planters for rice and vegetable crops, fodder harvesters and sugarcane harvesters. The use of draft animals is likely to be insignificant by 2030 in the region. While animal draft power is indigenous to a country and animal drawn implements are also locally produced, many countries in the region have limited manufacturing facilities for producing mechanical power sources and associated equipment. The removal of non-tariff barriers to trade in the region will contribute significantly to the reduction of cost of machines to farmers.

In case of imported equipment, major problems are insufficient after sales and extension services. The operators are not adequately trained and there are limited trained technicians to repair the imported machines. Imported machines are normally supplied with selected spare parts based on the experience in the country of origin. However, the breakdowns are related to operator skills, care and maintenance, field and environmental conditions which may not be the same in importing and exporting countries. If the machine breaks down during the working season and the required spare part is not available, the machine sits idle and farm work suffers resulting in significant loss. The country which imports machines from outside must make sure that there is a good dealership network providing necessary after sales and extension services. This also applies to remote areas (like islands) for the machines produced within the country.

Present level of mechanization and crop yields in many countries are quite low. There is labor shortage during peak periods and available agricultural labor is getting older and proportion of female labor is increasing. More labor saving and ergonomically appropriate equipment are required to facilitate the work of women and elderly agricultural workers.

In all developing countries, the percentage of labor in agriculture is very high compared to contribution of agriculture sector to GDP, resulting in relatively very low incomes of farmers and other agricultural workers. Mechanization helps in increasing yields by timely conduct of operations, efficient placement and application of inputs (seeds, fertilizers, pesticides and water) and decreasing drudgery. Governments should have policies to

promote mechanization for growth in agriculture, improved incomes of agricultural workers and food security.

Land holdings in many countries are small and fragmented. Consolidation of fragmented holdings helps in organizing resources and inputs more efficiently and provides easier access to farm machines even on small holdings. Governments should have policies to consolidate fragmented holdings.

The Asia and the Pacific has the largest area under irrigation, and the use of electric and diesel pump-sets has increased significantly, and will continue to increase. Due to increased demand for water from other sectors of economy, availability of water for agriculture is expected to decline. There is an urgent need to provide technical and financial support for development of irrigation infrastructure and R&D efforts particularly for controlled irrigation systems to improve water use efficiency and fertilizer use efficiency in irrigated agriculture.

Mechanization technologies were first adopted by the large farmers followed by medium scale farmers. Ownership of many farm machines is not economical for farmers if these machines are utilized only on their own holdings. The large numbers of owner farmers are the ones who are able to provide mechanization and other services to the more numerous small holder farmers. Increased and improved efficiency of utilization of machines available with farmers through custom hiring to neighbor farmers and or through larger operational holdings makes ownership of machines economical and profitable. In some countries, the availability of credit at subsidized rates has been catalytic to the rate at which farmers – especially the small and medium scale ones – are able to procure agricultural machinery and implements. In addition, assured support prices for the farmers' produce, as well as the availability of off and on farm custom hire possibilities where agricultural machinery could be used, further enhance the profitability of acquiring agricultural mechanization inputs by farmers. Even a very small farmer or an entrepreneur with no land can have a profitable business as a custom hiring service provider. There is a need for favorable government policies to support these service providers by providing them financial support and training.

In many countries, the large numbers of owner farmers played a critical role in facilitating the creation of a viable agricultural machinery and implement distribution and services sector. The high level of effective demand for agricultural machinery and equipment led to the creation of a competitive and viable manufacturing industry such that Japan, Korea, China and India have become globally leading players in this sector including becoming exporters. There is a need for favorable government policies to expand the manufacturing sector in all countries. Items of high demand like simple tools, implements, sprayers, irrigation pumps, threshers, and etc. should be produced locally. Manufacturing processes need improvements to produce quality machines with improved safety standards. There is need to develop and / or adopt low energy consumption machines and practices like no-till drills / planters and conservation agriculture.

Governments in many countries are providing support services for research and development; testing and standards; and for human resources development in support of agricultural mechanization. The agricultural engineering programs established in universities have been instrumental for the success of agricultural mechanization in these countries. A new breed of experts is required to implement new emerging technologies for sustainable agricultural mechanization. This requires strengthening of both public and private sectors institutions. There is need to revise curricula of colleges and universities to introduce new concepts like conservation agriculture (CA), precision farming, etc. Trainings of operators, farmers and technicians are necessary for successful implementation of new emerging technologies for sustainable agricultural mechanization. There is a need for favorable government policies to expand these support services to meet the needs of mechanization. In some cases regional training programs may offer economies of scale which may be organized with assistance from CSAM.

Business and enterprise friendly policies, laws, and regulations as well as physical and institutional infrastructures which encourage commercial activities and entrepreneurship in farming, input supply, produce handling, processing and marketing as well as in manufacturing have been and remain, the key factors to success of agricultural mechanization in most countries.

In recent years, efforts related to agricultural mechanization at regional and international level have increased. The Center for Sustainable Agricultural Mechanization (CSAM) and the establishment of the Asia - Pacific Network for Testing Agricultural Machinery (ANTAM) under the auspicious of CSAM should play major roles in facilitating regional cooperation in policy assistance, information sharing, collaborative R&D, harmonization of standards and testing procedures, capacity building, technology transfer, trade facilitation and investment.

REFERENCES

Binswanger, H. P. 1978. The Economics of Tractors in South Asia: An Analytical Review. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India and ADC, New York, USA.

Binswanger, H.P. 1986. Agricultural Mechanization: A comparative historical perspective. World Bank Research Observer, 1(1): 27–56.

Briones R. and J. Felipe 2013. Agriculture and Structural Transformation in Developing Asia: Review and Outlook, ADB Manila.

CSAM Country Reports 2014. Country Reports from Asia Pacific Countries on Current Status of Agricultural Mechanization as presented to the CSAM/ANTAM consultations of 2014.

FAO 2014. The State of Food Insecurity in the World 2014. Food and Agriculture Organization of the United Nations.

FAOSTAT 2014. Statistical Database. Food and Agriculture Organization. Available on line at http://faostat3.fao.org/faostat-gateway/go/to/home/EAccessed December 2014.

Kienzle, J.; J.E. Ashburner and B.G. Sims 2013. Mechanization for Rural Development: A Review of Patterns and Progress from Around the World. Integrated Crop Management. Vol. 20-2013. FAO. ISSN 1020-4555.

Mrema, G.C. and R.S. Rolle 2003. Status of the Post-Harvest Sector and its Contribution to Agricultural Development and Economic Growth in Value-Addition to Agricultural Products edited by Y. Mori, T. Hayashi and E. Highley published by JIRCAS, March 2003, Tokyo Japan, pp. 13-20.

MOA 2014. Sub Mission of Agricultural Mission Guidelines. Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India. http://farmech.gov.in/SMAM/Guidelines%20of%20SMAM1.pdf as cited on 27.8.2014.

OECD-FAO 2012. OECD-FAO Agricultural Outlook 2012. OECD Publishing, Paris.

OECD-FAO 2013. OECD-FAO Agricultural Outlook 2013. OECD Publishing, Paris.

Raj, K.N. 1973. Mechanization of Agriculture in India and Sri Lanka (Ceylon). International Labor Office, Geneva.

Renpu, B. 2014. Analysis of Trends of Agricultural Mechanization Development in Peoples Republic of China. 2000 – 2020. CSAM – Policy Brief, January, 2014.

Singh, G. and W.J. Chancellor 1975. Relation between Farm Mechanization and Crop Yield for a Farming District in India. Transactions of the American Society of Agricultural Engineers, Vol. 17(5): 808-813.

Singh, G. 2001. Relationship between Mechanization and Agricultural Productivity in Various Parts of India. In Agricultural Mechanization in Asia, Africa and Latin America, 32(2): 68-76.

Singh, G. 2013. Agricultural Mechanization in India. In: Mechanization For Rural Development: A Review of Patterns and Progress From Around the World- J. Kienzle, J.E. Ashburner, and B.G. Sims, eds. Integrated Crop Management Vol. 20-2013.FAO. ISSN 1020-4555.

Soni, P. 2014. “Key Issues that Shape Agricultural Mechanization Systems in Asia and the Pacific Region”. Presented at High-Level Multi-Stakeholder Consultations on Sustainable Agricultural Mechanization in Asia and the Pacific Region, 26-27 June 2014, Bangkok, Thailand.

UNESCAP 2014. Statistical Yearbook for Asia and the Pacific 2014. December 2014, Bangkok. http://www.unescap.org/resources/statistical.

Wang, M. 2013. China: Development of Farm Mechanization and the Agricultural Machinery Industry. In: Mechanization For Rural Development: A Review of Patterns and Progress From Around the World- J. Kienzle, J.E. Ashburner, and B.G. Sims, eds. Integrated Crop Management Vol. 20-2013. FAO. ISSN 1020-4555.

World Bank 2008. World Development Report 2008.

World Bank 2012. Agricultural Innovation Systems: An Investment Sourcebook. Washington, DC: World Bank.

World Bank 2013. Development Indicators. http://data.worldbank.org/indicator.

World Bank 2014. Development Indicators. http://data.worldbank.org/indicator.

Yang, J., Z. Huang, X. Zhang and T. Reardon 2013. The Rapid Rise of Cross-Regional Agricultural Mechanization Services in China. American Journal of Agricultural Economics (Paper and Proceedings), pp 1-7.

II. Agricultural Machinery Testing in the Asia-pacific Region

Contributed by Dr. Chan Chee Wan

1. INTRODUCTION

1.1 AGRICULTURAL MECHANIZATION IN THE ASIA-PACIFIC REGION

Majority of the Asia-Pacific region's poor depends on agriculture for its livelihood. The high food prices have affected many people in the region. Agricultural mechanization plays an increasingly important role in ensuring the sustainability of food security and reducing rural poverty. The annually declining total farm labour force coupled with increase of global population exacerbates the demand for food and fibre. A holistic Asia-Pacific approach in addressing agricultural production with mechanization is needed. In the globalised economy, it is also imperative for countries in the Asia-Pacific region to enhance environmentally friendly mechanization and automation processes to sustain productivity and competitiveness of agriculture and agro-based industry.

However, there is a large variation in the level of agricultural mechanization in the region, which is also lagging behind many developed countries. Generally, the level of agricultural mechanization in the Asia-Pacific region is still at a very basic stage (Soni and Au, 2010). Though mechanization has helped farmers in increasing crop yields and saving labour, over-investment in farm mechanization combined with machinery underutilization are causing the debt burden of some farmers. Besides, farm productivity gains have also not matched up to increases in the prices of production inputs. Various measures to further reduce the labour requirement in agriculture and increase the labour productivity are needed.

Addressing the labour productivity issue alone is not enough under the current competitive environment as consumers often demand for quality and safe farm produce while appealing for protection of the environment. The application of inappropriate mechanization practices can lead to many negative environmental impacts. Sustainable agriculture mechanization requires considerations on crop environment, production strategy, operations, machinery and its supporting technologies and services. Crop environment typically encompasses weather, soil, water, plant pest and disease, nutrient, type of crop and crop structure. The production strategy includes typical, organic and precision farming, crop rotation, variety of seeds, cropping intensity and farm infrastructure. While field operations typically involve land preparation, seeding/planting, fertilizing, crop care, harvesting, post-harvest and transport. The type of farm machinery used includes mounted, trailed, self-propelled, soil engaging and non-soil engaging. Finally the supporting technologies and services, such as farm management, education and training, after sales service, maintenance, finance, operators, incentives, policy and certification, are essential.

Table 1 summarizes farm mechanization in selected Asia-Pacific countries (Soni and Au, 2010). Land preparation, threshing and harvesting

remain as the three main labour intensive operations requiring the use of agricultural machinery in many countries irrespective of the level of mechanization. Some of the Asia-Pacific countries such as Cambodia, Fiji, Indonesia, Sri Lanka, Nepal and Papua New Guinea are at a lower level of mechanization.

Table 1. Farm mechanization in selected Asia Pacific countries

Country	Land Preparation	Planting	Threshing	Harvesting	Overall	Machinery Produce	Categories	Level of mechanization
Bangladesh	80%	Low	Over 80%	Low	Low	Near nil	III	Low
Cambodia	Low	Low	Low	Low	<10%	Near nil	III	Low
China	60%	35%		30%	42%	Extensive	I	High
Fiji	-	-	-	-	-	-	-	-
India	30%	10%	60%	20%	25 - 30%	Extensive	I	High
Indonesia	Low	Low	Low	Low	Low	Near nil	III	Low
Nepal	-	Low	Low	9 units combine	Low	Near nil	III	Low
Philippines	13.20%	0.20%	69%	Low	-	Few	II	Middle
Sri Lanka	Low	Low	Low	Low	Low	Near nil	III	Low
Thailand	High	Medium	-	-	Medium	Middle	II	Middle
Vietnam	72% (rice)	20%	100%	-	-	Middle	II	Middle
Republic of Korea	High	High	High	High	>70%	Extensive	I	High

(Source: Soni and Au, 2010) Note: - = Not available

The current and future supply and demand for agricultural machinery will affect the scope and plan of machinery testing in the Asia-Pacific region. The global agricultural mechanization survey (Böttinger et al., 2013) studied the general development tendencies affecting the future demand for agricultural mechanization, most important staple crops, major drivers for mechanization of cropping systems, trade related to agricultural machinery and the impact of selected issues on the demand for agricultural mechanization for the Asia-Pacific region over the next 10-20 years. Three countries in the region, namely China, India and Japan, were surveyed with the following observations:

- Low impact of natural conditions (rainfall, temperature, climate change, land, water availability) on future demand for agricultural mechanization with varying direction. Water availability might be a crucial point in the future.

- Uncertain economic conditions (technical progress, economic welfare development, oil price, economic crisis, energy supply, international agricultural trade) with positive impacts on the agricultural machinery demand due to the technical progress, the economic welfare development and the internationalization of agricultural trade. The ongoing economic crisis will reduce the demand for mechanization in agriculture in the next ten years. Furthermore, the effects of oil price and energy supply differ between the countries and depend on the individual structure of demand and supply.

- Demographic factors (population growth, aging population in rural areas, change in diet, urbanization and quality requirements of conditions) influence the development stages of mechanization. The mechanization level in developing countries and emerging economies is relatively low and with a need for further mechanization. The latter will become more relevant if people move out of the agricultural labor. Developed countries are over mechanized where any labor force losses can be compensated rather swiftly. Population growth and quality requirements of consumers contribute to demand for mechanization while aging population in rural areas or urbanization affect the demand for agricultural mechanization negatively in the developed countries.

- Political factors (food security goals, education of farm operators, research, subsidies, farm structure development and biofuel production) provide the most positive signals for a rising demand for agricultural mechanization. They are government-based subject to special protection through supportive policies for achieving food security goals and developing rural areas. Subsidies to farmers can lead to higher earnings, lower risks and therefore to a higher willingness to invest in the sector. Bio-fuel production, supported by governments, can also lead to a rising demand for agro-commodities and higher outputs in agriculture. Research, education and efficient farm structures are also important determinants for the demand for agricultural mechanization.

This paper reports the status of agricultural machinery testing in the Asia-Pacific region based upon a review of available industry data for agricultural mechanization and a survey conducted by CSAM in 2014 targeting 14 ANTAM member countries, namely, Bangladesh, Cambodia, China, Fiji, India, Indonesia, Malaysia, Nepal, Pakistan, Philippines, Papua New Guinea, Sri Lanka, Thailand, and Viet Nam. The survey investigated questions related to: (i) agricultural machinery industry likely to affect the future demand for agricultural mechanization; (ii) market for agricultural machinery which could affect the setting up of standardized testing centres of agricultural machinery; (iii) the technological issues related to quality and efficiency, machinery safety and environmental aspect of agricultural machinery usage; (iv) the development of common testing procedures and safety standards; and (v) the status of testing centres, test facilities, human capacity, policy and their capabilities. A detailed survey form was prepared for the assessment of the 14 ANTAM member countries on their testing centres, testing facilities and capacity of agricultural machinery by CSAM. The

underlying assumption of this survey is that responses received to the survey questions would provide a clear and reliable indication of the 14 ANTAM member countries status of agricultural machinery testing.

1.2 AGRICULTURAL MACHINERY INDUSTRY

The level of agriculture mechanization is influenced by the level of economic development, agricultural infrastructure, purchasing capacity of farmers, level of agricultural machinery industry and demand. The variation of mechanization levels of agricultural machinery industries and their use across the Asia-Pacific region is wide. China and India have emerged as big players in agricultural machinery manufacturing of the region. The agricultural machinery industry in China has been developed rapidly. Consequently, China has become a major producer of agricultural machinery along with its rapid development of agriculture. There are about 8,000 agricultural machinery manufacturers in China (Soni and Au, 2010) with 1,578 large enterprises, including main machines' manufacturers as well as spare parts producers. In India, the number of agricultural machinery manufacturers has reached over 16,000. At the same time, there is almost no agricultural machinery industry in some Asian countries, such as Bangladesh, Cambodia, Laos, Nepal, Fiji and Papua New Guinea.

Table 2 summarizes machinery usage among the Asia-Pacific countries based on field operations and choice of prime mover. Two-wheel power tillers (2WT) of the 10 to 20 horsepower size remain the most popular type of machine used by almost all the Asia-Pacific countries surveyed for land levelling and land preparation except Fiji and Papua New Guinea. It is commonly being used for land levelling in Bangladesh, India, Malaysia, Philippines, Sri Lanka, Thailand and Vietnam. More than 70% of their usage are reported in Bangladesh, Philippines, Sri Lanka and Thailand. Meanwhile, the use of power tillers in land preparation is common among the Asia-Pacific countries except Fiji and Papua New Guinea. The use of 2WT ditching work is being reported in Vietnam.

Four wheel tractors are widely used among surveyed Asia-Pacific countries, except Fiji and Papua New Guinea, for land levelling, land preparation, ditching and bunding operations (Table 2). Meanwhile, the use of machines for transplanting/seed drill is reported in Bangladesh, China, India, Indonesia, Malaysia, Pakistan, Thailand and Vietnam. Crop care operation using powered knapsack sprayers and broadcaster is common among most Asia-Pacific countries except Fiji and Papua New Guinea. The use of mechanical harvester is being reported in Cambodia, China, India, Malaysia, Pakistan, Thailand, Vietnam and some in the Philippines.

The survey commissioned by the Centre for Sustainable Agricultural Mechanization (CSAM) in 2014 had indicated the importance of the following agricultural machinery used by most of the Asia-Pacific countries, namely, power tillers, 4-wheel tractors and powered sprayers/broadcasters.

Table 2. Farm machinery usage in selected Asia-Pacific countries

Country	Land Levelling (%)		Land Preparation (%)		Ditching (%)		Bunding (%)		Crop Establishment (%)		Crop Care (%)		Harvesting (%)	Drying (%)
	2w	4w	2w	4w	2w	4w	2w	4w	T/D	B	S	B	-	-
Bangladesh	80	20	60	20	10	0	0	0	1-2	1	95	85	m	m
Cambodia	-	-	73	73	-	-	-	-	m	m	30	30	70	5
China	-	-	74	74	-	-	-	-	H	-	H	H	44	-
Fiji	-	-	-	-	-	-	-	-	-	-	-	-	-	-
India	10	60	20	75	0	20	2	60	40	50	27	11	H	-
Indonesia	-	-	H	-	-	-	-	-	M	-	-	-	-	-
Malaysia	10	87	10	90	-	100	-	50	10	90	90	80	100	-
Nepal	-	-	24	24	-	-	-	-	-	-	15	15	-	-
Pakistan	-	10	1	90	-	90	-	90	89	10	50	10	30-50	m
Papua New Guinea	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Philippines	90	5	80	15	m	m	m	m	m	m	3	5	5	-
Sri Lanka	70	28	70	28	m	m	m	m	m	m	20	20	-	-
Thailand	80	20	75	5	5	90	-	100	70	0	60	50	80	H
Vietnam	30	50	30	50	10	30	-	80	20	-	80	-	100	H

(Source: Survey of agricultural machinery test centres by CSAM, 2014)
Note: 2w= 2 wheel tractor, 4w = 4 wheel tractor, - = not available, m = manual, T/D= Mechanical transplanting/Drill, B = Mechanical Broadcasting, H = high, M = Medium

1.3 MARKET FOR AGRICULTURAL MACHINERY

Trade plays a crucial role in increasing agricultural machinery options available to farmers, improving quality through expanded competition in the market, providing more appropriate mechanized options suited to local soil and climatic conditions and stimulating innovation. Manufacturers often look to increase larger market shares of their agricultural machinery in the Asia-Pacific region. Standardized testing of agricultural machinery facilitates global fair trade of quality agricultural machinery which protects the welfare of

farmers, the industry and the environment. Besides, agricultural machines are characterized by very high and complex technical standards, strong pressure on costs, simplicity in the construction and permanent demand for innovations (Harms, 2003).

Overall, the Asia-Pacific region produces 30.48 % tractors sold worldwide (FAO, 2004) with India topping the list with more than 680,000 units in 2013 (VDMA, 2014) followed by China. There are about 20 tractor manufacturers in India while others producing diesel engines and agricultural tools (Anon, 2015). Many of the manufacturers in the region mainly rely on the "cut and weld" manufacturing, producing agricultural machinery such as manual weeders, threshers, winnowers.

CHINA

The 2014 VDMA agricultural machinery trade reported that China had gained considerable market share in agricultural machinery production while the importance of Europe is slowly but steadily declining (VDMA, 2014). There are world-renowned brand name agricultural machinery being produced in Asia for a growing market at their front door, which can constantly increase their machinery output. VDMA and Chinese industry representatives anticipated a slowdown in growth in 2014. China will continue to be one of the driving forces in the industry.

Modern Chinese farmers emphasize on technological efficiency and reliability (VDMA, 2014). The increase of farm sizes due to growing number of commercial farmers coupled with higher crop yields will require more machinery usage. Efforts by the Chinese central government to secure supply of food of appropriate quality for the growing population will further enhance the use of agricultural machinery. Various state support programs are available including price concessions on diesel, electricity, fertilizers and pesticides, as well as direct subsidies for modern agricultural machinery.

INDIA

Indian small tractor production is estimated to be about 6% of global agricultural machinery production. More than 680,000 tractors were produced in 2013, hence India continues to be the world's largest producer of tractors (VDMA, 2014). Despite majority of Indian farms are not mechanized, a mechanization rate of 30% to 40% in soil tillage, sowing and plant protection is reported to cover approximately 50 million farms. Tractors in India are also being used in the construction industry and airports solely as a means of transport which account for 10% to 15% of the turnover. A further 10% of the tractors sold are exported. Recent economic challenges in India have had little impact on the agricultural sector. The 2013 monsoon had provided sufficient rainfall in most parts of the country led to good yields for grain, oilseeds and cotton. Subsequent increase in agricultural income provide a positive impact on the agricultural machinery market resulting in increase of sales of tractors by 20%, with 86.9% being sold for agricultural purposes. The demand for modern large scale machinery is also expected to increase.

JAPAN

Japanese tractors are being used by many Asia-Pacific countries especially in wetland paddy production. The 30 hp Japanese small tractors have been popular where the 2013 tractor production increased by 37% (VDMA, 2014). They are used in gardening and landscaping. Tractors account for about one third of total Japanese agricultural machinery production and about 80% of its agricultural machinery exports. However, the export business has suffered in recent years due to the appreciation of the Japanese Yen with tractor export dropped by 11% to below 50%. For 2014, the Japanese agricultural machinery association (JAMMA) anticipates a decline in production and exports as well as a weaker domestic market.

KOREA

Tractors from Korea are popular for use in small part-time agricultural operations in the Asia-Pacific, America and Europe (VDMA, 2014). Production and export volumes are approximately one third of Japanese figures and rose sharply in the past three years. The Korean association (KAMICO) anticipates a stable production volume for 2014. The production of tractor models exceeding 30 hp is expected to grow by 4%.

1.4 TECHNOLOGY

Technological development trends for tractors have focused on goals of performance, safety, environmental compatibility, ergonomics and the integration of information technology in recent years (VDMA, 2014). The inclusion of information communication technology is a significant field of innovation, permitting satellite-assisted control of tractors, and automatic communication of tractors and mounted equipment. Recent requirements of the emission standards have become a central issue for manufacturers of both tractors and engines. Compliance with exhaust emission stage 4 has considerably reduced emissions of carbon dioxide and nitrogen, and has brought the industry in line with the standards of the automotive industry. It was reported that future development of tractor will be driven by the objectives of tractor compliance with exhaust emission regulation stages 4 and 5, increased efficiency of the entire vehicle, the networking of tractors and implements, and the automation and electrification of tractor implement systems.

Standardization in agricultural machinery manufacturing allows flexible utilization and reuse of components, economies of scale, and interoperability especially for mechanical system (Reid et al, 2003). The standardization of hitches, tires, belts, power take-offs, electronics and controls, such as networks and buses, will promote the advancement of agricultural equipment. Governments in more developed countries regulate safety, emissions, and fuel economy issues. The costs of the technologies to solve these issues are generally not scalable with equipment size, and thereby

becoming too expensive for the equipment in the less developed countries. It is expected that the current trend of disparity in tractor requirements between developed and less developed countries, especially in many of the Asia-Pacific countries will continue. These disparities should be considered by the agricultural machinery testing centres in the region especially China, India, Japan and Korea in performing the OECD tractor tests.

Quality and Efficiency of Agricultural Machinery

Region-wide safety, quality and suitability standards and guidelines on the production and operation of agricultural machines are imperative, as they can contribute to reducing occupational accidents and illnesses, key for policymakers working to reduce social and environmental costs currently borne by the governments. Although adaptive technology has been applied to address occupational safety and health concerns of farmers who operate agricultural machinery, much work in the area of mechanized agriculture still needs to be done.

Prime movers play a very significant role in agricultural mechanization. A survey on the quality of power tillers and 4-wheel tractors among the Asia-Pacific countries reflected that the quality of engine used needs to be improved. Factors such as: under power, oil pump and engine quality were reported (Table 3). Other problems faced by farmers were broken oil seals and V-belts. These quality factors of power tillers should be included in the various test codes and procedures to be harmonized among the Asia-Pacific member countries. Meanwhile, the quality factors of 4-wheel tractors in the Asia-Pacific countries are mainly related to engine oil pump and engine quality.

Table 3. Quality issues of prime mover usage in selected Asia-Pacific countries

Quality	China	India	Pakistan	Thailand	Indonesia	Vietnam	Bangladesh	Sri Lanka	Philippines	Malaysia	Cambodia	Fiji	Papua New Guinea	Nepal
2 Wheel Tractor														
Engine: Under power		/												
Engine: Oil pump, engine quality			/				/	/						
Others: Oil seals broken, V belts broken, others	/			/			/	/						
4 Wheel Tractor														
Engine: Oil pump, engine quality	/		/											

(Source: Survey of agricultural machinery test centres by CSAM (2014)
Note: / = Reported problem(s)

The efficiency issue faced by the Asia-Pacific countries was mainly related to the use of power tillers whereby poor machine control on slope, strong machine vibration, high fuel consumption and poor machine durability (Table 4). Response from several other Asia-Pacific countries using many of the 4-wheel tractors was not reported.

Table 4. Efficiency issues of prime mover usage in selected Asia-Pacific countries

Efficiency	China	India	Pakistan	Thailand	Indonesia	Vietnam	Bangladesh	Sri Lanka	Philippines	Malaysia	Cambodia	Fiji	Papua New Guinea	Nepal
2 Wheel tractor														
Poor machine control on slope		/												
Machine vibration			/											
High fuel consumption							/	/						
Poor durability								/						

(Source: Survey of agricultural machinery test centres by CSAM, 2014)
Note:
/ = Reported problem(s)
There were no complaints on the 4 wheel tractors.

Agriculture Machinery Safety

Agriculture is one of the most hazardous occupations worldwide, with the fatal accident rate in agriculture more than double the average for all other industries. In addition to striving for balanced economic growth, other objectives include enhancing farmers' occupational safety and health, increasing farmers' access to appropriate machinery and farm implements, addressing the efficiency of food production and management of lands more environmentally sustainable thus contributing to more resilient rural livelihoods. There is a need for a region-wide safety standards and guidelines on the operation of agricultural machines. Safety issues have always been important for agricultural equipment (Reid et al, 2003). Manufacturers pay special attention to ensuring products to meet expected regulatory guidelines for safety. Value-added features like automatic guidance can lead to increased productivity for the producer by increasing efficiency. However the operator's responsibility is also important. Decisions to increase productivity for the producer will have to be weighed against the safety requirements for products.

Safety issues related to the use of prime mover were mainly on power tillers and 4-wheel tractors (Table 5). Speeding, wrong operation and poor slope control of power tiller usage were mentioned especially in China. Meanwhile, lack of roll-over protective structure (ROPS) was reported by India and Sri Lanka for the small 4-wheel tractors. Other safety issues on the operation of 4-wheel tractors raised were speeding, wrong operation and poor brake system.

Table 5. Safety issues of prime mover usage in selected Asia-Pacific countries

Safety	China	India	Pakistan	Thailand	Indonesia	Vietnam	Bangladesh	Sri Lanka	Philippines	Malaysia	Cambodia	Fiji	Papua New Guinea	Nepal
2 Wheel tractor			/				/	/						
Speeding	/													
Wrong operation	/													
Poor slope control	/													
4 Wheel tractor							/							
No ROPS		/						/						
Speeding	/													
Wrong operation	/													
Poor brake			/											

(Source: Survey of agricultural machinery test centres by CSAM, 2014)
Note: / = Reported problem(s), and tick mark without remarks indicate safety issues on accident.

Agricultural Machinery and Environment

The issue of emission requirements to meet North American and European guidelines is creating pressures on the manufacturing of engines and power units in agricultural industries (Reid et al, 2003, Kobayashi T. 2003) by making certain models of equipment unprofitable. Keeping the industry healthy and profitable requires constant tracking of regulatory issues and estimation of their impact well in advance of their occurrence. Agricultural machinery manufacturers need to comply with the two different market demands for the specifications and features; characterized by high specifications and the simple specification agricultural machinery (Kobayashi, 2003). Compliance with high specifications products equipped with high performance, high durability and low price will require manufacturers to reduce manufacturing, developing and marketing costs.

It has been reported that most of the agricultural machinery used in the Asia-Pacific region are energy-intensive. There is a need to promote the application of energy efficient and safe agricultural machinery. Concerted and holistic approach should include capacity building, technology transfer, training of operators and mechanics, experience-sharing and needs assessment study.

Various agricultural machinery environment-related weaknesses were reported by some Asia-Pacific countries (Table 6). They were related to the use of power tillers and 4-wheel tractors. Too much noise, strong machine vibration and excessive smoke or gas were common. Meanwhile, excessive noise of the 4-wheel tractors was also mentioned by a few countries.

Table 6. Environmental issues of prime mover usage in selected Asia-Pacific countries

Environment	China	India	Pakistan	Thailand	Indonesia	Vietnam	Bangladesh	Sri Lanka	Philippines	Malaysia	Cambodia	Fiji	Papua New Guinea	Nepal
2 Wheel tractor							/							
Noisy		/							/					
Vibration		/												
Too much smoke/gas			/					/						
4 Wheel tractor							/							
Noisy			/					/	/					

(Source: Survey of agricultural machinery test centres by CSAM, 2014)
Note: / = Reported problem(s), tick mark without remarks indicate environmental issues.

1.5 DEVELOPMENT OF COMMON TESTING PROCEDURES AND SAFETY STANDARDS

The lack of safety and quality equipment hinders the growth of agricultural mechanization in the Asian countries. Common standards for agricultural machinery among member countries to maintain health and safety of the people and to facilitate trading of agricultural machinery are needed.

The International Organization for Standardization (ISO) defines a standard as a document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose. There are many standards being used in agriculture, mainly devoted to machinery and especially to work safety and ergonomics items. Currently, various national, regional and international standards are used in accordance with the rules of different countries and international bodies, and standards may be voluntary or compulsory. A serious existing problem is that standards dealing with the same item often are not harmonized among the various international bodies and even inside the single organization (Gasperaretto and Domenico, 2013).

International standards are requested by farmers, manufacturers, research and advisory organizations (Alt, 2013). International standardization for tractors and agricultural machinery was started in 1952 by the creation of ISO/TC 23 “tractors and machinery for agriculture and forestry”. A summary on the development of standards for agricultural machinery over time with respect to the expectations of the subjects of standardization and the technical specifications is listed below (Alt, 2013):

- 1950s: reduction of variety of types and designs
- 1960s: inter-changeability and usability
- 1970s: ergonomics and operator’s safety
- 1980s: tractor and implement interfaces (up-dating)
- 1990s: operator’s safety (CEN) and electronics (ISO)
- 2000s: consideration of systems and processes.

Standards for agricultural machines and tractors are developed to meet the objectives of inter-changeability between tractors, implements and farm management systems; to provide special requirements with respect to the operator's safety, environmental protection and road transport in order to support regional and international legislation; and to support co-operation at the international level.

2. SITUATIONAL ANALYSIS OF AGRICULTURAL MACHINERY TESTING IN THE ASIA-PACIFIC REGION

2.1 TESTING CENTRES, THE CENTRE FOR SUSTAINABLE AGRICULTURAL MECHANIZATION (CSAM) AND THE ASIAN AND PACIFIC NETWORK FOR TESTING OF AGRICULTURAL MACHINERY (ANTAM)

Testing Centres

Most of the testing centres in the Asia-Pacific countries are in the developing stage and sophisticated testing infrastructure is inadequate. The inadequacy and inaccessibility of well-equipped testing centres in the region hampers the proper testing and certification of agricultural machinery. Lack of common testing standards and certification increases the cost due to repeated testing of the same machinery by importers and exporters. At the same time, that countries accepting the machinery without any standard and compatibility checking due to unavailability of testing units for evaluation increases the vulnerability of agricultural accidents. Table 7 provides some basic information of agricultural machinery testing centres in the selected Asian Pacific countries. China and India appear to be the two largest and most capable agricultural machinery testing centres in the region among the 14 surveyed countries with respect to size, experience, and human capacity. The second group of testing centres is Bangladesh, Indonesia, Pakistan, Philippines, Sri Lanka, Thailand, and Viet Nam. Pakistan ranked the third in terms of size, experience and human capacity. While the other countries do not have any existing testing centres. Financial support remains an essential factor for the operation of the testing centres. All the existing testing centres are owned and financed by their respective governments to conduct voluntary and compulsory testing of agricultural machinery.

Table 7. Basic information of agricultural machinery test centre in selected Asia-Pacific countries

Basic Information	China	India	Pakistan	Thailand	Indonesia	Vietnam	Bangladesh	Sri Lanka	Philippines	Malaysia	Cambodia	Fiji	Papua New Guinea	Nepal
No of test centre	4	4	1	1	1	1	1	1	1	0	0	0	0	0
Experience (number of year)	4	4	3	3	3	3	3	3	3	0	0	0	0	0
Scope of Responsibilities	4	4	3	3	3	3	3	3	3	0	0	0	0	0
Number of Employees	4	4	3	2	1	3	1	3	2	0	0	0	0	0
Total Build-up Area	4	4	3	2	1	2	0	1	2	0	0	0	0	0
Ownership (P= Public benefit/ T=Third party/ Pr= Private/others)	P	P	P	P	P	P	P	P	P	NA	NA	NA	NA	NA
Supervisory Department (G= Government)	G	G	G	G	G	G	G	G	G	NA	NA	NA	NA	NA
Statutory Testing Requirement (V= Voluntary/ C=Compulsory, L=Loan, I = Insurance and etc)	V	V	V	V	V	V	V	V	C	NA	NA	NA	NA	NA
Financial Resources (G = Government)	G	G	G	G	G	G	G	G	G	NA	NA	NA	NA	NA

(Source: Survey of agricultural machinery test centres by CSAM, 2014)
Legend: [0] None, [1] Low, [2] Medium, [3] Large, [4] Very large, NA = Not available

Further analysis on the testing ability of agricultural machinery testing centres in selected Asia-Pacific countries shows a similar ranking with respect to their capability in the scope of testing, staff strength, physical facilities (laboratory areas and facilities) and the number of test report produced (Table 8). Both China and India are able to provide OECD testing of 4-wheel tractors for their export purposes. There are some potential testing centres which can be developed to a higher level of capability, and this includes Bangladesh, Indonesia, Pakistan, Philippines, Sri Lanka and Thailand. Further information is needed from the test centre in Viet Nam for its assessment.

Table 8. Testing ability of agricultural machinery test centre in selected Asia-Pacific countries

Testing Ability	China	India	Pakistan	Thailand	Indonesia	Vietnam	Bangladesh	Sri Lanka	Philippines	Malaysia	Cambodia	Fiji	Papua New Guinea	Nepal
Scope of Testing	4	4	2	NA	2	NA	3	3	2	NA	NA	NA	NA	NA
Number of Professionals	3	3	1	NA	NA	1	2	1	1	NA	NA	NA	NA	NA
Laboratory Area	4	4	1	NA	NA	1	3	2	2	NA	NA	NA	NA	NA
List of Facilities / equipment	4	4	1	NA	NA	NA	1	1	1	NA	NA	NA	NA	NA
Number of testing report conducted (year 2011, 2012 and 2013)	4	4	1	1	1	NA	3	NA	2	NA	NA	NA	NA	NA
Availability of Testing Reports	A	A	A	A	A	NA	A	A	A	NA	NA	NA	NA	NA

(Source: Survey of agricultural machinery test centres by CSAM, 2014)
Legend: [0] None, [1] Small/Low, [2] Medium, [3] Large, [4] Very large, NA = Not available, A = Available
Both China and India are able to provide OECD testing of 4-wheel tractors

Table 9 summarizes the number of testing reports conducted by China and India from 2011 to 2013. Obviously, prime mover remains as the main activities of these testing centres with more than 50% of their testing conducted. China reported a much more diverse test report conducted than India. Subsequently, the testing on land preparation and harvesting machinery forms the second largest group at 15.4% and 14.9% respectively. Testing of planting and stock breeding machinery formed the third group at 4.3% and 6.9% respectively.

Table 9. A sample listing of number of testing reports conducted by China and India

	China				India (CFMTTI, Burni)*		
Type of Machinery	2011	2012	2013	Average/year	2011	2012	2013
Prime Mover	99 (75%)	108 (58%)	114 (46%)	107 (57%)	58 (100%)	54 (96.4%)	10 (100%)
Land preparation	17 (12.8%)	35 (18.8%)	35 (14.1%)	29 (15.4%)	-	-	-
Planting	4 (3%)	3 (1.6%)	18 (7.3%)	8 (4.3%)	-	-	-
Harvesting	8 (6%)	32 (17.2%)	44 (17.7%)	28 (14.9%)	-	2 (3.6%)	-
Post-harvest processing	0 (0%)	0 (0%)	2 (0.8%)	1 (0.5%)	-	-	-
Farm products Primary processing	4 (3%)	0 (0)%)	0 (0%)	1 (0.5%)	-	-	-
Drainage and Irrigation	0 (0%)	4 (2.2%)	0 (0%)	1 (0.5%)	-	-	-
Stockbreeding	0 (0%)	4 (2.2%)	35 (14.1%)	13 (6.9%)	-	-	-
Total	**132**	**186**	**248**	188	58	56	10

*Note: * A total of 1376 machine test reports had been reported by CFMTTI, Burni since 1961.*

The Centre for Sustainable Agricultural Mechanization (CSAM)

There are several obstacles for farmers to adopt modern technologies, including lack of technical know-how, relatively high capital investment requirements (needs) and reluctance to adopt modern concepts. Specific farm mechanization interventions based on good agricultural practices (GAP) need to ensure that mechanization and technology are compatible with international standards and importers' requirements. The Asia-Pacific region currently lacks a focused mechanism of standardization of agricultural machinery testing.

CSAM, a regional institution under the umbrella of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), is mandated to promote sustainable agricultural mechanization for food security and rural poverty reduction in the Asia-Pacific region through technical cooperation, exchange of information and sharing of successful agricultural engineering, machinery technology and related disciplines, and development and extension in the area of sustainable agricultural mechanization. CSAM is focusing on diverse international standards and guidelines, such as ISO standards, the tractor testing codes programme of the Organization for Economic Cooperation and Development

(OECD), and FAO guidelines to strengthen implementation of its initiative to promote safe, efficient and environmentally friendly agricultural machinery. Strategies implemented by CSAM on the standardization of agricultural machinery testing include identifying policies and measures adopted by member countries; promoting synergy, complementarity and coherence of existing activities; maximizing impact and dissemination of outputs through existing networks to ensure sustainability of the results; and building extensive partnership with member countries, research institutes and relevant international organizations. The main target groups consist of government agencies in charge of agricultural mechanization, national designated testing stations, the private sector and agricultural extension organizations. Other relevant stakeholders include R&D institutes and civil societies.

The Asian and Pacific Network for Testing of Agricultural Machinery (ANTAM)

ANTAM is a flagship programme initiated by CSAM. ANTAM is a regional network composed of national testing stations of agricultural machinery of participating countries, research institutes, associations of agricultural machinery manufacturers and farmers organizations across the Asia-Pacific region. It was launched in November 2013 with participation of 19 member States of ESCAP. The Secretariat of ANTAM is based in CSAM. Participation in ANTAM is on a voluntary basis.

ANTAM is mandated to ensure quality agricultural machinery produced and traded in participating countries in the Asia-Pacific region through harmonization of national testing codes and standards of agricultural machinery, and application of uniform or mutually recognized testing procedures that address quality, performance, occupational safety and environmental sustainability of agricultural machinery.

ANTAM has set up a Technical Working Group to develop region-wide standard testing codes and procedures for agricultural machinery that are of popular use in the region.

2.2 AGRICULTURE MACHINERY STANDARDS AND TESTING

In the Asia-Pacific region, most developing countries lack technical know-how, infrastructure and trained technicians to conduct standard testing of agricultural machinery. Financial constraint and absence of coherent institutional and legal framework to promote sustainable agricultural mechanization have left the existing testing stations severely underdeveloped. This has given rise to the manufacture and trade of substandard machinery in some markets of the Asia-Pacific region, which has undermined both the economic and social wellbeing of farmers, and the competitiveness of the industry in the global market.

Testing and certification of agricultural machinery is important as agricultural machinery related accidents are increasing in developing countries. Machinery has the highest farm injury frequency and fatality rates worldwide (ILO, 2000). There is a need for coordinated activities to harmonize the test procedures, standards and specifications. International collaborative research on agricultural health and

safety issues is a promising way to alleviate the occupational health and safety hazards in agricultural activities.

At the same time, the region has emerged over the last two decades as the largest market of agricultural machinery in the world. According to the Work Bank estimate in 2010, the projected sales of agricultural machinery, implements and equipment will reach US$49 billion in 2015 in Asia as compared to US$27 billion in North America and US$20.5 billion in Western Europe (FAO, 2014). As the global centre of gravity of manufacturing and marketing of agricultural machinery has shifted to Asia, harmonization of testing codes and procedures plays an important role to facilitate fair trade through reduction of unnecessary technical barriers to trade.

Currently, countries across the region are using a mix of national and a few internationally recognized testing codes and procedures of agricultural machinery. Testing in most developing countries is not mandatory both for production for domestic markets and imported machinery. Testing codes and procedures developed by the Regional Network for Agricultural Machinery (RNAM)1 in the 1980s are still being used by some countries in the region. Some countries have established standardization agencies to oversee formulation of testing codes while a few others are in the early stage of establishing national testing stations. These efforts are designed to improve domestic capacity to produce and export quality machinery and to ensure the safety and quality of imported machinery. Japan and the Republic of Korea take the lead in adopting internationally recognized testing codes while China and India have set up national testing networks with other developing countries following behind.

Testing centres across the region are equipped with various kinds of facilities to assess and evaluate the performance of agricultural machines. There is duplication of testing facilities in some countries in the region while in some other developing countries the establishment of testing facilities remains a problem. The lack of information and knowledge sharing in this area has hampered not only the distribution of agricultural machinery, but also its improvement to meet the requirements of global standards. Furthermore, lack of regional testing standards in compliance with prescribed safety and environmental standards has also created safety and environmental problems. At present, countries in the region have realized the importance to adopt region-wide standard testing codes and procedures for the benefit of farmers, food production and the environment.

[1]The Regional Network for Agricultural Machinery (RNAM) was established by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) in cooperation with the United Nations Industrial Development Organization (UNIDO) and the Food and Agriculture Organization (FAO) in 1977 in Los Baños, the Philippines. There were eight participating countries: India, Indonesia, Islamic Republic of Iran, Pakistan, Philippines, Republic of Korea, Sri Lanka and Thailand. In 2002, RNAM was upgraded to a Centre known as the Asian and Pacific Centre for Agricultural Engineering and Machinery (APCAEM) located in Beijing. APCAEM then adopted its current name as Centre for Sustainable Agricultural Machinery (CSAM) in 2012.

3. SIX SUCCESS FACTORS

Currently, the Asia-Pacific region does not have a focused, regional mechanism for testing of agricultural machinery. Sustainable intensification of agricultural production in the region requires immediate actions both at the national and regional levels to promote the development and adoption of standard test codes and procedures. The experience and success of the European Network for Testing of Agricultural Machinery (ENTAM) on harmonization of regional testing codes and procedures for mutual recognition of testing reports and certificates provides a reference for the similar initiative in the Asia-Pacific region. The testing stations in ENTAM partner countries have signed an agreement to recognize test reports. Six key factors essential for ANTAM are suggested:

- Adoption of a common standard – International (ISO) /Regional
- Harmonized standards, testing codes and certification
- Endorsement / empowerment of testing centres
- Recognition of certified test reports
- Mutually agreeable regulation procedures – test reports
- Functioning and effective Technical Working Group (TWG) and testing centres

3.1 ADOPTION OF INTERNATIONAL (ISO) /REGIONAL STANDARDS

Agriculture is characterized by the high degree of heterogeneity with respect to the growing conditions & strategies and the resulting methods of operation. The agricultural industry offers a wide range of specific machines adapted to the individual conditions. Due to the leading role of tractors for the mechanization of agriculture and the need to design the process chains according to the local conditions, standardized interfaces are necessary to allow farmers to choose among various tractors and implement types. For example, the mechanical interfaces for mounting (three-point-linkage / ISO 730) and powering (power take-off PTO / ISO 500) were standardized at early stage but require the permanent adaptation to the state of art with respect to the increasing performance of the tractors and implements. The most recent amendment to the PTO standard allows now the transmission of mechanical power of up to 450 KW.

As modern agricultural equipment is not only most powerful but also intelligent, the publication of the ISOBUS standards ISO 11783 has been recognized as an important milestone. This standard allows the data transfer between tractors and implements and via the so-called task management, the data exchange with the management software in the farmer's office. In the meantime, it is obvious that ISO 11783 is much more than a standard and ISOBUS should be seen as a technology allowing developing more functionalities such as headland management or auto-guidance systems.

Agriculture is faced with an increasing volume of legislation with respect to machinery requirements, operator's safety, protection of the environment and safe road transport. However, the specific conditions in agriculture require specific regulations considering the typical operating conditions such as seasonal use and

range of crop, weather and soil conditions; availability for optimum usage; robustness ensuring a high degree of reliability; the machine functions (direct contact with soil and crops); high volumes of material to be picked-up, worked, stored and distributed again or overloaded; and smooth work flow as one of the most important design objectives (for economic and safety reasons).

The legislation in many countries had accepted that standardization is a qualified and trustful partner in providing appropriate technical specifications to support the implementation of the general legal requirements. Many safety standards are available for most agricultural machines and are published as ISO standards ensuring the acceptance at the European and international level. Some examples include standards on operator's safety and the protection of the environment when applying pesticides, which are supported by the specifications of EN ISO 16119 and EN ISO 16122, showing the state of the art of new sprayers and providing recommendations for their routine inspections. Other examples are on road transport standardization with its focus on steering and braking systems or components for hitching. The series of hitch standards covers the wide range of different coupling devices and is used in national or regional type approval procedures for on-road use of tractors and machines. The role of standardization as platform for co-operation is sometimes underestimated. International standardization committees and working groups allow the contact to highly qualified experts coming from different organizations (agricultural machinery companies, advisory bodies, scientific and research institutes, test centers, authorities) and disciplines (agriculture, mechanical engineering, communication and information technology) and the access to knowledge at the international level.

International standardization on agricultural machinery is characterized by very clear rules and processes through discussion of interested parties which is based on technical arguments and searching for consensus on the individual issues. Standardization projects are actively supported by providing technical input. The ISO technical committees of TC 23 follow these rules in order to ensure the acceptance of their published standards and contribute to an efficient, time and resources saving working style. The ISO technical sub-committees (SC) on standardization for agricultural machines TC 23 had been active in developing many standards. A listing of the ISO TC 23 and the number of agricultural machinery standards is shown (Table 10). Details listing the various ISO TC 23 agricultural machinery standards are also provided in Table 11.

Table 10. ISO sub-committee standards and number of standards on agricultural machinery

Sub-committee	Title	No.
ISO/TC 23/SC2	Common tests	35
ISO/TC 23/SC3	Safety and comfort	11
ISO/TC 23/SC4	Tractors	49
ISO/TC 23/SC6	Equipment for crop protection	42
ISO/TC 23/SC7	Equipment for harvesting & conservation	21

ISO/TC 23/SC13	Powered lawn and garden equipment	13
ISO/TC 23/SC14	Operator controls, operator symbols and other display, operator manuals	9
ISO/TC 23/SC15	Machinery for forestry	15
ISO/TC 23/SC17	Manually portable forest machinery	25
ISO/TC 23/SC18	Irrigation and drainage and systems	34
ISO/TC 23/SC19	Agricultural electronics	39
ISO/TC 23/	1.1 Others	36

Table 11. Selected ISO standards on agricultural machinery

ISO Codes	Descriptions
ISO/TC 23 /SC2 Common Tests for Agricultural tractors - Test procedures	PTO, Rear 3-pt. link lifting capacity, partial power PTO, Guards for PTO drive-shafts, Turning and clearance diameter, steering capability, Exhaust smoke, Engine air cleaner, Low temperature starting, Centre of gravity, Roll-over protective structures (ROPS) - Dynamic test and acceptance conditions Seat belts, anchorage strength requirements, Operator's seat, noise at the operator's position, Axle power, drawbar power, Hydraulic power at tractor/implement interface, Max speeds, Brakes and braking devices Electromagnetic compatibility
ISO/TC 23/SC3 Safety and Comfort	Tractors and agricultural machinery - Seat belts anchorage location requirements General requirements - agricultural machinery Safety Power-driven soil-working machines – Safety Solid fertilizer distributors machinery – Safety Seed drills - safety Auto-guidance systems for operator-controlled tractors and self-propelled machines -- Safety requirements Agricultural trailers and trailed equipment -- Drawbar jacks Tractors and self-propelled machinery - Operator controls - Actuating forces, displacement, location and method of operation Self-propelled machinery -- Assessment of stability Guards for moving parts of power transmission

ISO/TC 23/SC6 - Equipment for crop protection	Sprayers - Connection threading Safety - Sprayers and liquid fertilizer distributors Test methods for: sprayer nozzles, hydraulic sprayers Anti-drip devices performance, nozzles and manometers Distributing granulated pesticides or herbicides Agricultural sprayers -- Tank nominal vol. and filling hole diameter Air-assisted sprayers for bush and tree crops Knapsack motorized air-assisted sprayers - Test methods and performance limits Traceability - Spray parameter recording, reciprocating positive displacement pumps and centrifugal pumps, volume of total residual Air-assisted agricultural sprayers, Boom steadiness, environmental requirements for sprayers, evaluation of cleaning systems (External & Internal cleaning) of tank, Drift classification, Classification of field crop sprayers by field measurements, Field measurement of spray distribution in tree and bush crops, lab. measurement of spray drift -- Wind tunnels, field measurement of spray drift, engine-driven mist blowers -- Safety requirements
ISO/TC 23/SC18 - Irrigation and drainage and systems	Volumetric valves -- General requirements and test methods Rotating sprinklers, Sprayers, Automatic irrigation systems -- Hydraulic control, traveler irrigation machines laboratory and field test methods, Emitters and emitting pipe, Irrigation valves, Pressure losses in irrigation valves, Filters for micro-irrigation, Direct-acting pressure-regulating valves, Centre-pivot and moving lateral irrigation machines with sprayer or sprinkler nozzles, Wiring and equipment for electrically driven or controlled irrigation machines, Safety devices for chemigation, Test facilities for agricultural irrigation equipment

ISO TC23 constantly up-dates its published standards such as standards specifying the mechanical and hydraulic interfaces between tractors and implements (Alt, 2013; Cedarquist, 2013). The tractor committee SC 4 revises the tractor safety standard ISO 26322 to include the replacement of national and regional tractor regulations. The SC 2 committee for testing is working with the Organization for Economic Co-operation and Development (OECD) towards a joint ISO-OECD standards for the benefit of farmers and industry. ISO and OECD had a joint memorandum of understanding to avoid duplication of work on the testing of roll-over protective structures (ROPS) which was cancelled before being enforced (Alt N., 2013).

Some current works of the ISO TC 23 Sub-committees are listed below (Alt, 2013):

- The safety and comfort committee SC 3 provided a new version of EN ISO 4254-1 in 2013 which deals with all relevant risks for agricultural machinery and provides general safety requirements applicable to all types of mounted, towed or self-propelled machines. The standard

provides conformity to the European machinery directive with high acceptance in other regions. Further harmonization of standards is initiated on machine specific standards for soil working equipment such as seed drills and fertilizer distributors. Similar new initiatives are being carried out for the high voltage systems and automated machine operation. The SC 3 had completed work on safety standards revision for combine, forage and cotton harvesters (EN ISO 4254-7) and the new safety standard for bale wrapping machines. Revisions of the baler and mower standards are already announced.

- The sprayer committee SC 6 developed the environment related standard series EN ISO 16119 (new sprayers), EN ISO 16122 (inspection of sprayers) and EN ISO 19932 (knapsack sprayers). These new standards caused the revision of existing sprayer standards which specify test procedures and are used as reference standards.

- The electronic committee SC 19 revised the ISOBUS standard ISO 11783 as the core standard which allows the communication between tractors, implements and farm management systems. This standard consists of 14 parts and requires the permanent adaptation to the state of art and the inclusion of new functionalities in order to reflect the developments in the IT sector and to ensure the inter-changeability ("plug and play"). Additional standards will be necessary to allow the automated operation of individual machines as well as the aligned operation of various machines (fleet management).

International standardization is faced with an increasing number of requests for new standards or the adaptation of existing ones. Increasing number of projects, its complexity of new technologies coupled with the need to provide timely standards had caused a conflict due to the limited resources. Improved co-ordination and priority setting is important. There is an opportunity for future collaboration between ANTAM and ISO towards this initiative. Challenges include developing standards for different types of agricultural machines under local market demands and high quality standard.

Almost all the current ANTAM member countries are also members of ISO (Table 12) except Cambodia. It is logical that all ANTAM member countries should also adopt ISO as the international standard for ANTAM. Besides, almost all current ANTAM member countries are having the national standardization institute, except Cambodia, Fiji and Nepal. The existence of both the ISO and the national standards among current ANTAM member countries provides a favourable platform for the adoption of a common regional standard for ANTAM. Besides, there are a few other related regional standard organizations such as the Pacific Area Standards Congress (PASC) and the ASEAN Consultative Committee for Standards and Quality (ACCSQ) which may be helpful for ANTAM. It is suggested that ANTAM should establish some of its regional standards on agricultural machinery, unique to the Asia-Pacific member countries such as the power tillers, in collaboration with other relevant international and regional organizations such as ISO, PASC and ACCSQ.

There is a need to design common agricultural machinery standards for the Asia-Pacific region to promote agricultural development. In addition, this initiative can also facilitate trade, test codes and schemes of agricultural machinery, besides serving an expanded role in addressing the pressing issue of mechanization adoption.

The development of approved and harmonized standards at international level combining standardisation, testing and certification together is needed (Liberatori, 2013). Globalisation requires both technical standardisation and mutually agreeable common rules in order to assure all stakeholders a fair competition and trade. There is a very important role for CSAM to play via ANTAM by facilitating harmonised test codes of agricultural machinery to ensure that regulations, standards, testing and certification procedures do not create unnecessary obstacles, while also providing legitimate policy objectives such as the protection of human health and safety of food production and the environment. Transparency and openness in the harmonisation process will benefit companies and countries with limited resources trying to meet the requirements of their export markets. Besides, standards which set criteria and define a minimum level of requirements should be made clear for a better evaluation of the test results (Liberatori, 2013). The development of harmonized standards together with a harmonized test code and certification system offers a common platform for the testing of agricultural machinery by ANTAM, a guarantee to all stakeholders. Besides, certification will offer an assurance service with a regulatory function for enforcing standards.

Liberatori (2013) described the experiences of the European Network for Testing Agricultural Machines (ENTAM) in the harmonization of standardization, testing and certification of agricultural machinery. The common acceptance of a standard among test centers is a pre-requisite for ENTAM. An agreement is then signed by different testing stations in Europe to provide a common testing activity and mutually recognized test reports and certifications. Take sprayers for example, member countries of ENTAM drafted a common testing codes of a selected sprayer, based on existing harmonized international standards, and perform a sample test to check the result. Two machines were selected: a boom sprayer and an orchard sprayer for testing following test codes provided in the common methodology. A technical review meeting was held and results discussed to check the differences. Significant differences were noted due to different interpretation of the test codes by the respective test centers despite common environmental conditions. Therefore, the harmonized test codes need to clearly explain the test conditions and procedure in order to have a similar output in results not depending on the laboratory.

Prime Movers

Prime movers are reported to be the main type of agricultural machinery tested by some of the Asia-Pacific countries such as China and India (Table 2). Besides, they represent at least 50% of the number of agricultural machines tested annually (Table 9). Both the national and OECD test codes were used in the testing of 4-wheel tractors by China and India (Table 8). Successes in the annual increase of tractor sales by China and India further indicated the acceptance in using these

test codes both at the national and international level. Table 12 provides a list of OECD tractor test codes. The OECD test codes are a good example of standardization, testing and certification under the umbrella of an intergovernmental organization. These standards provide inter-changeability between tractors, implements and farm management systems, and safe and environmentally friendly use of machines.

The OECD Tractor Codes was established in 1959 with 26 participating countries consisting 30 testing stations worldwide. Participation is voluntary with national designated authorities (NDA). There are nine test codes covering tractor performance, noise, ROPS and FOPS (Table 12). The uniqueness of OECD tractor codes are:

- Quantifiable tests for reliable comparison between countries
- Global network of testing stations
- Inter-governmental organisation
- Third party certification
- Transparency
- Changes agreed by consensus

Table 12. Selected OECD tractor test codes

OECD Codes	Descriptions
2	Tractor performance
3	Strength of protective structures for tractors (dynamic test)
4	Strength of protective structures for tractors (static test)
5	Noise measurement at the driver's position(s)
6	Front-mounted protective structures on narrow-track wheeled
7	Rear-mounted protective structures on narrow-track wheeled
8	Protective structures on track laying tractors
9	Protective structures for tele-handlers (testing of falling-object and roll-over protective structures fitted to self-propelled variable reach all-terrain trucks for agricultural use)
10	Falling object protective structures

Note: OECD = Organization for Economic Co-operation and Development

OECD tractor test does not cover small field plots and wet field operation in many of the Asia-Pacific countries. Toshikuni and Uemura (2013) described that standards are written for product designs which are current, and cannot cover all new concepts and ideas. The system for creating standards is a slow process. They reported big differences of required specifications for the tractors in dry field farming with high mass and traction used, and in the wet paddy field with small

body and light weight. There is a role for ANTAM in helping the development of adapted test methods for the Asia-Pacific countries. Currently, some of the national test codes for 4-wheel tractors of China and India may be harmonised with the OECD test codes. Li (2013) reported that various processes practised in China on the agricultural machinery standardisation.

Power tillers are a very common 2-wheel prime mover used in many Asia-Pacific countries. Similar harmonization of the standards and test codes via ANTAM should be attempted.

Sprayers

Safe application of sprayers requires an integrated approach including quality standardized machinery as well as the operation. Kienzle (2013) reported the harmonization initiative in Europe such as the good agricultural practice guidelines for pesticide application. The ISO TC23 workgroup is working to establish general guidelines for good agricultural practice in the application of pesticides (ISO TC 23/SC 6, 2004). There is a strong movement by the European Union (EU) to harmonize the regulations regarding pesticide application. Safe and efficient pesticide application is crucial for reducing hazards related to agricultural pesticide use. A clear political agenda in several European countries to reduce the use of pesticides is favorable for legislation on safe pesticide application. The issues of sprayer standards, working conditions and operator training are being addressed by legislation at national as well as regional level. Proposals for mandatory sprayer tests, operator licenses and registration of spray equipment are important. Strict adherence to good agricultural practices for pesticide application and extremely tight drift legislation are needed.

Recent maximum residue levels in the EU for import products have resulted in an increased interest in good pesticide application practices and safe equipment. High levels of standards of quality application equipment and operator proficiency are set in Europe. Proactive steps in adopting and implementing strict regulations regarding the high level of quality equipment and practices used for the application of pesticides are needed. The current updated version of the FAO Code of Conduct on Distribution and Use of Pesticides encourages member countries to introduce the necessary steps to improve pesticide application which reduce the hazards related to pesticide use.

Huang et al (2011) reviewed the utilization of crop protection equipment in agricultural production in China. The Chinese sprayer standard, GB 10395.6-2006 that adopted ISO 4254-1995, is mandatory for the industry. The China Compulsory Certification (CCC, “Triple C”) is the new compulsory safety and quality mark for the Chinese market towards safety standards, effective on May 1, 2002. The compulsory certification of test on crop protection machinery was assigned to be tested and certified by the China Agricultural Machinery Testing Centre (CAMTEC). The process of CCC certification consists of documents application, type testing, initial factory inspection, evaluation of certification results and the approval of certification, and follow-up inspection. All appropriate provisions in GB 10395.1 and GB 10395.6 were employed as the requirements and test methods for CCC. In

2009, 324 test certificates were issued. Some common processes practiced in the standardization of sprayers include:

- Frequent updating of standards for vocabulary and terminology reflecting technological development;
- Field operations standards closely following the progress of new technology;
- Shift of emphasis from merely operational performance to both operational and safety performance;
- Changes from the evaluation of whole machine to individual evaluation of parts;
- Fast preparation and revisions of standards.

They predict future trend in the standardization of crop protection equipment as:

- Increase importance of environmental aspects;
- Systematic and soundness of standards system will be strengthened;
- Cycle of standard preparation will be shortened along with the increase in emerging technologies;
- Precise pesticide application will be important in standards for improving quality of agricultural products.

Noise

Kesavan (2013) suggested that the impact of noise on bystanders in the case of tractors that operate mostly in rural areas is not an issue. Instead, he mentioned that the impact of noise on the tractor operator can be effectively minimized by using low cost ear muffs. Noise suppression efforts would add to the cost of tractors and hence cost of food production unnecessarily. He reported that international standards must be relevant to every situation, region and geography and should consider cost effective, practical and enforceable solutions especially in the developing countries. Noise reduction should consider norms in population density, vehicle dense and road dense areas. Use of cost effective and simple methods of noise suppression for the operator is available and should be recommended. Standards need to be locally relevant and sensitive, cost effective, enforceable and sustainable.

Table 13 shows a summary of laws, regulations and testing standards and codes of agricultural machinery test centres in selected Asia-Pacific Countries. Most of these countries, except Cambodia, are ISO members, and they also have their existing national standard institutions (except Cambodia, Fiji and Nepal). This is favourable for the adoption and harmonization of standards for ANTAM among these countries. Both China and India had conducted extensive tests on agricultural machinery with many existing national standards and test codes. Other countries showing promising capability include Pakistan, Philippines and Thailand. The RNAM test codes are being used by Bangladesh, Pakistan, and Sri Lanka.

Table 13. Laws, regulations and testing standards and codes of agricultural machinery test centre in selected Asia-Pacific countries

Items	China	India	Pakistan	Thailand	Indonesia	Vietnam	Bangladesh	Sri Lanka	Philippines	Malaysia	Cambodia	Fiji	Papua New Guinea	Nepal
Laws and Regulations	Strong	Strong	NA	NA	NA	NA	Moderate	NA	Moderate	NA	NA	NA	NA	NA
ISO Member	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
National Standards Organization	GB	BIS	PSQCA	TIS	SNI	TCVN	BSTI	SLSI	PAES	SIRIM	NA	NA	NISIT	NA
List of Standards	12 (National), 269 (Industry), >500 (Regional)	Many	RNAM	43 (TIS)	Low	2 (TCVN)	RNAM	RNAM	209 (PAES)	NA	NA	NA	NA	NA
List of Codes	81 (Adopting OECD)	Many	RNAM	NA	Low	NA	RNAM	RNAM	209 (PAES)	NA	NA	NA	NA	NA

(Source: Survey of agricultural machinery test centres by CSAM, 2014) Legend: Y = Yes, N = No, NA = Not available

Having favourable laws, regulations and testing standards and codes of agricultural machinery is not enough. The availability of strong supporting policy and efforts on standardization and certification in selected Asia-Pacific countries (Table 13) further enhances the harmonization process.

Table 14. Supporting policy and efforts on standardization and certification in selected Asia-Pacific countries

Institutions	China	India	Pakistan	Thailand	Indonesia	Vietnam	Bangladesh	Sri Lanka	Philippines	Malaysia	Cambodia	Fiji	Papua New Guinea	Nepal
Existing policy	Y	Y	Y	N	Y	Y	Y	N	Y	Y	N	N	N	N
Government	Y	Y	Y	N	Y	Y	Y	N	NA	Y	N	N	N	N
R&D institution	Y	Y	Y	Y	Y	NA	Y	Y	NA	Y	N	N	N	N
Available incentives (grants)	Y	Y	Y	N	NA	NA	Y	N	NA	Y	N	N	N	N
Available trainings	Y	Y	N	N	Y	NA	Y	Y	NA	Y	N	N	N	N

(Source: Survey of agricultural machinery test centres by CSAM, 2014) Legend: Y = Yes, N = No, NA = Not available

3.3 ENDORSEMENT / EMPOWERMENT OF TEST CENTRES

The adoption of harmonized standards and test codes for ANTAM shall be followed with actual machine testing. Testing based on harmonized standards and test codes play a key role in the ANTAM standardization process. It is based on a mutually agreed methodology that translates harmonized standards in procedures or test codes stating how to apply and verify the standardized requirements of a product or process. The test shall be performed by an independent third party for a certification. The testing can be considered as a harmonized part of the process.

Samarakoon (2012) suggested the following regional approaches for setting up agricultural machinery testing centres for ANTAM. The following modified approaches based on the above observations and the survey of the selected Asia-Pacific countries were suggested for each ANTAM selected test centres:

- To be implemented within the existing institutional framework of the participating countries. This is in response to the needs of existing Asian regional economic entities.
- A review of the national agricultural machines testing and evaluation needs for each selected country which will include:

  - Reviewing existing national testing standards and recommending the appropriate adjustments to meet the ISO and ANTAM standards.

  - Evaluating existing national institutions to identify testing equipment needs and related training for future operation of the station based on the harmonized ANTAM standards and test codes.
- Providing human resource development for the operation of the centre, equipment acquisition, installation and operation appropriate for the harmonized ANTAM standards and test codes. Besides, guidance on the management methods required for an efficient operation of the testing station is also needed.
- Harmonized ANTAM standards and test codes selection may need to consider the adaptation of ANTAM member countries needs, for example, remarks of ENTAM experiences on issues and challenges of ENTAM's harmonized testing done in member countries for a reliable and consistent test results and analysis (Liberatori, 2013):

  - Review testing policies and procedures for the operation of installed testing equipment

  - Formalizing methods for collecting, analyzing and evaluating the test results

- Establish common policies on publication of testing reports of ANTAM

  - A systematic procedure for transmitting test reports

  - Publication of test reports within the agricultural community and the equipment industry.

3.4 RECOGNITION OF CERTIFIED TEST REPORTS

ISO defines certification as: "the provision by an independent body of written assurance (a certificate) that the product, service or system in question meets specific requirements". Besides, the same website states that it "is not involved in the certification to any of the standards it develops. Certification is performed by external certification bodies ...." The certification process by ENAMA on OECD test report of each tractor test, issued by the national stations having performed the tests and approved according to the OECD Codes, is a good example to be followed. The access to these ANTAM test reports and their possible distribution remain the testing stations' responsibility with the notification of the Secretariat of ANTAM. The certification of ANTAM test reports has to follow well defined rules, and has double benefits: first to assure fulfilment of all the requirements, second market recognition of the certification mark, a guarantee that the product or process is made with respect of all requirements (Liberatori, 2013).

Besides, it is useful to know that the ISO Committee on Conformity Assessment (CASCO) has produced a number of standards that relate to the certification processes. The certification is therefore the final act of a process that states officially the positive results of the testing activity based on standards. The certification process has to comply with a well established procedure stated by ANTAM, and should be performed by an accredited certification body. This is an important part of the assessing process that everything contained in the standard has been checked with a positive result. Besides it assesses that the results are all obtained with the same method and procedure, making it possible to compare. Figure 1 provides an example of the preparation and publication of the certified test report for ANTAM, similar to the OECD tractor test report validation process. The OECD programme works via country national authorities designated for implementing the codes, and performs tractor tests according to common harmonized procedures with results submitted to OECD for approval. By certifying the quality of the traded material, the approval granted by the OECD facilitates international trade. This programme, with decades of experience, can share its experiences and provide technical input to ANTAM. In addition, experiences of ENTAM in the handling of certified test report is also useful. The appointment of an accredited independent certification body for ANTAM test reports can be effected through the ANTAM annual meeting. While CSAM as the Secretariat of ANTAM playing a coordinating role in testing activities carried out by ANTAM member countries, harmonization of standards and optimizing testing activities will enable member countries of ANTAM to cooperate and avoid duplication of work and costs of testing in different countries. With mutual recognition of testing results, it serves to achieve neutral test results, efficient use of test rigs and test implements of ANTAM member countries by testing only a specific machine at a certain designated testing station. Finally, this provides independent test reports hence bettering services to manufacturers, farmers and dealers.

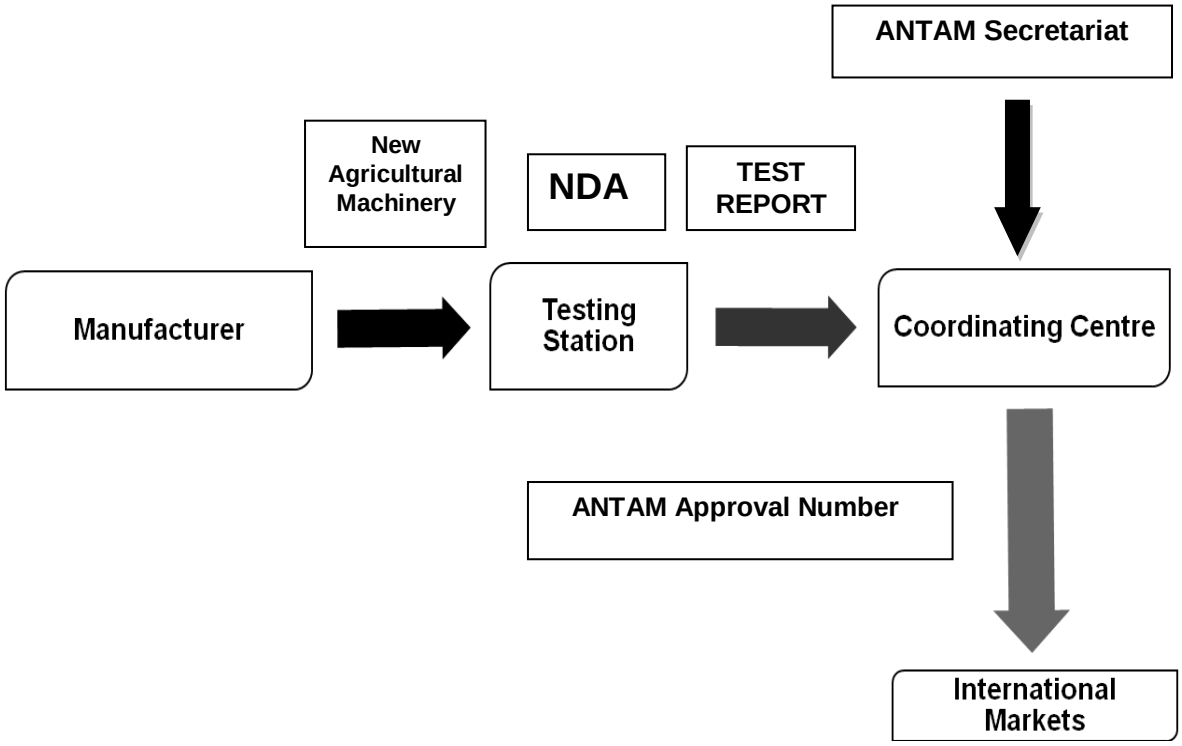


Figure 1. An example of flow process of the preparation and publication of certified test report by ANTAM

3.5 MUTUALLY AGREEABLE REGULATION PROCEDURES – TEST REPORT

A harmonized enforcement of the certified ANTAM test reports among ANTAM member countries is important for its effective implementation. Currently, there exists variation among ANTAM member countries in their procurement procedures of agricultural machinery. The acceptance of a certified ANTAM test report of agricultural machinery, by each ANTAM member country, as conforming to the procurement specifications, is important for trade. Hence, it is necessary that the regulation procedures among ANTAM member countries in accepting the certified ANTAM test report be harmonized. Examples from the OECD's Tractor Codes programme and ENTAM can be referred to. In addition to OECD, experiences from the ENTAM are also useful. The existence of various laws and regulations among many Asia-Pacific countries coupled with strong supporting policies and efforts on standardization and certification contributes to enforcing mutually agreeable regulation procedures for certifying ANTAM test reports.

3.6 FUNCTIONING AND EFFECTIVE TECHNICAL WORKING GROUP (TWG) AND TEST CENTRES

A functioning and effective Technical Working Group (TWG) and test centres are crucial for the operation of ANTAM. Improved linkages among CSAM and

engineering and other professional associations in the agriculture sector in member countries will strengthen and nurture the TWG. Communications with country focal points through e-Newsletters, an activity calendar, e-mail lists and web-based discussion groups are some convenient means. The ANTAM Secretariat can also seek improved linkages with regional research institutions undertaking joint research, information dissemination and implementation of joint projects as well as providing policy advice and capacity development. Member countries had agreed to form the Technical Working Groups (TWG) in developing the ANTAM standardized test codes and procedures at the 1st Annual Meeting of ANTAM held on 16 September 2014 in Beijing, China. The effectiveness of ANTAM standardized test codes and procedures is dependent upon voluntary compliance with the test codes and procedures adopted. Member countries should get involved in the development of such test codes and procedures.

The 1st ANTAM meeting had recommended that the TWG shall consult the Technical Reference Unit (TRU) via the ANTAM Secretariat in the development of new test codes and procedures. A written, specific outline of the standard should be prepared by the TWG. Proposals should avoid duplication of content covered in any existing international test codes and procedures. Each member of ANTAM proposing test codes and procedures shall suggest individuals best qualified to assist in developing test codes, with recognition of the need to make pending activities known to the affected, interested parties. It was suggested that the members of the TWG shall function as individuals and not as agents or representatives of their employers. The TWG members are appointed on the basis of their qualifications and ability to contribute to the work of the TWG

The responsibility of the TWG shall be clearly defined. It is essential that the TWG developing draft test codes and procedures shall obtain broad representation, providing an opportunity for inputs from qualified individuals, substantially interested producers, consumers, and general interest groups together with the ANTAM Secretariat. The 1st ANTAM meeting had further suggested that the ANTAM annual meeting has the responsibility to adopt all draft test codes and procedures submitted by the ANTAM Secretariat. Finally, the TWG shall make an annual report to the ANTAM Secretariat through the ANTAM annual meeting.

Funding remains an important factor for the successful operation of both the TWG and ANTAM. A mechanism should be planned whereby each respective member country can contribute towards the smooth operation of all TWG and ANTAM annual meetings. Other important supporting duties of the TWG shall include infrastructure and human resource capacity building of each ANTAM test centres.

4. CHALLENGES AND CONSTRAINTS

The following are the challenges and constraints faced by ANTAM for sustainable operation:

- Disparity in the level of mechanization and imbalances among the three groups of the Asia-Pacific countries with respect to the capabilities of their testing centres (Table 7 and 8). The request for new standards and facilities due to the development and introduction of new technology/product will require continuing efforts by the TWG and ANTAM to develop new standards and revision of test codes.

- The huge gap in economic development, underdeveloped agricultural infrastructure, insufficient purchasing power, and significant different level of agricultural machinery industry among the group 1 (Chin and India) and group 3 (Cambodia, Fiji, Papua New Guinea and Nepal) member countries in the region. The harmonization of standards and test codes needs to strike a balance among these countries especially the group 1 and group 3.

- Constraints: funding for group 3 countries in attending the TWG meetings.

- Governance and coordination of ANTAM will require the continuing cooperation and support of all member countries.

- The involvement of stakeholders will require continuous support and acceptability by end users, manufacturers and traders among member countries. The support and cooperation will very much depend on the benefits and success of test reports conducted and their impact on respective end users, manufacturers and traders.

5. RECOMMENDATIONS

The following recommendations are suggested for ANTAM:

- A survey was conducted among selected 14 Asia-Pacific member countries on their mechanization status, machinery usage, manufacturing supporting and machinery acquisition, supporting institutions of mechanization, farm infrastructure environment, machinery testing centres and policy matters on standardization. Feedback from some of the member countries is not complete for one reason or another. A similar follow up data collection need to be implemented using the similar form so that the needs, capability, test centre facilities, human capacity development and other ANTAM related issues can be thoroughly gauged and addressed.

- Emphasis on the continuing comprehensive data/document collection of various national standards and agricultural machinery test codes – currently existing and practiced among member countries. Recognizing differences among member countries and establishing harmonized factors.

- Establish a review mechanism for focal points of various member countries based on their annual performance with the objective to select the most appropriate TWG members for an effective functioning of the TWG.

- Continuing support by the Technical Reference Unit (TRU) together with the OECD, ENTAM and relevant collaborating partners is important and needs to be enhanced. This is especially important for development of cooperative testing and harmonized standardization procedures, comparison of test centres, test facilities and capabilities.

- Harmonized adoption of agricultural mechanization among member countries in the Asia-Pacific region is very important. The continuing promotion of good communications among TWG members by identifying similarities and differences among country standards is needed.

- New technology will require setting up new testing methodology similar to ENTAM. Scope for R&D to strengthen testing technology should be identified based on recommendations from the various TWG meetings.

- Capacity building and expert exchange to help building/updating/ upgrading test facilities through training courses under ANTAM.

- Continuing support to infrastructure building of test centres of ANTAM.

6. REFERENCES

Anon. (2015). Tractors in India. http://en.wikipedia.org/wiki/Tractors_in_India.

N. Alt (2013). International agricultural machinery standards for the benefit of agriculture and industry. Proc. 23rd Meeting of the Club of Bologna. Nov 9-10, 2012, Bologna, Italy.

S. Böttinger, R. Doluschitz, J. Klaus, C. Jenane and N. Samarakoon (2013). Agricultural Development and Mechanization in 2013 A Comparative Survey at a Global Level. United Nations Industrial Development Organization (UNIDO), Vienna, Austria.

S. Cedarquist (2013). ASABE and international standardization: a decade of harmonization and collaboration. Proc. 23rd Meeting of the Club of Bologna. Nov 9-10, 2012, Bologna, Italy.

FAO (2014). Sustainable agricultural mechanization strategy (sams) for asia and the pacific region. A draft report of the high-level multi-stakeholder consultation on sustainable agricultural mechanization in Asia and the Pacific, 26 – 27 June, 2014 Bangkok, Thailand. E. Gasparetto and Domenico (2013). Past and present of agricultural machinery standardisation. Proc. 23rd Meeting of the Club of Bologna. Nov 9-10, 2012, Bologna, Italy.

H. H. Harms (2003). How to reduce manufacturing and management costs of tractors and agricultural equipment. Proc. 14th Meeting of the Club of Bologna. 2003, Bologna, Italy

C. Huang, X.S. Zhang, L.J. Ma, J.B. Chen, S.S. Lv (2011). Equipment for Crop Protection: Standardization Development in China. Agricultural Engineering International: CIGR Journal. Manuscript No.1262. Vol. 13, No.1, 2011.

ILO (2000). World Labour Report 2000: Income security and social protection in a changing world. pp16.

T. R. Kesavan (2013). Emission and noise norms – Developing Countries, Proc. 23rd Meeting of the Club of Bologna. Nov 9-10, 2012, Bologna, Italy.

J. Kienzle (2013). The importance of equipment standards and related legislation for pesticide safety. Proc. 23rd Meeting of the Club of Bologna. Nov 9-10, 2012, Bologna, Italy.

T. Kobayashi (2003). How to reduce manufacturing and management costs of tractors and agricultural equipment. Proc. 14th Meeting of the Club of Bologna. 2003, Bologna, Italy.

S.J. Li (2013). Standards of agricultural machinery in China, (CAAMS, People Republic China). Proc. 23rd Meeting of the Club of Bologna. Nov 9-10, 2012, Bologna, Italy.

S. Liberatori (2013). Standardisation, testing and certification together for a new combined success. Proc. 23rd Meeting of the Club of Bologna. Nov 9-10, 2012, Bologna, Italy.

Ministry of Agriculture (MOA) (2013). China Agricultural Machinery Testing Center (CAMTC). www.nj.agri.gov.cn.

J. F. Reid, W.R. Norris and J. Schueller. (2003). How to reduce manufacturing and management costs of tractors and agricultural equipment. Proc. 14th Meeting of the Club of Bologna. 2003, Bologna, Italy.

N Samarakoon (2012). Guidelines for the establishment of agro-machinery testing centers. A presentation at The Eighth Session of the Technical Committee Meeting of UNAPCAME 23-25 October 2012.

P. Soni and Y. G. Ou (2010). Agricultural Mechanization at a Glance - Selected Country Studies in Asia on Agricultural Machinery Development.

N. Toshikuni and K. Uemura (2013). Standardization for new concept products: the need to accelerate localization. Proc. 23rd Meeting of the Club of Bologna. Nov 9-10, 2012, Bologna, Italy.

III. A Case Study on Testing & Appraisal System of Agricultural Machinery in China

Contributed by Ms. HAN Xue

China is an agricultural country with a population of 1.3 billion people. The development of modern Chinese agriculture is closely connected with the development of modern agricultural machinery. Agricultural mechanization plays a critical and strategic role in ensuring adequate supply of agricultural products. Moreover, mechanization also contributes to substantial reduction of the use of labor in agricultural operations, thus encouraging labor force to move out of farming activities and participate in urban jobs.

Within the last ten years, China has formulated and implemented a series of policies and regulations to support the fast development of agricultural mechanization. To promote mechanization and involve farmers in this important process, the central government has gradually increased subsidies for the purchase of agricultural machines. As a result, the quantity of agricultural machinery and equipment has sharply increased, with significant increase of level of mechanization in agricultural operation, rapid growth of the agricultural machinery cooperative and service organizations, and increased gross output value of agricultural machinery industry.

From 2004 to 2013, the 10 years were considered the golden era of Chinese agricultural mechanization development. In 2013, the national comprehensive mechanization level of crop tillage, planting and harvest reached up to 59.48%. Specifically, the mechanization level of crop tillage, planting and harvest were 74.11%, 47.37% and 44.40%, respectively. The power of agricultural machinery in China totaled about 1.039 billion kilowatts, while the number of large and medium-sized tractors and combine harvesters reached 5.27 million and 1.42 million, respectively.

Under the supervision of the Ministry of Agriculture and the provincial agricultural mechanization departments, the agricultural machinery testing and appraisal system represents an important public service. Since the 1950s, it has provided an important technical support for the healthy development of agricultural mechanization.

To date, there are 35 agricultural machinery testing and appraisal institutions at and above provincial level. These institutions have recommended a variety of advanced, applicable, safe and reliable agricultural machines to farmers, and have helped accelerate the promotion of new technologies and supported product quality improvement.

Nonetheless, the testing system does not have adequate capabilities to keep up with the increased demand as a result of agricultural mechanization reform. Standard agricultural machinery testing and appraisal is to be improved and the testing results haven't been mutually recognized nationwide so far.

In the future, efforts need to be made to reform and explore the agricultural machinery testing and appraisal mechanism to further adapt to the demand of agricultural mechanization reform and market oriented development. At the same time, testing method should be further unified, mutual recognition of testing results should be gradually achieved, and duplication of test be reduced. In a word, the collective efforts should be directed toward the realization of a more unified, coordinated national agricultural machinery testing and appraisal system.

Over the years, the Center for Sustainable Agricultural Mechanization (CSAM) has been committed to promoting the Asian and Pacific Network for Testing Agricultural Machinery (ANTAM). The Network aims to promote wellbeing of farmers, safety of food production and protection of the environment, and intra-regional trade of agricultural machinery. Through harmonization of testing standards and procedures and mutual recognition of testing results, the Network is mandated to address quality, performance, occupational safety and environmental sustainability of agricultural machinery.

Currently, developing countries in Asia suffer from inadequate testing infrastructure, underdeveloped human capacity and inaccessibility to sophisticated facilities. Meanwhile, the lack of common testing standards and certification increases the production cost due to repeated testing of the same machinery by importers and exporters. As a member of ANTAM, the China Agricultural Machinery Testing Centre has accumulated rich experiences in promoting standard testing in China. The operational mode of agricultural machinery testing and appraisal system in China could be a reference for the establishment and improvement of ANTAM. In the future, China's testing and appraisal system will develop and progress together with ANTAM.

1.BRIEF INTRODUCTION OF AGRICULTURAL MECHANIZATION IN CHINA

1.1 GOVERNMENT SUBSTANTIAL SUPPORT TO AGRICULTURAL MECHANIZATION

Since 2004, China has released a series of laws and regulations related to agricultural mechanization[2]. The central government has allocated special funds as subsidies for farmers and agricultural machinery service organizations to purchase modern equipment. From 2004 to 2013, the Central government has allocated a total of CNY 96.7 billion to agricultural machinery purchase subsidy. In the same decade, the input for agricultural machinery purchase subsidy has increased from CNY 70 million to CNY 21.75 billion. The amount of subsidies provided by the government at different levels from 2004 to 2013 is shown in Figure 1.1:

[2] These include *Law of the People's Republic of China on Promotion of Agricultural Mechanization, Law of the People's Republic of China on Farmers' Specialized Cooperatives*, *Regulations for the Safety Supervision and Management of Agricultural Machinery*, and *Opinions of the State Council on Sound and Rapid Development of Agricultural Mechanization and Agricultural Machinery Industry*.

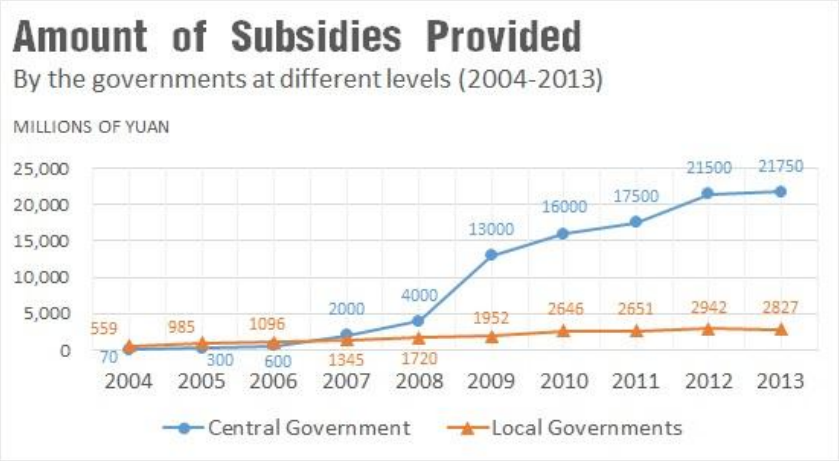


Figure 1.1: Amount of Subsidies Provided by the Governments at Different Levels (2004-2013) (Unit: Millions of Yuan)

1.2 RAPID INCREASE OF OVERALL LEVEL OF MECHANIZATION OF AGRICULTURAL PRODUCTION

As a result of government's support, the national comprehensive mechanization level of crop tillage, planting and harvest reached up to 59.48% with crop tillage, planting and harvest reaching 76.00%, 48.78% and 48.15%, respectively in 2013.

According to China Agricultural Mechanization Statistics Year Book of 2013, the mechanization level of China's three major crops- wheat, rice and corn- has greatly improved. Specifically, wheat production reached mechanization level of 93.71%,; while the production of both rice and corn surpassed 73% However, the mechanization level of rice sowing and corn harvesting remained still relatively low at 36.10% and 51.57%, respectively (Figure 1.2).

In the meantime, the total power of agricultural machinery in China reached about 1.039 billion kilowatts. The number of large and medium-sized tractors increased from 1.12 million in 2004 to 5.27 million in 2013, while combine harvesters rose from 0.41 million to 1.42 million, at a compound annual growth rate (CAGR) of 18.8 percent and 14.8 percent, respectively. (Table1.1).

Table 1.1: Statistics of Agricultural Mechanization (2004-2013)

Year	Total power (millions of KW)	Large and medium-sized tractor (millions)	Combine harvester (millions)	Comprehensive mechanization level (%)	Mechanical plowing (%)	Mechanical sowing (%)	Mechanical harvesting (%)
2004	641	1.12	0.41	34.32	48.9	28.84	20.36
2005	685	1.40	0.48	35.93	50.15	30.26	22.63
2006	726	1.68	0.57	39.29	55.39	32	25.11

2007	769	2.05	0.63	42.47	58.89	34.43	28.62
2008	822	3.00	0.74	45.85	62.92	37.74	31.19
2009	875	3.51	0.86	49.13	65.99	41.03	34.74
2010	928	3.92	0.99	52.28	69.61	43.04	38.41
2011	977	4.41	1.11	54.82	72.29	44.93	41.41
2012	1026	4.85	1.28	57.17	74.11	47.37	44.40
2013	1039	5.27	1.42	59.48	76.00	48.78	48.15

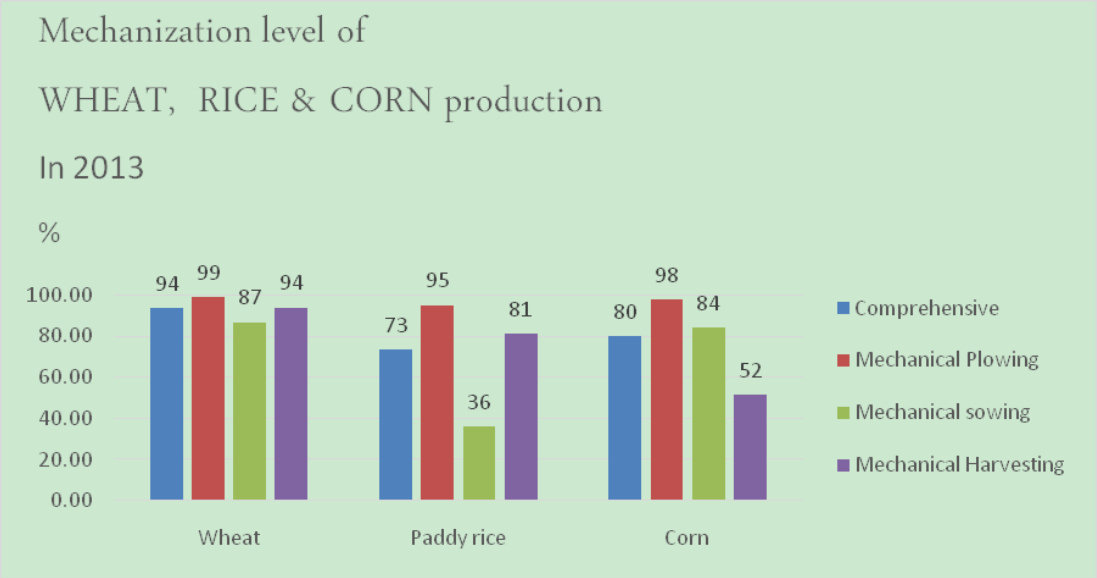


Figure 1.2: Mechanization Level of Wheat, Rice and Corn Production in 2013

1.3 SCIENTIFIC AND TECHNOLOGICAL INNOVATION

Significant progress has been made in scientific and technological innovation, where R&D and manufacturing capability have been greatly strengthened. For example, large horsepower agricultural tractors have been improved while equipment for paddy rice transplanting and harvesting has approached mature stage. Moreover, technological breakthroughs have been made in mechanized corn harvesting, and potato seeding and harvesting.

New progress has been made in technical innovations in various other fields, such as mechanization for rapeseeds, forage, sugarcane harvesting, water-saving irrigation, weeding and returning to field, and for combined field operation, animal husbandry, forestry, fruit production, and processing of agricultural produce.

Furthermore, agricultural machinery R&D institutions are paying increasing attention to innovation and intellectual property rights protection in recent years.

1.4 EXPANSION OF AGRICULTURAL MACHINERY SOCIAL SERVICE

After the introduction of agricultural machinery subsidy policy, the total number of China's agricultural machinery cooperative organizations and large agricultural machinery owners has rapidly expanded. By the end of 2013, there were 168,600 agricultural machinery service organizations in China, among which, over 42,200 were specialized agricultural machinery cooperatives.

On the one hand, government subsidies contributed to the rapid adoption and innovation of agricultural machinery in China; while on the other hand, agricultural mechanization promoted farmers' income increase and supported rural economic development. In 2013, the annual gross revenue of agricultural mechanization operation reached CNY 510 billion (Table 1.2).

Table 1.2: Development of Agricultural Machinery Social Service Organizations (2004-2013)

Year	Quantity of agricultural machinery service organizations (thousands)	Specialized agricultural machinery cooperatives (thousands)	Gross revenue of agricultural machinery operation (billion Yuan)
2004	166.90	-	**242.15**
2005	187.80	-	**260.61**
2006	273.20	-	**282.93**
2007	250.60	-	**298.67**
2008	165.60	8.60	**346.65**
2009	175.30	14.90	**389.69**
2010	171.50	21.70	**416.73**
2011	170.60	27.80	**450.90**
2012	167.00	34.40	**477.90**
2013	**168.60**	**42.20**	**510.79**

1.5 THRIVING AGRICULTURAL MACHINERY INDUSTRY

By the end of 2013, China had 2,154 large-scale agricultural machinery manufacturers (with an annual output value exceeding CNY 20 million), with gross industrial output value of about CNY 377.9 billion (Figure 1.3). The structure of the industry has been optimized with some leading manufacturers. In 2013, the total amount of agricultural machinery import and export of China reached USD 11.92 billion, a two-fold increase over 2006 (Figure 1.4).

Figure 1.3: Development Status of Agricultural Machinery Industry (2006-2013)

Figure 1.4: Import & Export of Agricultural Equipments (2006-2013)

1.6 PUBLIC SERVICE AND SUPPORTING SYSTEM FOR AGRICULTURAL MECHANIZATION

Since the 1980s, a relatively comprehensive public service and supporting system of agricultural mechanization, which includes management, technology extension, testing and appraisal, safety supervision, research and training systems for agricultural mechanization, has been established.

The agricultural mechanization administrative departments at all levels of the government are strengthening public service capabilities in agricultural mechanization in key fields including testing and appraisal.

Table 1.3: Development of Public Service System in 2013

Type of Institutions	Number	Number of Personnel	
		Total	Scientists & Engineers
Administrative	32,632	107,184	54,550

Testing and appraisal	35 (at and above the provincial level)	1322	986
Technology extension	2573	22,335	13,907
Safety supervision	2,851	32,067	15,629
Research	80	3051	2030
Education and training	1,754	19,689	13,057

1.7 OUTLOOK OF AGRICULTURAL MECHANIZATION DEVELOPMENT IN CHINA

In the next decade, China will step into an important era of deepening reform and opening-up in several aspects. Industrialization and development of information technology will strongly support the advancement of agricultural technologies.

It is estimated that by 2020, the comprehensive mechanization rate of crop tillage, planting and harvesting will surpass 75%. Moreover, the production of major food crops including wheat, corn and rice is expected to complete full mechanization. Great progress will be made in mechanized production of major economic crops and modern facility agriculture. Agricultural mechanization will play a leading role in every aspect of modern agricultural development in China.

2. AGRICULTURAL MACHINERY TESTING AND APPRAISAL SYSTEM IN CHINA

2.1 BRIEF INTRODUCTION

2.1.1 Definition and Function

The agricultural machinery testing and appraisal is an important service provided by the Ministry of Agriculture and the provincial agricultural mechanization departments. Introduced in the 1950s, it has provided important technical support for the development of agricultural mechanization in China.

According to "*Measures of the Ministry of Agriculture for Testing and Appraising the Agricultural Machinery*", agricultural machinery testing and appraisal in China refers to the technical appraisal on the applicability, safety and

reliability of the agricultural machinery. To promote popularization and guide farmers in the selection of appropriate equipment, the agricultural machinery testing and appraisal system aims to promote agricultural production and serve the interests of farmers.

Any product that has passed the appraisal is eligible for inclusion into the support scope of state policies for financial subsidy, preferential credit and the government procurement list designed to promote technologies and popularization of agricultural mechanization, and will be popularized by agricultural administrative departments and institutions for popularizing agricultural technology.

2.1.2 Classification

The agricultural machinery testing and appraisal in China is divided by two levels, ministerial and provincial respectively. Producers or dealers of agricultural machinery can submit their products for appraisal on voluntary basis. Products that have passed the appraisal at the ministerial level do not need to undertake tests at the provincial level any more.

The ministerial appraisal mainly focuses on agricultural machinery with common technological features and scope which can be applied nationwide, while the provincial appraisal focuses on machinery with strong regional features and limited application scope.

The testing & appraisal has three main purposes (Table 2.1):

(I) Popularization: to comprehensively test performance and certify whether the tested machinery is suitable for popularization.

(II) Model selection: to be conducted by comparing test of similar types of machineries and selecting better models.

(III) Special items: to assess special performances of agricultural machinery, such as safety, reliability, energy consumption and emission etc..

The testing and appraisal for popularization is the main type of testing and appraisal in China.

Table 2.1: Classification of the Testing and Appraisal in China

Analysis items	Type		
	Appraisal for popularization	**Appraisal for model selection**	**Appraisal for special items**
Main functions	Conducting technical appraisal on applicability, safety and reliability of agricultural machinery, comprehensively appraising the performances of agricultural machinery and appraising whether the	Conducting a comparison test of similar agricultural machinery and selecting applicable models.	Assessing and appraising the special performances of the agricultural machinery.

	machinery is suitable for popularization.		
Main contents	Including production conditions audit, product performance test, safety inspection, reliability evaluation, applicability evaluation, operating manual examination and quality guarantee certificate examination and conducting user survey, etc.	According to different model selection purposes, conducting product performance test, safety inspection, reliability evaluation, applicability evaluation and advancement evaluation, etc..	According to different appraisal demands, conducting appraisal of such special items as safety, reliability and energy efficiency and environmental protection performances, etc.
Technical basis	Appraisal codes for popularization	Appraisal codes for model selection	Appraisal codes for special items

2.2 METHODOLOGY AND ASSESSMENT CRITERIA

2.2.1 Contents

The testing and appraisal for popularization mainly comprises the following contents:

1) Production conditions audit

The contents of production conditions audit mainly include: competency of enterprise personnel, production and testing equipments, technical documents, production process and after-sales service, product consistency, production safety and so on. Such audit is carried out by a team of examiners which generally consists of 2-3 people. On-site audit time is generally no more than three days.

2) Performance test and safety inspection

Performance test items shall be capable of reflecting the demand for evaluating operating requirements of the said product, which generally covers: operating capacity, operating quality, dynamic performance, environmental protection, energy consumption, and compatibility with other machines and tools.

The contents of safety inspection cover two aspects: devices and operational information. Safety device tests include moving parts, protective device for high-temperature parts and safe operating requirements for overload protection, emergency protection, electricity leakage protection and lighting. The test of operational information focuses on safety mark, for example, the functioning of safety operating devices and other necessary safety signs.

Safety check is conducted in accordance with the requirements of relevant national mandatory standards. In case of absence of such standards, reference is drawn to those specified in GB 10395.1 and GB 10396.

3) Reliability and applicability evaluation

The reliability (the ability of machines to perform specified functions under the certain condition) evaluation methodology is explicitly specified according to specific products. The reliability test may be conducted according to relevant national and professional standards. In case of adoption of this method, the testing items, testing methods and assessment criteria are specified.

Combining reliability investigation with production assessment may also be adopted. Such methodology involves a work plan, an investigation list and assessment criteria for reliability and validity of production assessment. Reliability test report by agricultural machinery testing and appraisal institutions above the provincial level may also be directly adopted as reliability evaluation references.

Items under applicability test are determined according to the application scope of products requested by the enterprise. Items and methods of evaluation are explicitly specified in the codes according to specific products. Testing results of products with provincial appraisal certificate for popularization can be regarded as evaluation reference for the specific region. The applicability evaluation may be conducted through on-site testing and/or applicability investigation, and the selected testing site and the investigation region shall be representative. For products with distinctive applicability, such as power machinery, harvest machinery, farming machinery, planting machinery, at least 3 testing sites should be selected within the application scope of products requested by the enterprise.

4) Examination of operating instructions

The contents of examination should at least include: technical specification, safety precautions, operating instructions, maintenance instruction, adjustment method and adjustment amount, list of quick-wear parts, printing quality etc. Specially, the operating instructions should be in popular and easy-to-understand language and easy to be understood by farmer users.

5) Examination of "three guarantees" certificate

The “three guarantees” in China particularly refer to the unconditional return, exchange and repair of products in after sales service. Examination of the "three guarantees" certificate is conducted in accordance with "*Regulations for Repair, Replacement and Return Responsibilities of Agricultural Machinery*". The examination includes: name of product and manufacturer, power requirement, repairer, validity of the "three guarantees" certificate for complete machine and main components, list of main components, maintenance records including delivery time, handover time, repair situation, refunds or exchanges invoices and etc..

6) User survey

User survey is a technical process of collecting and analyzing opinions on agricultural machinery in use from randomly chosen users according to the methodology. The contents of user survey include applicability, reliability, operation convenience, maintenance convenience, after-sales service and safety accidents. The user list will be provided by the production enterprise, which should include at least name, mailing address and phone number of the buyers. And the number of users

listed should not be less than five times of users surveyed. On-site or questionnaire investigation methods can be employed and adopted.

2.2.2 Appraisal criteria

A step-by-step evaluation methodology is adopted for qualification evaluation of indexes in appraisal for popularization. Level 1 indexes include: production condition audit, performance test and safety inspection, reliability evaluation, examination of operating instructions, examination of "three guarantees" certificate and user survey. Level 2 indexes include all indexes involved in technical requirements and performance testing.

All of Level 1 indexes must be qualified, and level 2 indexes may be divided into Classes A, B and C according to importance degree. Number of allowable defects for Class A indexes shall be 0; number of allowable defects for Classes B and C indexes shall be not more than 3.

If Level 1 indexes are all qualified, the approval for popularization is granted. In case that nonconformity of partial items (excluding testing items) occurs and the nonconformity may be corrected within a short period, the enterprise is allowed to make correction within a period not more than 3 months. In case corrected indexes are satisfactory, approval for popularization is granted. In case corrected indexes are still not satisfactory, the enterprise will fail the appraisal for popularization.

2.3 LEGAL BASIS

Agricultural machinery testing and appraisal regulatory framework in China is relatively well developed. For instance, the legislation on promotion of agricultural mechanization issued in 2004 provides legal status for agricultural machinery testing and appraisal institutions and guidance for testing of machinery.

According to the *Law on Promotion of Agricultural Mechanization*, the Central government supports efforts to promote the wide use of advanced and applicable agricultural machines among peasants and agricultural production and operation organizations. The agricultural machines for popularization should meet the need of local agricultural development and the machines should have to be proved to be advanced and applicable through experiment in the area.

The administrative departments for agriculture will publish the catalogue of the advanced and applicable agricultural machines which is supported by the Central government or government at provincial level, and make adjustment to the catalogue regularly.

To have their products included in the catalogue, manufacturers or sellers of agricultural machines may entrust testing institutions to make a technical appraisal of the machinery on a voluntary basis.

Another important rule governing agricultural machinery testing and appraisal is "*Measures of the Ministry of Agriculture for Testing and Appraising the Agricultural Machinery*", which was issued as Order 54 of the Ministry of

Agriculture, explicitly specifies the principle, content, procedure, timeliness and responsibility of the agricultural machinery appraisal work.

In recent years, the Chinese government has taken major steps in upgrading the regulatory framework regarding testing and appraisal of agricultural machinery. Table 2.2 offers an overview of the most relevant laws.

Table 2.2: Law and Regulations Governing Agricultural Machinery Testing and Appraisal

Number	law and regulations	Release time
1	Law of the People's Republic of China on Promotion of Agricultural Mechanization	2004/6/25
2	Measures of the Ministry of Agriculture for Testing and Appraising the Agricultural Machinery	2005/7/26
3	Measures for Implementation of Agricultural Machinery Appraisal for Popularization	2010/8/4
4	Management Rules for Certificate and Sign of Agricultural Machinery Appraisal for Popularization	2005/10/25
5	Certification Rules for Appraisal Ability of Agricultural Machinery Testing and Appraisal Institutions	2005/10/25
6	Implementation Rules of Verification of Ministerial Appraisal Ability of Agricultural Machinery Testing and Appraisal Institutions(Tentative)	2006/12/7
7	Management Rules for Agricultural Machinery Testing and Appraisal Codes of the Ministry of Agriculture	2011/11/7
8	Implementation Rules of Ministerial Agricultural Machinery Appraisal for Popularization	2012/2/10
9	Management Rules for Examiner and Inspector of Ministerial Appraisal for Popularization of the Ministry of Agriculture" and other specific operation method	2012/4/18

All the afore-mentioned laws, measures and rules are applicable to the management of ministerial and provincial agricultural machinery appraisal for popularization. Depending upon specific needs, local governments have formulated some additional specific requirements and regulations for testing and appraisal.

2.4 TECHNICAL BASIS

Chinese agricultural machinery testing and appraisal system gives great attention to technical applicability and safety. To this end, the codes specify the content, condition, and methodology to be followed. The codes are divided into ministerial and provincial level codes, and classified into three appraisal categories, specifically: codes for popularization, for model selection and for special items. In recent years, the Ministry of Agriculture and all provinces have revised the codes for

popularization, model selection and other technical specifications based on the national and professional standards.

At present, the Ministry of Agriculture has released five general codes and 81 appraisal codes of agricultural machinery appraisal for popularization. Table 2.3 presents an overview of the current effective codes directory for ministerial popularization appraisal. The provincial institutions should conduct testing in accordance with ministerial codes. Machinery utilized only in some regions can be tested at a local level according to the provincial codes by reference to the work process of ministerial appraisal. Table 2.4 illustrates the amount of testing codes for provincial popularization appraisal.

The "Management Rules for Agricultural Machinery Testing and Appraisal Codes of the Ministry of Agriculture" was released in 2011, defining the formulation, revision, examination and approval procedures of the ministerial appraisal codes.

According to the management rules, agricultural machinery testing institutions can propose to revise ministerial codes and submit them to the China Agricultural Machinery Testing Center (CAMTC) prior to the end of October every year. The CAMTC technical committee is in charge of studying the recommendations on the revision plans and reporting to the Agricultural Mechanization Department of the Ministry of Agriculture for examination and approval. Each institution should complete the revision work before April 20 of the next year, and submit to the CAMTC after being checked and signed by the technical director of the institution.

The CAMTC should organize a meeting to examine the draft code according to the rules for examination and approval of code and the relevant technical documents based on which the code is draft. The approval materials for ministerial code should be submitted to the Ministry of Agriculture within 10 working days after the meeting is completed. Annex I explains in detail the rules regarding drafting appraisal codes.

Table 2.3: Directory of Current Codes of the Ministerial Agricultural Machinery Testing & Appraisal for Popularization

No.	Number	Name of Codes	No.	Number	Name of Codes
1	DG/T 001-2011	Agricultural wheeled and crawler tractors	**44**	DG/T 044-2011	Feed mixer
2	DG/T 002-2011	Walking tractor	**45**	DG/T 045-2011	Granular-feed press
3	DG/T 003-2011	Agricultural diesel engine	**46**	DG/T 046-2011	Feed processing unit
4	DG/T 004-2012	Tillage machine	**47**	DG/T 047-2007	Ventilator
5	DG/T 005-2007	Rotary cultivator	**48**	DG/T 048-2007	Fruit grading machinery
6	DG/T 006-2012	Micro tillage machine	**49**	DG/T 049-2007	Fruit washing and waxing machine

7	DG/T 007-2006	Planter	**50**	DG/T 050-2012	Milking machinery
8	DG/T 008-2009	Rice transplanter	**51**	DG/T 051-2012	Milk storage (refrigerated) tank
9	DG/T 009-2011	Power sprayer	**52**	DG/T 052-2011	Forage harvester
10	DG/T 010-2011	Boom sprayer	**53**	DG/T 053-2009	Forage grass tearing chopper
11	DG/T 011-2011	Knapsack sprayer-duster	**54**	DG/T 054-2012	Total mixed ration preparation machine
12	DG/T 012-2006	Hand sprayer	**55**	DG/T 055-2009	Manure cleaner
13	DG/T 013-2006	Pedal sprayer	**56**	DG/T 056-2012	Roller shutter machine
14	DG/T 014-2009	Grain combine harvester	**57**	DG/T 057-2011	Cole combine harvester
15	DG/T 015-2009	Corn harvester	**58**	DG/T 058-2011	Whole set of rice milling equipment
16	DG/T 016-2006	Field straw chopper	**59**	DG/T 059-2011	Large sprinkler
17	DG/T 017-2006	Grain drier	**60**	DG/T 060-2011	Box-type hatching machine
18	DG/T 018-2006	Whole set of seed processing equipment	**61**	DG/T 061-2011	Feeder for chicken
19	DG/T 019-2011	Agricultural screw press	**62**	DG/T 062-2011	Chicken farming equipment, cage and cage frame for laying hens
20	DG/T 020-2011	Centrifugal pump	**63**	DG/T 063-2011	Aerator
21	DG/T 021-2011	Submersible electric pump	**64**	DG/T 064-2011	Feeding machine
22	DG/T 022-2011	Micro pump	**65**	DG/T 065-2011	Straw pellet press
23	DG/T 023-2011	Feed grinder	**66**	DG/T 066-2011	Underwater dredging machinery
24	DG/T 024-2011	Hay cutter	**67**	DG/T 067-2011	Hydraulic pond excavating unit
25	DG/T 025-2012	Cotton harvester	**68**	DG/T 068-2011	Separating equipment for oily water on

					fishery vessel bilge
26	DG/T 026-2012	Subsoiler	**69**	DG/T 069-2011	Fishery vessel winch
27	DG/T 027-2007	Rotary drill seeder	**70**	DG/T 070-2012	Hydraulic turnover plow
28	DG/T 028-2007	No-tillage planter	**71**	DG/T 071-2012	Biaxial stubble rotary cultivator
29	DG/T 029-2011	Air-assisted sprayer	**72**	DG/T 072-2012	Pastoral management machine
30	DG/T 030-2011	Electric sprayer	**73**	DG/T 073-2012	Disk harrow
31	DG/T 031-2011	Thermal aerosol sprayer	**74**	DG/T 074-2012	Seeding tray seeding planter
32	DG/T 032-2007	Pump for plant protection machinery	**75**	DG/T 075-2012	Insecticidal lamp
33	DG/T 033-2007	Thresher	**76**	DG/T 076-2012	Tea leaf picker
34	DG/T 034-2007	Seed cleaner	**77**	DG/T 077-2012	Peanut harvesting machinery
35	DG/T 035-2007	Seed coating machine	**78**	DG/T 078-2012	Potato harvesting machinery
36	DG/T 036-2011	Rice mill	**79**	DG/T 079-2012	Tea cylinder water-removing machine
37	DG/T 037-2011	Small roller mill	**80**	DG/T 080-2012	Tea rolling machine
38	DG/T 038-2011	Whole set of small flour processing equipment	**81**	DG/T 081-2012	Tea dryer
39	DG/T 039-2007	Potato starch processing machinery	**82**	TZ 1-2011	Rules for Drafting Appraisal Codes for Popularization of Agricultural Machinery
40	DG/T 040-2007	Light and small sprinkler	**83**	TZ 2-2006	Operation manual examination
41	DG/T 041-2011	Hay mower	**84**	TZ 3-2006	Quality guarantees certificate examination
42	DG/T 042-2011	Hay rake	**85**	TZ 4-2011	Production conditions audit
43	DG/T 043-2012	Baler	**86**	TZ 5-2006	User survey

Table 2.4: Amount of Codes of the Provincial Agricultural Machinery Testing & Appraisal for Popularization (in 2013)

Province	Amount of codes	Province	Amount of codes
Beijing	44	Hubei	63
Tianjin	32	Hunan	105
Hebei	27	Guangdong	158
Shanxi	70	Guangxi	74
Inner Mongolia Autonomous	24	Hainan	4
Liaoning	24	Chongqing	9
Jilin	19	Sichuan	56
Heilongjiang	140	Guizhou	18
Shanghai	31	Yunnan	/
Jiangsu	145	Shanxi	/
Zhejiang	53	Gansu	71
Anhui	86	Qinghai	16
Fujian	96	Ningxia	17
Jiangxi	37	Xinjiang	62
Shandong	50	State Owned Farm in Heilongjiang	96
Henan	97	Xinjiang Production and Construction Corps	/

2.5 TESTING AND APPRAISAL INSTITUTIONS

2.5.1 Nationwide Distribution of Institutions

Agricultural machinery testing and appraisal should be implemented by institutions belonging to the agricultural mechanization administrative department of the government above provincial level. To be recognized, institutions should meet the following requirements:

(1) Be legally registered as a non-profit public organization;

(2) Satisfy national metrology requirements;

(3) Possess the capabilities in terms of staff, sites, equipment and facilities to perform agricultural machinery testing and appraisal works;

(4) Implement the working systems and operations according to the requirements of the appraisal of agricultural machinery.

So far, a total of 35 agricultural machinery appraisal institutions above the provincial level are active in China. These include CAMTC, Crop Protection Machinery Testing Station of CAMTC, Fishery Machinery Testing Station of CAMTC, Agricultural Machinery Testing Station of the State Owned Farm in Heilongjiang Province, and Testing Station in Xinjiang Production and Construction Corps, which together with stations of other provinces, form a comprehensive nation-wide network. All above agricultural machinery testing and appraisal institutions are public institutions affiliated with the Ministry of Agriculture and agricultural mechanization administrative departments of governments at the provincial level.

By the end of 2013, the nationwide agricultural machinery testing and appraisal network had more than 1,300 employees, among which, more than 1,000 were specialized technical personnel, with more than 11,400 sets of instruments and equipment, and around 940,000 m² of working area, including 120,000 m² for laboratories.

Table 2.5: List of Agricultural Machinery Testing and Appraisal Institutions at and above Provincial Level in China

No	Name of the Institutes	Staff Number (person)	Floor Area（m^2）	Instruments & Equipment（sets）
1.	China Agricultural Machinery Testing Center, Ministry of Agriculture	102	46104	600
2.	Beijing Municipal Agricultural Machinery Testing & Extension Station	56	4339	132
3.	Tianjin Municipal Agricultural Machinery Testing Station	32	3240	89
4.	Hebei Provincial Agricultural Machinery Testing Station	31	6700	343
5.	Shanxi Provincial Agricultural Machinery Quality Supervision & Management Station	50	10000	1117
6.	Agricultural and Animal Husbandry Machinery Quality Supervision & Management Station of Inner Mongolia Autonomous Region (Pasture Machine Testing Station of CAMTC)	59	20000	498
7.	Liaoning Provincial Agricultural Machinery Quality Supervision & Management Station (Fodder and Grain Processing Machine Testing Station of CAMTC)	66	18400	196
8.	Jilin Provincial Agricultural Machinery Testing Station	71	46800	585

9.	Heilongjiang Provincial Agricultural Machinery Testing Station (Northern Economic Crops Machine Testing Station of CAMTC)	77	17508	537
10.	Shanghai Municipal Agricultural Machinery Testing Station	15	150000	315
11.	Jiangsu Provincial Agricultural Machinery Testing Station	65	186760	460
12.	Zhejiang Provincial Agricultural Machinery Testing & Extension Station	10	4600	150
13.	Anhui Provincial Agricultural Machinery Testing Station	39	20453	209
14.	Fujian Provincial Agricultural Machinery Testing & Extension Station	24	508	64
15.	Jiangxi Provincial Agricultural Machinery Testing Station	21	20000	240
16.	Shandong Provincial Agricultural Machinery Testing Station	33	138100	420
17.	Henan Provincial Agricultural Machinery Testing Station	25	46620	375
18.	Hubei Provincial Agricultural Machinery Testing Station	23	6600	297
19.	Hunan Provincial Agricultural Machinery Testing Station	60	59000	330
20.	Guangdong Provincial Agricultural Machinery Testing Station	28	9780	993
21.	Agricultural Machinery Testing Station of the Guangxi Zhuang Autonomous Region (Subtropical Crops Machine Testing Station of CAMTC)	30	13000	354
22.	Hainan Provincial Agricultural Machinery Testing & Extension Station	20	3000	35
23.	Chongqing Municipal Agricultural Machinery Testing Station (Irrigation Machine Testing Station of CAMTC)	41	16038	391
24.	Sichuan Provincial Agricultural Machinery Testing Station	63	11299	334
25.	Guizhou Provincial Agricultural Machinery Testing Station	75	/	634
26.	Yunnan Provincial Agricultural Machinery Testing Station	12	240	20
27.	Shaanxi Provincial Agricultural Machinery Testing Station	16	350	177
28.	Gansu Provincial Agricultural Machinery Testing Station	40	5000	176
29.	Qinghai Provincial Agricultural and Animal Husbandry Machinery Testing Station	25	250	144
30.	Agricultural Mechanization technology extension station of the Ningxia Hui Autonomous Region	36	2667.56	91
31.	Agricultural and Animal Husbandry Machinery Testing Station of Xinjiang Uygur Autonomous Region	37	60603.03	620
32.	Crop Protection Machinery Testing Station of CAMTC	24	4000	215

33.	Fishery Machinery Testing Station of CAMTC	19	2498	380
34.	Agricultural Machinery Testing Station of State Owned Farm in Heilongjiang Province	28	3700	439
35.	Testing Station in Xinjiang Production and Construction Corps	14	557	30

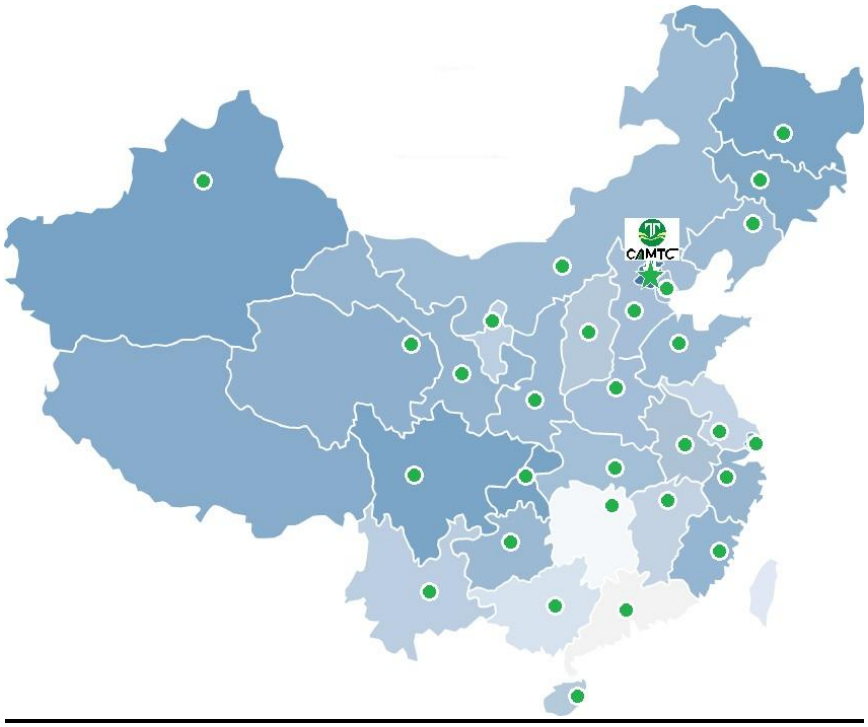


Figure2.1: Distribution of Agricultural Machinery Testing and Appraisal Institutions above Provincial Level in China

2.5.2 Brief introduction of CAMTC

The China Agricultural Machinery Testing Center is the leading national institutions. It was founded in 1951 as the national level institution for agricultural machinery testing and appraisal, and it is registered as public institution with an independent legal entity position for science and technology and quality technical supervision.

The total area of the Center is 46,104 m^2 of which the testing fields occupies 29,251 m^2, the total building area is 19,810 m^2, of which the testing laboratories area is 3,185 m^2. By 2013, the office employees 102 people, including 12 professor level engineers, 31 senior engineers and 34 engineers.

Since its establishment, CAMTC worked on testing, quality inspection and supervision, aiming to support production, extension of advanced and appropriate

machinery, and the improvement of technical performance and quality. Throughout the years, CAMTC has been widely recognized not only in China and but also abroad[3].

CAMTC is equipped with functional testing laboratories for tractors, engine, water-saving irrigation, plant protection machinery, and even spare parts. Moreover, CAMTC possesses tractor test ground and over 600 sets of domestic and imported equipment and facilities.

In addition, CAMTC can carry out test and inspection of more than 80 kinds machines and spare parts in accordance with national and international standards, such as tractor internal combustion engines, combine harvesters, field management machinery, post-harvest processing machinery, farm and sideline products primary processing machinery, seed processing machinery, and animal husbandry and aquaculture breeding machinery.

2.6 MANAGEMENT SYSTEM

2.6.1Laboratory qualification accreditation management

According to the regulations, institutions providing notarization data to the general public must pass the assessment of its metrological verification, testing capability and reliability, which are carried out by the metrology administrative department of the government above the provincial level. Data provided by product quality inspection institutions can be legally used as notarization data for issuing trade certificates, product quality evaluation and results identification.

Product quality inspection institutions acquiring metrology accreditation certificates can apply the metrology accreditation symbol (CMA, China Metrology Accreditation) on its product inspection report for the inspection items listed in the certificate.

All agricultural machinery testing and appraisal institutions have passed the metrology accreditation carried out by authorized organizations, and their inspection jobs must be within the range of metrology accreditation.

2.6.2 Specialized management of testing and appraisal

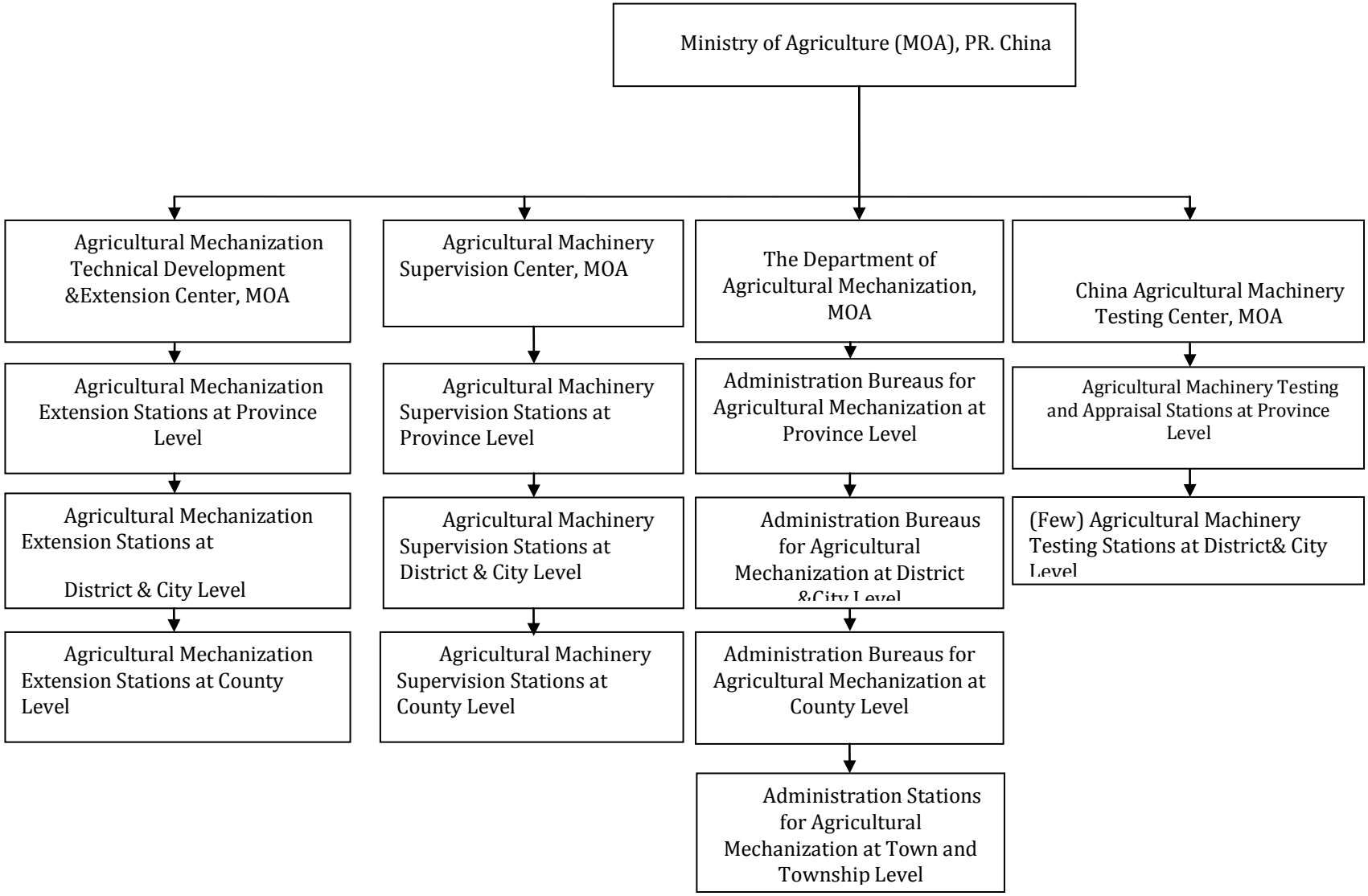
The Agricultural Mechanization Department of the Ministry of Agriculture and their counterparts in the provincial government respectively determine and take charge of agricultural machinery testing and appraisal institutions and related work.

3 Such recognized organizations include “Authorized Testing Laboratory in Accordance with OECD Standard Codes for the Official Testing of Agricultural and Forestry Tractors”, “Certified Laboratory of Agricultural Machinery”, “National Tractor Quality Supervision and Inspection Centre (Beijing)”, “Testing Center of Quality Inspection & Supervision for Agricultural Machinery of the Ministry of Agriculture(MOA)”. CAMTC affiliated institutions include “China Certification Center of Agricultural Machinery(CAM)”, “Information Center of China Agricultural Machinery Information Website”, “Qualification and Training Center for Agricultural Machinery Vocational Skills”, “Agricultural Machinery Repairing & Maintenance Management and Service Center”, “Technical Subcommittee on Agricultural Mechanization of the National Agricultural Machinery Standardization Technical Committee”, “Agricultural Machinery Quality Complaint & Supervision Center of Consumers’ Association”, and “China Agricultural Mechanization Association (CAMA)”.

The Ministry of Agriculture is in charge of formulating, adjusting and issuing the guideline on the types of products subject to the national appraisal. Moreover, the Ministry of Agriculture is also responsible for issuing testing codes. Similarly, local agricultural mechanization administrative department respond directly to the central government and discharge functions within their administrative area.

In addition, the agricultural mechanization administrative department at the national level supervises conditions of popularization certificates, symbols on products and general appraisal procedures. When complaints are reported by users, the administrative department will organize an investigation to further check on the appraisal.

Figure 2.2: Organizational Framework of Agricultural Mechanization Management in China



2.6.3 Authorization of Testing and Appraisal Institutions

According to the regulations, the authorization to undertake ministerial and provincial appraisal tasks should be issued by the competent administrative departments of agricultural mechanization through technical verification.

The verification includes qualification and metrology accreditation, which aims to assess instruments and equipment, facility environment, operation specifications and personnel quality which correspond to the applied certification items.

Since 2006, the Ministry of Agriculture organized and carried out three batches of ministerial appraisal ability authorization, and increased the quantity of the institutions responsible for ministerial appraisal up to 30. Those 30 institutions carry out the work of ministerial appraisal according to the "five uniformity" principles:

- uniform application acceptance;
- uniform appraisal codes;
- uniform charging standard;
- uniform arrangement of appraisal tasks;
- uniform issuance of certificates and logos,

The “five uniformity” principle promotes fairness and efficiency of the ministerial appraisal for popularization, strengthens the authority of the system, and promotes a balanced development of appraisal institutions both at the national and local level.

2.6.4 Supervision and Inspection over Institutions

In order to promote the standardized development of agricultural machinery testing and appraisal, the Ministry of Agriculture carries out on-site supervision and inspection over competent institutions. The main contents of supervision and inspection cover the management condition and the service deployment condition of agricultural machinery appraisal for popularization.

From 2012 to 2014, the Ministry dispatched 10 inspection teams to carry out on-site supervision and inspection over the management and services, and the results of inspections were issued by the Ministry to promote further standardization among testing centers.

2.6.5 Personnel Management

Personnel engaging in agricultural machinery testing and appraisal include examiners and inspectors. Examiners are engaged in the production condition audit for popularization as well as the supervision and inspection within the validity period of the certificate, while inspectors are engaged in performance testing for popularization of the agricultural machinery. Examiners and inspectors should have attended national training and have the necessary qualifications. CAMTC is responsible for training, examination, registration supervision of the examiners engaging in ministerial appraisal.

2.6.6 Procedure

The machinery producers or the sellers that apply for testing and appraisal should submit the following materials to these institutions: (1) application forms; (2) copies of the business licenses of enterprise legal persons; (3) the documents related to the new product; (4) the product standard; (5) the product specifications.

The agricultural machinery testing and appraisal institutions should examine the application materials within 10 days after receiving the applications, decide whether or not to accept, and notify the enterprises in writing.

Institutions should issue the appraisal reports to the enterprises within 15 days after the end of the test. They are also in charge of submitting reports and relevant materials to the competent administrative departments.

The Department of Agricultural Mechanization, MOA, has 15 days to check if the provided material is complete and accurate and in accordance with relevant regulations. Then the departments should contact specialized media to introduce the new products.

Regarding the popularization appraisals, the competent administrative departments should issue the certificates within 10 days after the announcement, and authorize manufacturers to display the appraisal symbol.

The working procedures of ministerial appraisal for popularization are shown in Figure 2.3. The provincial appraisal should follow the working procedures of the ministerial appraisal.

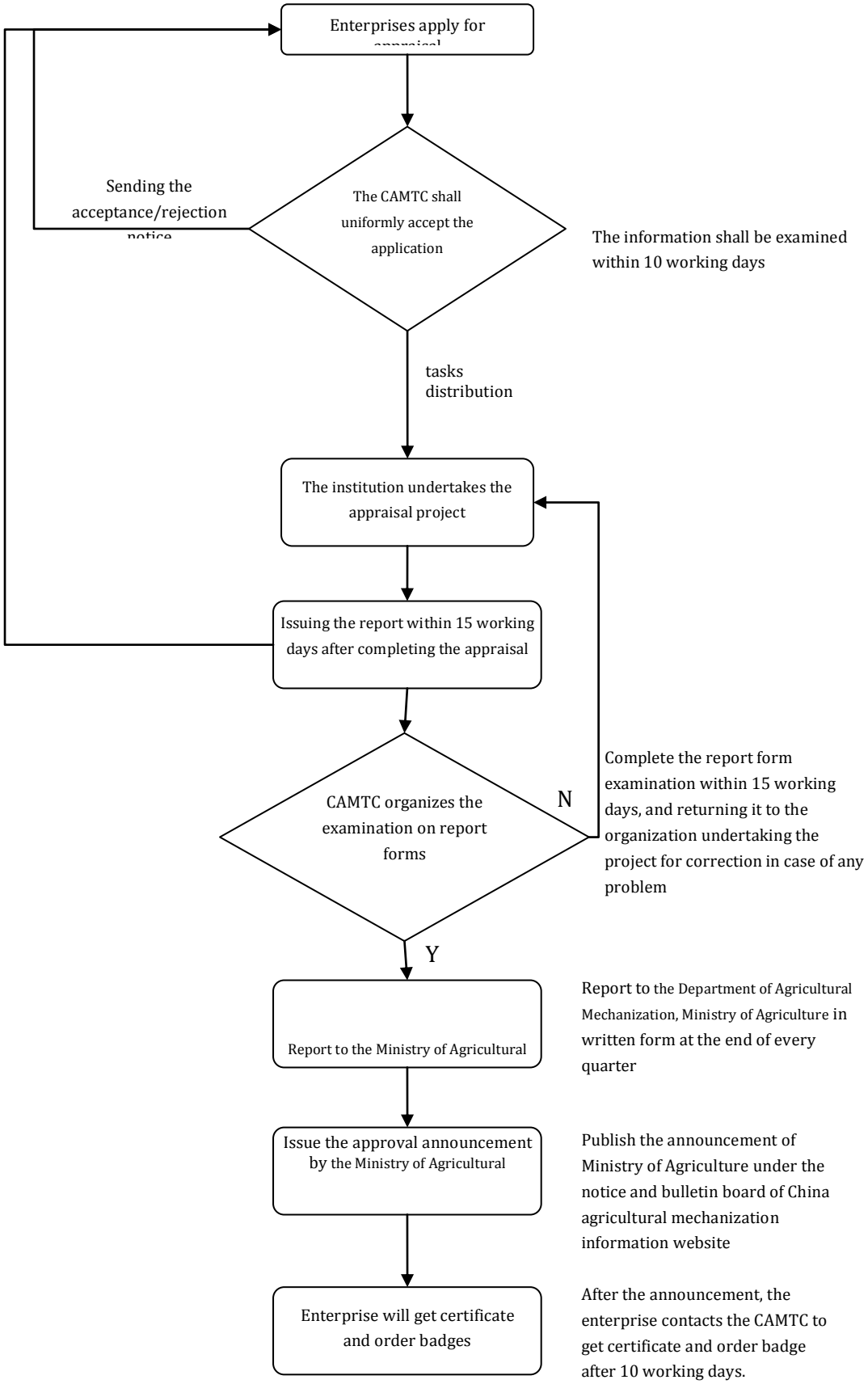


Figure 2.3: The Working Procedures of Ministerial Appraisal for Popularization

2.7 OUTCOMES OF TESTING AND APPRAISAL

Testing and appraisal provides powerful technical support and guarantees the standardized evolution of agricultural mechanization. Over the years, testing and appraisal institutions have supported the development and popularization of many important machines and tools, including chemical fertilizer deep placement, precision sowing, cereal drying and straw turnover, etc..

In particular, since the implementation of national machinery purchase subsidy policy, agricultural machinery testing and appraisal results have served as one of the necessary preconditions for formulating "Catalogue of Agricultural Machinery Products Popularized by the State" and have greatly improved the overall quality of subsidized products and provided significant technical support for effective implementation of the policy.

Another important contribution of the testing and appraisal system is to guide farmers in the purchase of equipment. Throughout the years, the "Certificate for Agricultural Machinery Appraisal for Popularization" has become an important tool for agricultural machinery companies to purchase products and for farmers to select machinery. It is a nationwide guarantee of quality for farmers and is now starting to gain international recognition. In fact, some foreign manufacturers have recently started to apply for the Chinese certification in order to enter into the Chinese market.

Moreover, the system has promoted technological advancement and guided manufactures toward common guidelines. As a matter of fact, the system forces companies to improve products performance in terms of safety and environmental standards, and encourages them to eliminate outmoded products. The system also provides companies with feedback on product performance. It analyzes the existing problems and proposes suggestions for improvement. Especially, the test for popularization, which combines testing and investigation, provides important information on quality, technology and market competitiveness.

The following tables provide statistics on certificates for popularization issued at ministerial and provincial levels from 2010 to 2013.

Table 2.6: Statistics on Appraisal Certificates for Popularization of Machinery Issued at the Ministerial Level between 2010 and 2013

No	Categories	Items	Quantity of Appraisal Certificates			
			2010	2011	2012	2013
01	tillage and soil preparation machinery	rotary tiller	63	13	36	140
		agricultural tiller	3	1	2	2
		mini-tiller	9	3	6	164
		field manage machine	0	0	0	9
		subsoiler (combined tillage machine）	2	0	0	0

02	planting and fertilization machinery	single seed drill（precision drill）	0	0	0	7
		no-tillage seeding drill	0	0	1	19
		Rotary drill	12	0	2	5
		rice transplanter	39	32	35	60
03	field management machinery	knapsack sprayer	54	15	15	14
		boom sprayers	21	12	6	7
		air-assisted sprayers	5	1	6	4
		dry fog machine	0	0	0	0
		electric power sprayer	1	4	0	0
		motorized sprayer	3	3	4	1
04	harvesting machinery	grain combine-harvester	122	114	107	145
		corn combine	75	94	112	141
		rape (seed)harvesting machine	0	0	32	14
		cotton harvesters	0	0	0	0
		forage harvester	0	0	0	3
		straw shredding returning machine	3	2	0	17
		bundling machine	0	0	1	2
05	post-harvest processing machinery	grain drier	6	0	3	16
06	agricultural products primary processing machinery	agricultural spiral oil press	6	4	0	0
07	arainage and irrigation machinery	centrifugal pump	2	0	3	2
		submersible motor-pump	17	4	0	23
		micro pump	1	0	0	0
		small-sized light sprinkler	0	0	7	0
		large-sized sprinkler	0	0	0	0
08	animal	excrement cleaner	0	0	1	0

	husbandry and aquaculture machinery	milking machine	0	0	4	23
		milk tanks	0	0	8	12
		feed preparation machine（TMR）	3	0	1	4
		aerator	0	0	4	2
		feeder	0	0	0	1
09	power machinery	wheeled tractor	320	226	237	450
		crawler tractors	5	6	4	3
		2 wheel tractors	102	81	26	66
		agricultural diesel engine	137	48	72	28
others			55	16	13	108

Table 2.7: Statistics on Appraisal Certificates for Popularization of Agricultural Machinery Issued at Provincial Level between 2010 and 2013

No.	Province/Autonomous Region/Municipality	Quantity of Certificates			
		2010	2011	2012	2013
1	Beijing	10	5	/	8
2	Tianjin	12	24	9	9
3	Hebei	310	258	269	264
4	Shanxi	202	225	30	76
5	Inner Mongolia Autonomous	210	177	148	120
6	Liaoning	200	105	69	119
7	Jilin	72	63	34	50
8	Heilongjiang	210	260	328	148
9	Shanghai	38	55	45	29
10	Jiangsu	545	449	421	458
11	Zhejiang	/	/	135	197
12	Anhui	331	332	429	524
13	Fujian	173	204	104	384
14	Jiangxi	205	84	118	31
15	Shandong	533	480	401	191

16	Henan	505	364	463	468
17	Hubei	/	223	271	256
18	Hunan	495	140	174	176
19	Guangdong	66	108	34	53
20	Guangxi	132	87	70	121
21	Hainan	/	0	0	0
22	Chongqing	181	60	135	197
23	Sichuan	205	150	162	256
24	Guizhou	15	46	42	/
25	Yunnan	60	76	71	93
26	Shanxi	0	0	0	0
27	Gansu	288	253	353	270
28	Qinghai	127	38	41	32
29	Ningxia	51	51	39	46
30	Xinjiang	/	198	261	290
31	Nongken State Owned Farm in Heilongjiang	102	189	179	184
32	Xinjiang Production and Construction Corps	0	0	0	0

2.8 DEVELOPMENT EXPERIENCES IN CHINA

The Chinese experiences have four fundamental characteristics:

Firstly, agricultural machinery testing and appraisal work is supported by a comprehensive system of regulations. Establishing and improving laws and regulations is one of the most important conditions to regulate market system and to promote smooth healthy development of agricultural mechanization. This is also a necessary condition for development of the appraisal system.

Secondly, non-profit agricultural machinery testing and appraisal institutions are supported by investment from the government. The Chinese government has been giving greater attention to the testing system, subsidizing the agricultural machinery testing and appraisal institutions by investing in laboratory testing equipment and providing testing subsidies.

Thirdly, in order to achieve the coordination and development of agricultural machinery testing and appraisal work, systematic resources must be incorporated

and fully exploited. Unified and normative standards and work procedures shall be developed, while unified management mode shall be established.

Finally, an important component of the Chinese agricultural machinery testing and appraisal system is human resource development, particularly regular training of employees and certification of their technical competence.

2.9 CHALLENGES AND OUTLOOK FOR FUTURE DEVELOPMENT IN CHINA

2.9.1 Challenges

The rapid development of agricultural mechanization is a challenge to effectiveness of the agricultural machinery testing and appraisal system.

Upon the full implementation of the subsidy policy, the types and quantity of agricultural machinery needed to be certified quickly raised. The agricultural machinery testing and appraisal system lacks of technical and infrastructural support to satisfy the rapid increase of testing needs.

Moreover, imbalances among institutions nationwide, in terms of professional personnel and structural capabilities are undermining the potential outcome of the system. For instance, the nationwide agricultural machinery testing and appraisal ability allocation list shows the testing and appraisal for some products, like tilling planting and fertilizing machinery are relatively well developed, whereas facilities for products like plant protection, renewable energy equipment, are less developed and cannot meet the markets demands.

Another constraint is posed by management of the agricultural machinery testing and appraisal system nationwide. Specifically, the ministerial appraisal management system and technical specification, as well as provincial codes need to be greatly improved. Moreover, it is important that national authorities establish a standardized training mechanism for professionals.

Furthermore, R&D on agricultural machinery testing should be encouraged, especially in areas of agricultural machinery testing and appraisal including, applicability, safety and reliability.

2.9.2 Outlook

In recent years, rural economy in China has entered into a new stage with huge market potentials both for production and usage. In particular, new types of management system, such as family farms, will play an important role, along with improvement of farm infrastructure. This environment will greatly support efforts for agricultural mechanization.

In the future, the demand for agricultural machinery will be increasing rapid with higher requirements for product performance and quality. To meet these demands, agricultural machinery testing and appraisal institutions must upgrade testing equipment, methodology, and evaluation criteria and develop human resources.

In order to face the challenges, competent authorities need to focus on the following reforms and initiatives:

Revise the legal framework and enhance the level of standardization. Specifically, the "Measures of the Ministry of Agriculture for Testing and Appraising the Agricultural Machinery" and other relevant regulations will be revised along with management rules of testing and appraisal codes. Agricultural machinery testing and appraisal institutions will have more decision-making right on approval and certification, in order to maximize the simplified procedures, easing the burden on enterprises and improve the work efficiency.

Promote technological innovation. Research on test methodology will be strengthened along with automatic and digital testing instruments.

Strengthen the overall coordination. The nationwide agricultural machinery testing and appraisal ability for main crops like cotton, oil and sugar will be enhanced. Supporting machines and tools will be provided for water-saving irrigation, precision sowing, high-efficiency plant protection and crop straw comprehensive utilization. Testing and appraisal ability will also be increased for the high-yield, high-efficiency, resource-saving and environmentally friendly technologies and machines.

Institutions at the national level will concentrate on appraisal of products with wider application and high technology that are suitable for popularization nationwide. Meanwhile, provincial institutions should develop their regional ability for machines used for cash crops of their particular regions.

ANNEX:

(Unofficial translation)

GENERAL APPRAISAL RULES FOR POPULARIZATION OF AGRICULTURAL MACHINERY

TZ 1-2011

Rules for Drafting Appraisal Code for Popularization of Agricultrual Machinery

1 SCOPE

The Rules specify the numbering rules and requirements for structure and drafting of appraisal code for popularization of agricultural machinery.

The Rules are applicable to the drafting of appraisal code for popularization of agricultural machinery, and may be referred to by the appraisal code for model selection and special items of agricultural machinery.

2 NORMATIVE REFERENCES

The following documents for the application of this document are essential. Any dated reference, just dated edition applies to this document. For undated references, the latest edition (including any amendments) applies to this document.

GB/T 1.1	"Directives for Standardization - Part 1: Structure and Drafting of Standards"
GB/T 2260	"Codes for the Administrative Divisions of the People's Republic of China"
GB 10395.1	"Agricultural and Forestry Machinery - Safety - Part 1: General Requirements"
GB 10396	"Tractors, Machinery for Agriculture and Forestry, Powered Lawn and Garden Equipment - Safety Signs and Hazard Pictorials - General Principles"
TZ 2	"General Appraisal Rules for Popularization of Agricultural Machinery - Examination of Operating Instructions"

TZ 3	"General Appraisal Rules for Popularization of Agricultural Machinery - Examination of 'Three Guarantees' Certificate"
TZ 4	"General Appraisal Rules for Popularization of Agricultural Machinery - Examination of Production Conditions"
TZ 5	"General Appraisal Rules for Popularization of Agricultural Machinery - User Survey"
	"Regulations for Repair, Replacement and Return Responsibilities of Agricultural Machinery"

3 TERMS AND DEFINITIONS

For purpose of this document, the following terms and definitions apply.

3.1 Appraisal code for popularization of agricultural machinery (hereinafter referred to as "code")

The document which specifies the appraisal contents, testing conditions, testing methods and judgment rules regarding appraisal for popularization of agricultural machinery and serves as the appraisal reference for the popularization of agricultural machinery upon approval of competent departments for farm mechanization at or above the provincial level.

3.2 Safety

Refer to the capability of agricultural machinery products to protect the safety of human, machine, environment and agricultural product quality under specified service conditions.

3.3 Reliability

Refer to the capability of agricultural machinery products to maintain specified functions and characteristics under specified conditions and within the specified time limit (or operating quantity).

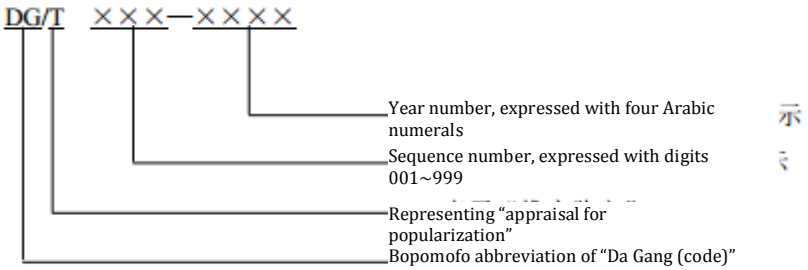
3.4 Applicability

Refer to the capability of agricultural machinery products to maintain specified characteristics and meet the requirements for local agricultural production under local natural conditions, crop variety and farming system.

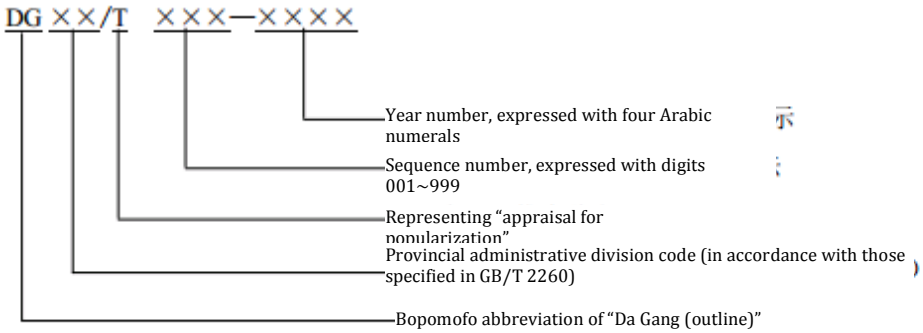
4 CODE NUMBERING RULES

Serial number of the code consists of code number, sequence number and year number.

Serial number of appraisal code for popularization of agricultural machinery by the Ministry of Agriculture:



Serial number of provincial (district and municipal) appraisal code for popularization of agricultural machinery:



5 STRUCTURE OF THE CODE

5.1 Cover

5.2 Contents

5.3 Foreword

5.4 Scope

5.5 Normative references

5.6 Terms and definitions (if required)

5.7 Basic requirements

5.7.1 Documents required to be supplemented by the applicant

5.7.2 Testing conditions

5.7.3 Requirements for accuracy of the tested parameters and instrument and equipment

5.7.4 Prototype (sample) determination

5.8 Appraisal contents and methods

5.8.1 Technical requirements and performance test

5.8.2 Safety check

5.8.3 Reliability evaluation

5.8.4 Applicability evaluation

5.8.5 Examination of operating instructions

5.8.6 Examination of "three guarantees" certificate

5.8.7 Examination of production conditions

5.8.8 User survey

5.9 Judgment rules

5.9.1 Single item judgment

5.9.2 Comprehensive judgment

5.10 Appendixes

6 DRAFTING CONTENTS AND REQUIREMENTS

6.1 General

The code shall be complete and intact regarding contents, clear regarding drafting level, and concise and explicit in language expression. Figures, tables, formulae, referenced standards, quoted provisions and charts, numerical value expression, and units and symbols for quantities thereof shall all meet those specified in GB/T 1.1. See Appendix A for font and font size requirements, and Appendix B for typesetting requirements.

6.2 Cover

See Appendix C for contents of and drafting format for the cover.

6.3 Contents

Foreword, chapters, Level 1 articles and appendixes with titles and their corresponding page numbers are listed in the sequence to draft concrete contents of the code. Terms in "Terms and Definitions" shall not be listed, and contents for electronic text shall be automatically generated.

6.4 Foreword

Requirements and recommendatory provisions, formulae, figures and tables shall not be included. The following contents shall be given successively as appropriate:

- Drafting rules referred to for the code preparation, with TZ 1 mentioned;

- Formulation and reversion of the code; in case of reversion, explanation for all or some other documents superseded by the code shall be given, and main technical changes from the previous edition shall be listed;

- Information about the proposing and jurisdiction of the code. "Appraisal Code for Popularization of Agricultural Machinery" is proposed by Department of Farm Mechanization of the Ministry of Agriculture of the People's Republic of China and under the jurisdiction of China Agricultural Machinery Testing Centre.

- Drafting organization(s) and chief drafting staff of the code. The drafting organization(s) of the code shall be given in full name(s) and present name(s).

For example, this code is drafted according to TZ 1-2011 "Rules for Drafting Appraisal Code for Popularization of Agricultural Machinery".

This code is herein formulated for the first time. (This code is revised from DG/T ×××-××××.)

This code is proposed by: Department of Farm Mechanization of the Ministry of Agriculture of the People's Republic of China.

This code is under the jurisdiction of China Agricultural Machinery Testing Centre.

Drafting organization of this code: ...

Chief drafting staff of this code:...

6.5 Scope

Scope of products and condition requirements applicable to this code shall be herein given. If necessary, the scope not applicable to this code may also be given, excluding requirements. For example, this code specifies the appraisal contents, methods and judgment rules regarding the appraisal for popularization of ...

This code is applicable to the appraisal for popularization of ...

6.6 Normative references

Normative references for the code shall be national standards, professional standards, general appraisal rules for popularization of agricultural machinery, similar appraisal code or other regulations; in principle, mandatory standards are quoted without indicating the date; the arrangement sequence is from national standards, professional standards, general rules, code to other regulations in serial number from the small to the big. Documents referred to in drafting the code shall not be listed in "Normative References".

"Normative References" shall be led out with the introduction below:

"The following documents for the application of this document are essential. Any dated reference, just dated edition applies to this document. For undated references, the latest edition (including any amendments) applies to this document."

For example, the following documents for the application of this document are essential. Any dated reference, just dated edition applies to this document. For undated references, the latest edition (including any amendments) applies to this document.

GB/T ××××-×××× "××××××××"

JB/T ××××-×××× "××××××××"

NY/T ××××-×××× "××××××××"

TZ ×××-×××× "××××××××"

DG/T ×××-×××× "××××××××"

6.7 Terms and definitions

Terms and definitions shall be given in case misunderstanding will be caused regarding their meanings or puzzle or ambiguity will be generated regarding technical contents while no definition is given.

"Terms and Definitions" shall be led out with proper introduction below:

"For the purposes of this document, the following terms and definitions apply." or "For the purposes of this document, terms and definitions specified in ..... and those below apply."

For example,

For the purposes of this document, the following terms and definitions apply.

×××× (terms)

×××× (definitions)

6.8 Basic requirements

6.8.1 Documents required to be supplemented by the applicant

Besides materials submitted in application, documents required to be supplemented by the applicant shall generally cover:

a) Confirmation form for product specification, stamped by official seal (see 6.9.1.1 of the Rules for concrete requirements);

b) Prototype photos (which shall be capable of fully reflecting prototype features);

c) Hard copy of approval of product registration trademark (if any);

d) Manual for compilation of enterprise quality management system or quality manual;

e) Brief introduction on enterprise;

f) Other necessary documents. If product drawings are demanded, requirements for category and quantity of product drawings shall be indicated in the code.

6.8.2 Testing conditions

Requirements for testing conditions like environment, field, material and prototype status for testing are specified.

Testing conditions shall meet those specified in relevant standards, and technical status of the prototype shall be adjusted according to those specified in operating instructions. If testing conditions are relatively more or much more complex, they may be separately stated in corresponding testing items.

6.8.3 Requirements for accuracy of the tested parameters and instrument and equipment

Requirements for accuracy of the tested parameters are such specified to include at least: names of the tested parameters, measuring range and accuracy requirements. Accuracy requirements shall meet those specified in relevant standards. Instrument and equipment for the test shall be subjected to metrological verification or calibration and within the period of validity. In case requirements for accuracy ratings of main instruments and equipment are specified as required, list of recommended instrument and equipment may be given as the informative appendix, at least covering: name of the instrument and equipment, measuring range and accuracy rating.

Note: Instrument and equipment used by drafting organization(s) cannot be referred to for determination, in particular, resolution ratio cannot be regarded as the accuracy which is with no plus-minus sign.

6.8.4 Prototype (sample) determination

It shall be specified prototype (sample) requirements, source, sampling methods, sampling site, sampling base and sampling quantity, and it shall be clarified prototype (sample) purpose, delivery mode and disposal mode after appraisal. In general, at least 10 prototypes/samples (at least 5 large machine tools and complete plants) shall be randomly sampled in market or service site, and such random sampling may not be restricted by sampling base. Storage place, put-into-service conditions and purposes shall be specified regarding the standby prototype (sample) once required to be sampled.

If components need to be tested in consideration of certain technical requirements for prototype overall test, sampling base and quantity for components shall also be specified. If reliability test is required, prototype to be subjected to reliability test shall also be determined according to those specified in relevant standards.

If prototype can cover other types of machinery, conditions for covering shall be specified.

For example, prototype (sample) shall be accepted product manufactured in recent half a year and provided by the manufacturer for free, and randomly sampled,

by the appraisal unit (or relevant departments entrusted), at the storage site or production line designated by the applicant or the manufacturer, with the base not less than ×× set(s) (sampling in market or service site is not herein restricted) and quantity being × set(s) of which × set(s) for ×× test and × set(s) for standby use. Prototype (sample) is sent by the applicant or the manufacturer to the destination for testing and disposed by the supplier in case the applicant has no objection to the testing results. If test halts not because of quality issue of the machinery, standby prototype can be used for re-test.

6.9 Appraisal contents and methods

6.9.1 Technical requirements and performance test

6.9.1.1 Main technical parameters checking and measuring

Technical parameters specified for checking and measuring prototype (sample) should be listed to at least cover items and methods for checking and measuring.

"Confirmation Form for Product Specification" in the code shall be given in form of appendix, contents of which shall be capable of characterizing primary structural features and technical parameters of product and specific items shall not be less than those within the scope given by product nameplate.

Note: This article is usually for describing sample features and not serving as reference for judgment; if required by laws and regulations or contents concerned really need to be assessed, this article may be listed as reference for judgment, however, for which qualification judgment criteria and allowable deviation range shall be defined, covering overall dimension, operating quality and the minimum ground clearance of the prototype.

6.9.1.2 Performance test

Items to be subjected to performance test and testing methods shall be specified, and approval standards for single item and judgment rules if necessary.

Performance test items shall be capable of reflecting the demand for evaluating operating requirements of the said product, generally covering: operating capacity, operating quality, dynamic performance, environmental protection, energy consumption, mating with other machines and tools and other indexes.

6.9.1.3 Inspection of assembly and appearance quality

The contents, methods, approval standards for single item and judgment rules regarding inspection of assembly and appearance quality are specified.

6.9.1.4 Operating convenience inspection

The contents, methods, approval standards for single item and judgment rules regarding inspection of operating convenience are specified.

Inspection contents and methods shall be described regarding specific machinery type. Inspection contents may cover:

a) Operating convenience of operating device;

b) Difficulty level for adjusting, repairing and replacing spare parts;

c) Accuracy of operating device to complete specified action;

d) Deviation of indicated adjustment amount from practical adjustment value of machine tool;

e) Whether the points for maintenance are convenient for operating and the number of points for maintenance is reasonable;

f) Difficulty level to charging or feeding various auxiliary materials (such as oil plants, seeds and fertilizers);

g) Difficulty level to remove residues;

h) Rationality for structure design of the operating device;

i) Degree of operating force;

j) Comfort and field of view.

6.9.2 Safety check

The contents, methods, approval standards for single item and judgment rules regarding safety check are specified.

Safety check shall be in accordance with the requirements of relevant national mandatory standards, or those specified in GB 10395.1 and GB 10396 for absence of special mandatory standards. The specific check position, check method and qualification requirements shall be made clear for specific products, it is not allowed to write only standard numbers and simply copy original text, and randomness and uncertainty of the check shall be avoided. Meanwhile, check contents which have effects on safety production shall be paid close attention.

The contents of safety check mainly include two parts: safety device and safe operating information; check for safety device mainly aims at check of exposed moving parts, protective device for high-temperature parts and safe operating requirements for overload protection, emergency protection, electricity leakage protection and lighting; check for safe operating information mainly aims at safety mark, prompt for safety operating device and other necessary safety signs and requirements etc.

6.9.3 Reliability evaluation

The reliability evaluation method shall be explicitly specified according to specific products. The reliability test may be conducted according to relevant national and professional standards, in case of adoption of this method, the testing items, testing methods and judgment rules shall be specified; the method combining reliability investigation with production assessment may also be adopted, in case of adoption of this method, the plan, list for investigation and judgment rules for reliability investigations as well as judgment rules for availability of production

assessment shall be specified; reliability test report and result by other agricultural machinery testing and appraisal institutions above the provincial level according to requirements of specified national or professional standards may also be directly adopted as reliability evaluation references. Other feasible methods for reliability evaluation are encouraged for exploration.

6.9.4 Applicability evaluation

The testing items, testing methods, evaluation methods and determination methods for application scope of applicability evaluation are specified.

Applicability evaluation shall be aimed at important and directly related elements. The elements with indistinctive applicability may not be evaluated and the reasons thereof shall be stated in the code.

The testing conditions for items in applicability test shall be determined according to the application scope of products expressed by the enterprise, items and methods of the evaluation shall be explicitly specified in the code according to specific products. The result for products with provincial appraisal certificate for popularization may be regarded as evaluation reference for this region. The applicability evaluation may be conducted in the way of fixed-point testing and/or applicability investigation, and the selected testing point and investigation region shall be representative. For products with distinctive applicability, such as power machinery, harvest machinery, farming machinery, planting machinery etc., at least 3 testing points shall be selected within the application scope of products expressed by the enterprise.

The result of applicability evaluation may be expressed in the suitable way within application scope of products expressed by the enterprise or in other suitable ways.

6.9.5 Examination of operating instructions

The contents, methods, approval standards for single item and judgment rules regarding examination of operating instructions are specified.

Examination of operating instructions may be directly by reference to TZ 2 and with some supplement and refinement as required. The contents of examination shall at least include: technical specification, safety precautions, operating instructions, maintenance instruction, adjustment method and adjustment amount, list of quick-wear parts, printing quality etc. On the basis of providing comprehensive and correct contents, examination of operating instructions shall be in popular and easy-to-understand language and easy to be understood by farmer users.

6.9.6 Examination of "three guarantees" certificate

The contents, methods, approval standards for single item and judgment rules regarding examination of "three guarantees" certificate are specified.

Examination of "three guarantees" certificate shall be in accordance with "Regulations for Repair, Replacement and Return Responsibilities of Agricultural Machinery". Examination of "three guarantees" certificate may be directly by reference to TZ 3 and with some supplement and refinement as required. The

contents of examination shall at least include: product name, matched power (the item may be deleted if there is none), manufacturing enterprise, repairer, validity period (month) of "three guarantees" for complete machine and main components, list of main components, repair records (including delivery time, handover time, to-be-repaired fault, repair situation, refunds or exchanges certificate etc.), description of situations without "three guarantees" (mainly including: impropriety of use and maintenance, self-refitting, disassembly or correction in violation of rules, without effective invoice, un-maintenance for original state of damage, driving without certificate (the item may be deleted in case of nonperformance of certificate management) and fault due to force majeure).

6.9.7 Audit of production conditions

The contents, methods, approval standards for single item and judgment rules regarding examination of production conditions are specified.

Audit of production conditions may be directly by reference to TZ 4, meanwhile, necessary production equipment and technological equipment, instrument and equipment for testing and inspection, and type and number of sampled components and parts as well as number of inspection items shall be made clear in corresponding appraisal code for product popularization.

6.9.8 User survey

The method, range, quantity, classification of fault phenomenon, statistical analysis method and qualification criterion etc. regarding user survey are specified.

The user survey may be directly by reference to TZ 5 and with some supplement and refinement as required, such as making clear quantity and item of the survey.

6.10 Judgment rules

Methods for single judgment and comprehensive judgment are specified.

6.10.1 Single item judgment

Classification, qualification criteria and judgment rules of each index are specified. Those have been specified in corresponding items of appraisal contents and methods may be quoted directly.

Step-by-step judgment method is adopted for qualification judgment of indexes in appraisal for popularization. Level 1 indexes include seven: technical requirements and performance testing, safety check, reliability evaluation, examination of operating instructions, examination of "three guarantees" certificate, examination of production conditions and user survey; Level 2 indexes include all indexes involved in technical requirements and performance testing.

Level 1 indexes must be qualified; Level 2 indexes may be divided into Classes A and B or Classes A, B and C according to importance degree. Number of allowable defects for all classes of indexes in each level shall be specified. Number of allowable defects for Class A indexes shall be 0; number of allowable defects for Classes B and C indexes shall be 1~3. All levels of indexes shall be listed for expression. Except judgment principle for safety items and items of technical requirements and

performance testing, judgment principle for other items in Level 2 indexes shall all be expressed in corresponding articles.

See Table C.1 in Appendix C for the compiling format for table of qualification judgment.

Indexes of applicability evaluation should not be subjected to qualification judgment and application scope of the product shall be explicit.

6.10.2 Comprehensive judgment

Comprehensive judgment principle of appraisal for popularization is specified.

In case Level 1 indexes are all qualified, the appraisal conclusion for popularization is "Pass".

In case that nonconformity of partial items (excluding testing items) occurs and the nonconformity may be corrected within a short period, the enterprise is allow to make once correction within a period not more than 3 months.

In case corrected indexes are satisfactory, the appraisal conclusion for popularization is "Pass". In case corrected indexes are still not satisfactory, the appraisal conclusion for popularization is "Fail".

6.10.3 Expression of conclusion

Comprehensive conclusion of the appraisal for popularization is expressed by dividing into two parts: result of qualification judgment and result of applicability evaluation.

For example, appraisal for popularization (of agricultural machinery product of certain model) is passed and the scope of application is ...

6.11 Appendix

Table for testing records, operating instructions, illustration statements etc. of the testing may be incorporated in appendixes of the code if necessary.

APPENDIX A (NORMATIVE)

Appraisal Code for Popularization of Agricultural Machinery

DG

农 业 机 械 推 广 鉴 定 大 纲

DG/T ×××-××××

代替DG/T ×××—××××

Grain Combine

谷物联合收割机

Issued on: ××-××-××

Issued by the Ministry of Agriculture of the People's Republic of China

××-××-××发布　　××-××-××实施

中华人民共和国农业部　发布

Figure A.1 Format of Cover of the Appraisal Code for Popularization (Grain Combine)

APPENDIX B

Table B.1 Qualification Criteria

Level 1 index	**Level 2 index**				
Item	**Class**	**No.**	**Item**	**Unit**	**Qualification Criteria**
Safety check (qualification requirements: number of allowable defect for Class A index is 0)	A				
Technical requirements and performance testing (qualification requirements: number of allowable defect for Class A index is 0; number of allowable defect for Class B index is no greater than 1; number of allowable defect for Class C index is no greater than 2)	A				
	B				
	C				
Reliability evaluation	/	/	/	/	
Examination of operating instructions	/	/	/	/	
Examination of quality guarantees certificate	/	/	/	/	
Audit of production conditions	/	/	/	/	
User survey	/	/	/	/	

UNITED NATIONS
ESCAP
Economic and Social Commission for Asia and the Pacific
CSAM

United Nations
Centre for Sustainable Agricultural Mechanization

A-7/F, China International Science and
Technology Convention Centre
No.12, Yumin Road, Chaoyang District
Beijing 100029, P.R.China

Tel: (86-10) 8225 3581
Fax: (86-10) 8225 3584
info@un-csam.org
www.un-csam.org