Agricultural Mechanization at a Glance
Selected Country Studies in Asia on Agricultural Machinery Development

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To prepare for the study report, field visits were made by the writers to Bangladesh, China, India, Republic of Korea, the Philippines and Thailand, which represent varying levels of development of agricultural machinery in Asia to collect information and consult with various stakeholders including the government, research institutes and the private sector. The cooperation and support received for the study from Bangladesh Agriculture Research Institute (BARI), Indian Council of Agricultural Research (ICAR), Central Institute of Agricultural Engineering (CIAE) of India, Central Farm Machinery Testing and Training Institute (CFMTTI) of India, Rural Development Administration (RDA) of Korea, China Agricultural Machinery Testing Centre, South China Agricultural University, Ministry of Agriculture and Cooperatives of Thailand, University of the Philippines, Los Baños (UPLB), Department of Agriculture of the Philippines, and Asian Institute of Technology (AIT) was gratefully acknowledged.

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Executive Summary

Home to more than 64 percent of the world's undernourished people, the Asia-Pacific region is threatened by lingering food insecurity and thus is in urgent need of increasing food production. In recent years, the promotion of farm mechanization, which has proven to be an effective way to increase agricultural productivity, has exerted revolutionary impact on the agricultural sector of this region. However, the region is still characterized by huge technological gaps and varying levels of mechanization. Meanwhile, the application of agricultural machinery has caused environmental concerns due to high energy consumption and posed safety hazards as a result of substandard machines and lack of training.

Aiming at the analyzing the contributing factors and providing practical strategies to address the above-mentioned issues, the study reviews the economic, social and agricultural development, especially the development of agricultural mechanization in Asia by conducting studies on challenges and prospects of agricultural mechanization in six selected Asian countries. It also explores the feasibility of establishing an "Asia Pacific Network for Testing Agricultural Machinery" (ANTAM), which was proposed at the Roundtable Forum for the Regional Agricultural Machinery Manufacturers/Distributors Associations held in Seoul, Korea in November 2006.

The study points out that traditional agricultural techniques and cultivation practices have changed significantly with breakthroughs of science and technology. It analyzes a host of factors that affect agricultural mechanization of the region, including overall level of economic development, migration of rural labor, land utilization, agricultural production, food demand, agricultural machinery industry, trade and manufacturing capacity and testing. The study examines the interactions among agricultural mechanization, food production and agricultural development of the region.

Six countries were chosen for case studies, namely Bangladesh, China, India, Republic of Korea, Thailand and the Philippines, representing different stages of agricultural mechanization. Through visits and talks with policy makers, researchers and the private sector in the six countries, and thorough review of country reports prepared by representatives to the Technical Committee of UNAPCAEM, the authors have collected extensive data and information on agricultural mechanization, and conducted thorough analysis. The study identifies the main characteristics of agricultural mechanization of each country, and assesses their respective needs in agricultural mechanization.

The feasibility study on the establishment of "ANTAM" is an important part of this report. "ANTAM" is proposed with an aim to promote introduction of uniform testing procedures and safety standards of agricultural machinery, and facilitate intraregional trade. Based on the selected country case studies, the study extrapolates the general characteristics of agriculture mechanization in the region, assesses the overall level of agricultural mechanization, and identifies major constraints to agricultural mechanization. According to the study, while there exists strong demand for agricultural mechanization in the region, there are undeniable imbalances that impede the development of such a network, including huge gaps in economic development, underdeveloped agricultural infrastructure, insufficient purchasing power of farmers, and significantly different level of agricultural machinery industry. The study groups countries in the region into three categories according to their levels of agricultural mechanization, and points out the common constraints they are facing, i.e. fragmented lands, diverse machinery types and facilities, poor utilization rate and higher fuel consumption and lack of knowledge and skill of users, artisans and traders. The authors also provide the overall situation of testing and certification of farm machinery in this region, and draw a comparison with the European Network for Testing Agricultural Machines (ENTAM). While ENTAM might be a useful model to

assimilate for Asia, the authors argue that there are a host of constraints including financial, administrative and stakeholders that need to addressed first.

The authors believe that agricultural mechanization will play an irreplaceable role in increasing agricultural production in the Asia-Pacific region by upgrading traditional agriculture, achieving high and stable yield, and improving the quality and value-added of agricultural products. At the same time, efforts need to be made to address safety and environmental issues associated with agricultural mechanization in the course of development.

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Chapter I

REGIONAL OUTLOOK

1.1 Social and economic development in Asia and the Pacific

Asia and the Pacific is a huge and diverse region with countries varying greatly in size and level of development: it has three of the world's most populous countries, emerging economies that have become the engine of global growth, many Pacific Island states, and a few of the world's poorest countries. While the Asia-Pacific region is commended for its impressive gains in social and economic development, it faces remarkably uneven progress across the region towards the attainment of the Millennium Development Goals. Since 2007 it has faced a series of challenges, such as the food-fuel crisis, climate change and the global financial crisis, offsetting its efforts towards inclusive and sustainable economic and social development.

Across the region, rapid economic growth has contributed to the improvement of living standards. Between 1990 and 2004, more than 350 million people escaped from poverty (ESCAP, 2009). However, more than 60 percent of the world's undernourished population still lives in Asia and the Pacific, according to the ESCAP theme study on Sustainable Agriculture and Food Security published in 2009.

As the first global economic contraction in modern times hit Asia and the Pacific in late 2008, economic growth among developing economies of the region decelerated sharply from a pre-crisis level of 9.1 per cent in 2007 to 4.0 per cent in 2009. That the growth rate remained positive was due to continuing rapid growth in China (8.7 per cent) and India (7.2 per cent). However, if those two powerhouses are excluded, growth of developing economies in the rest of the region contracted to 0.6 per cent, much the same as in the rest of the world (ESCAP Social and Economic Survey, 2010).

Thanks to the stimulus package unleashed by governments across the world, the world has entered a slow recovery period in a post financial crisis era. Strong support from expansionary policies has also helped Asian and Pacific economies to reverse their declines, and a notable recovery is expected in 2010. For the developing economies of the region, GDP is expected to grow by 7.0 per cent in 2010, following an estimated growth of 4.0 per cent of the previous year (ESCAP Social and Economic Survey, 2010).

In Asia and the Pacific the majority of poor people lives in the rural areas and derive most of their income from agriculture – so are likely to benefit from agricultural growth. Since the 1970s such growth was based largely on the Green Revolution which helped the region achieve significant yield increases – though the high input intensity also caused well documented problems. Now, as the region aims for more balanced economic growth, it needs a second, more knowledge-intensive green revolution that combines advances in science and agricultural engineering with the region's unique traditional knowledge to make agriculture more environmentally resilient (ESCAP Social and Economic Survey, 2010).

1.2 Agricultural development – World at a glance

So far, world agriculture has been able to respond to the rising demand for crop and livestock products. Although the world's population doubled between 1960 and 2000 and levels of nutrition improved markedly, the prices of rice, wheat and maize – the world's major food staples – fell by around 60 per cent. The fall in prices indicates that, globally, supplies not only kept pace with demand but even outstripped it.

Globally, producers have satisfied effective market demand in the past, and there is every

likelihood that they will continue to do so. But effective demand does not represent the total need for food and other agricultural products, because hundreds of millions of people lack the money to buy what they need or the resources to produce it themselves. Thus, even if there is sufficient potential for production in the world as a whole, there will still be problems of food security at the household or national level. In urban areas, food insecurity usually reflects low incomes, but in poor rural areas it is often inseparable from problems affecting food production. In many areas of the developing world, the majority of people still depend on local agriculture for food and/or livelihoods but the potential of local resources to support further increases in production is very limited, at least under existing technological conditions. In such areas agriculture must be developed through support for agricultural research and extension and the provision of credit and infrastructure, while other income-earning opportunities are created. If this is not done, local food insecurity will remain widespread, even in the midst of global plenty (http://www.fao.org/docrep/004/y3557e/y3557e04.htm).

Agriculture has changed significantly with advances in science and technology. Traditional agriculture was mostly dependent on human labor and draught animals. Modern agricultural practices are mainly based on machines especially high-speed, powerful tractors and its implements. Tractors with mounted and trailed implements allow the mechanization of many agricultural operations. Agricultural mechanization has not only changed the characteristics of labor in agriculture but also influenced the workload. The timeliness of operation and increased capacity of production resulted in the need for higher speeds, bigger and heavier machines. During the operation of these machines by human beings, the load on the operator as well as occupational and health hazards are found to be increased, which lead to impair the performance of the operator. In farm works, the fatigue and discomfort to which workers are subjected are not only due to the physical labor but to vibration and noise as well (Huang & Suggs, 1967).

Since ancient times agriculture is the main occupation of Asian region and still the trend is continuing. In last century, enormous population growth, urbanization and industrialization led not only to a dwindling supply of arable land per capita but drastic reduction in the forest land as well. Figure 1.1 shows the recent land utilization of the total available land in the world. Because of its size and its population Asia is near top producer in every major crop (rice, barley, wheat, maize, sorghum, potatoes and sweet potato). Other continents have high production in their own traditional / cultural niches or due to favorable climate (both are often linked) like wheat, barley and potatoes in Europe, maize in the Americas, and sorghum in Africa.

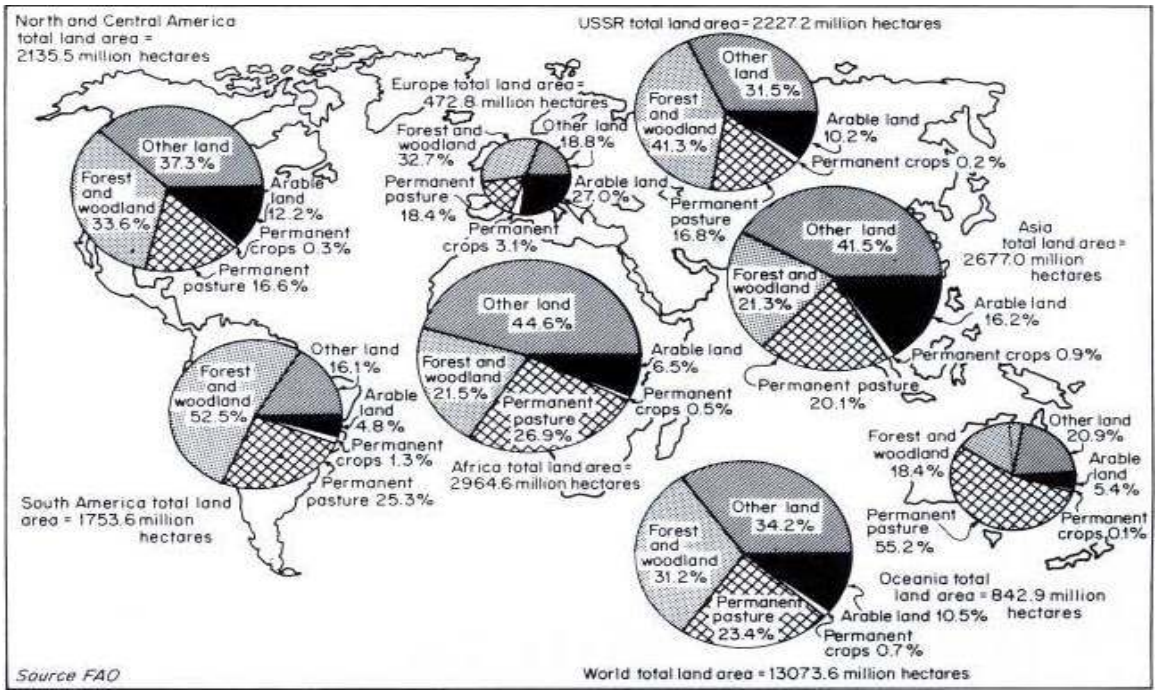

Figure 1.1: Available land utilization in the world (Source: www.fao.org)

The increasing demand for food and fiber by growing population necessitates increased productivity, which in most cases will render into the use of high inputs and mechanical power.

1.2.1. Agricultural economics

Countries in the Asia-Pacific region are traditional agricultural countries. Agriculture plays an important role in their national economy. In the past decades, with increased industrialization, the economic structure of this region has been dramatically changed. Other sectors of the economy have become big contributors to the economy rather than agriculture.

The contribution to GDP by agriculture and the agriculture population as a percentage of the total in these countries can be found in Table 1.1 and Figure 1.2 respectively. In South Korea, contribution to GDP by agriculture is less than 5 per cent, so agriculture is no longer the most important sector for the economic growth. In India, Sri Lanka, Indonesia, Philippines, Thailand, Mongolia, Malaysia and China, agriculture contributes less than 20 per cent of their GDPs, but the agriculture population (as percentage of the total) in these countries is still 40-90 per cent. Only in South Korea and Malaysia is the agricultural populations less than 10 per cent.

Therefore, while agriculture has lost its dominant role as the major contributor to the economy, it is still very much a dominant sector in most Asian and Pacific countries because a large number of people are still employed by the agricultural sector.

Table 1.1 Contribution to GDP by agriculture in Asian and Pacific countries (%)

	Agriculture, value added (% of GDP)			
	2000	2005	2007	2008
Burma	57	..	..	..
Laos	53	46	40	..
Nepal	41	36	34	34
Cambodia	38	32	32	..
Mongolia	33	25	23	..
Pakistan	26	21	21	20
Bangladesh	26	20	19	19
Vietnam	25	21	20	..
India	23	19	18	18
Sri Lanka	20	12	12	13
Fiji	17	15	..	..
Indonesia	16	13	14	14
Philippines	16	14	14	15
China	15	13	11	11
Thailand	9	11	12	..
South Korea	5	3	3	3
Malaysia	1	8	10	..

(World Bank 2009)

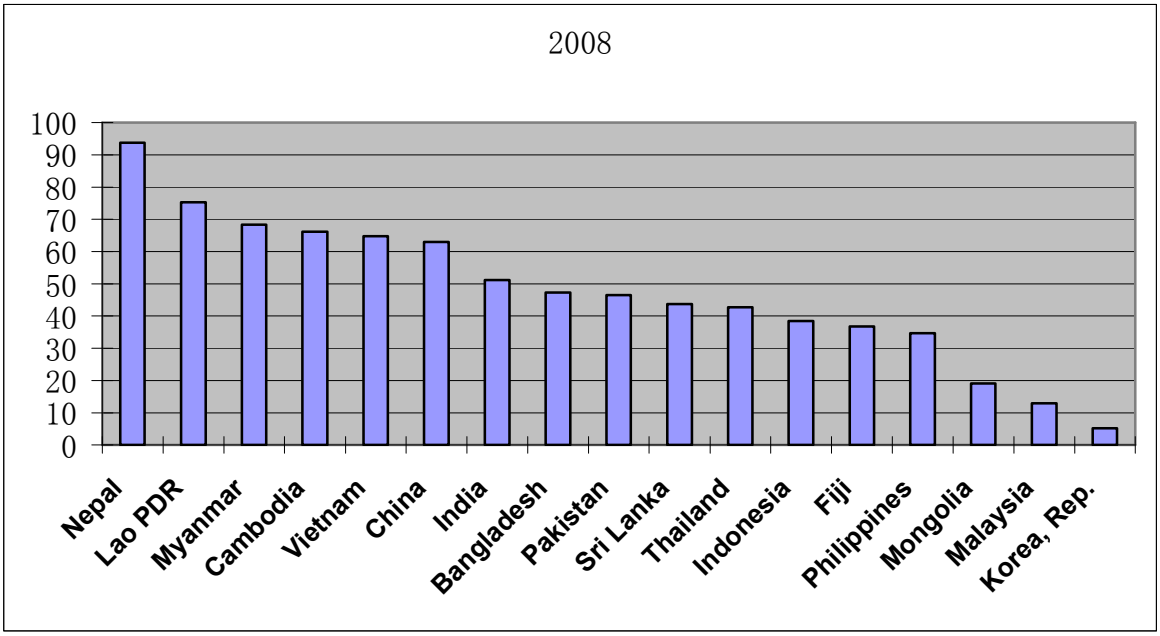

Figure 1.2: Agriculture population as percentage of total (%) in 2008
(World Bank 2009)

1.2.2 Agricultural production in Asia and the Pacific

1） Main crops

In North East Asia, Mongolia's main agriculture is raising livestock and growing some silage crops. Over 75 per cent of the rural population are engaged in extensive livestock production. South Korea's major crops are rice, soybean, fruits and vegetables. China's main crops are wheat, rice, maize, soybean, cotton, silage, rape, sugarcane, vegetables and fruits. In South-East Asia, main crops are rice, maize, soybean, cotton, sugarcane, fruits and vegetables. Among all the crops, rice is the number one crop in the Asia and Pacific region.

2） Commercialization of agricultural products

In Asia and the Pacific, agriculture is not an isolated sector. Grain production does not only contribute to domestic consumption but also plays significant role in export earnings. For example, India ranks the second in the world in farm produce and Thailand the 5th in rice production in the world. The selected products exported and imported by Asia-Pacific developing countries are shown in Table1.2

Table 1.2: Products exported and imported by Asian and Pacific developing countries

	Exporters	Importers
Rice	Viet Nam	Philippines, Malaysia
	Pakistan	Islamic Republic of Iran
	India	Saudi Arabia
	Thailand	China; Hong Kong, China; Malaysia; Singapore
Maize	China	Republic of Korea, Malaysia
Frozen beef	India	Malaysia, Philippines
Frozen pork	China	Hong Kong, China; Singapore
Bananas	Philippines	Republic of Korea, China
Apples	China	Indonesia, Thailand, Singapore, Philippines, Hong Kong, China; Malaysia
Black fermented tea	Sri Lanka	Islamic Republic of Iran; Pakistan; Hong Kong, China
Crude palm oil	Indonesia	India, Malaysia
	Malaysia	India, Pakistan, China
Palm oil and its fractions	Indonesia	China, Pakistan, India
	Malaysia	China, Pakistan, Turkey
Cocoa beans	Indonesia	Malaysia, Singapore, China

Source: Stevens, C., J. Kennan and M. Meyn (2007). "South-South Trade in Special Products", ICSTD Issue Paper No. 8, June 2007.

(Stevens,C,J.Kennan and M.Meyn 2007**)**

1.3 Agricultural mechanization in Asia and the Pacific

1.3.1 Region at a glance

While there is need for countries in the region to substitute traditional agricultural practices with mechanized production techniques, there is also a vast difference in the level of agricultural mechanization among the Asia-Pacific countries. China and India have significant development in adopting farm mechanization. South-East Asian countries like Cambodia, Thailand and Vietnam are adopting advanced machinery in farm operations. But in most countries, agricultural mechanization is still in the developing stage. In these countries farmers still use inefficient manual tools which resulted in low production. For instance, in Bangladesh and Nepal, the land size is small, which has prevented farmers to adopt large machinery. Lack of appropriate machinery to conduct various farming operations has left farmers with no choice but to continue with traditional farming techniques.

Due to increase in population the demand for food and fiber is likely to increase. At the same time the percentage of total economically active population (Figure 1.3) and the total labor force involved in agricultural activities are getting smaller every year (Figure 1.4). The following data are from Bangladesh, India and South Korea to exemplify the above statement, due to large differences in agricultural development. India and Bangladesh are chosen to represent countries with high percentage of population involved in agriculture and South Korea as a low percentage of population involved in agriculture. Unpredictable agricultural conditions, use of traditional methods and lack of modern facilities are some of the causes for the decline of agricultural employment. This indicates that there probably is a great need of agricultural mechanization to produce enough food to fulfill the country's requirement.

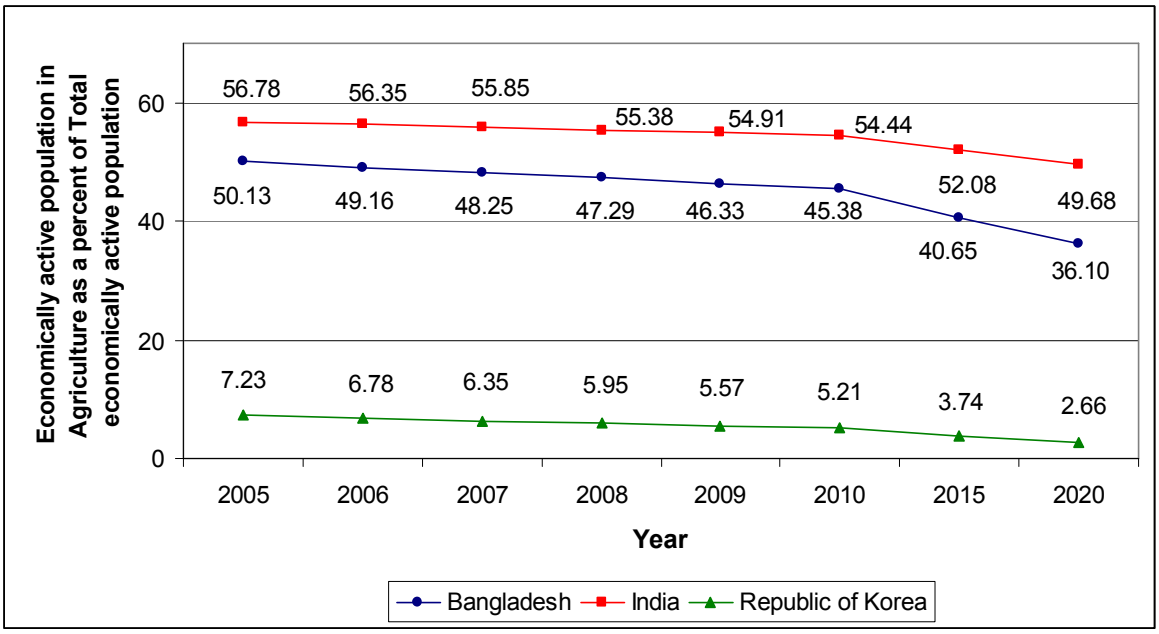

Figure 1.3: Economically active population in agriculture as a percent of total economically active population (Earth Trends)

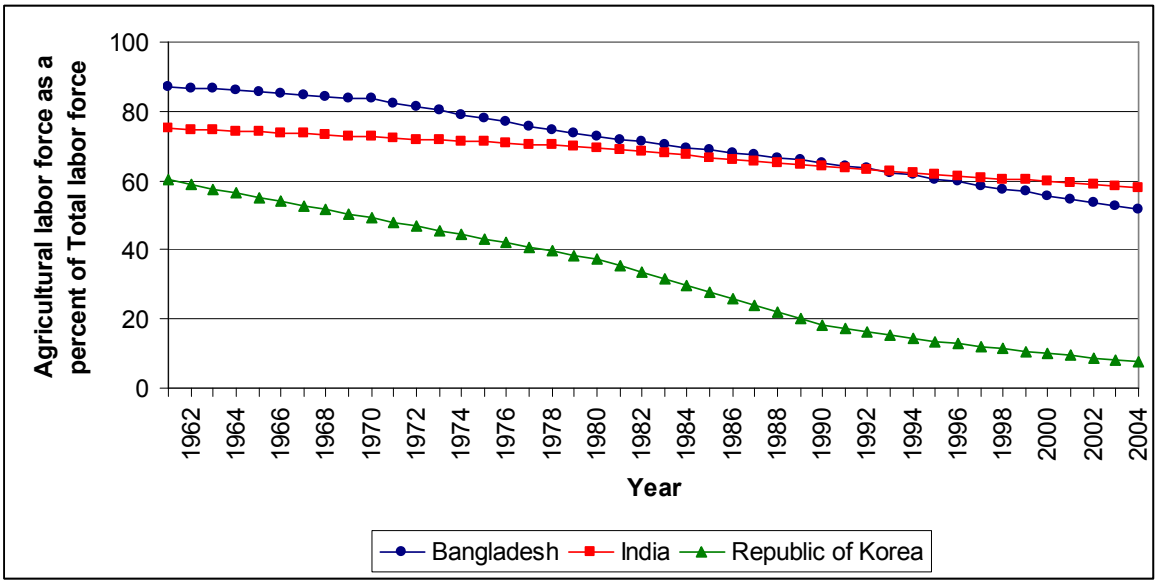

Figure 1.4: Agricultural labor force as a percent of total labor force (Earth Trends)

Agricultural labor intensity is the number of agricultural workers per hectare of arable and permanent cropland. In the year 2003, agricultural labor intensity in India and Republic of Korea was just 1.61 and 1.11 while, in Bangladesh it was 4.69 (Figure 1.5). These figures clearly point out the essential need of mechanization in India and Republic of Korea.

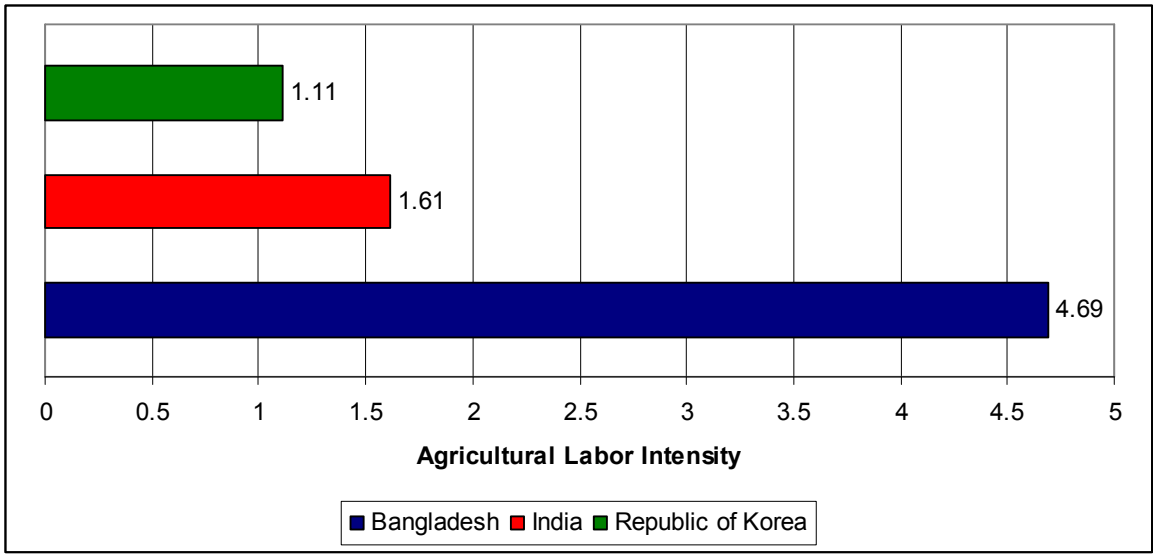

Figure 1.5: Agricultural labor intensity in selected Asian countries in 2003 (Earth Trends)

Agriculture has to grow at 4 per cent for India to maintain a sustainable annual GDP growth of about 8 to 9 per cent. The country is facing unprecedented degradation of land and groundwater resources due to increasing urbanization and industrialization with growing population. The agricultural productivity of India has to be almost double to meet the food and fiber needs of growing population by 2050 (Ali, 2007).

In spite of being a large importer of agricultural products, Republic of Korea strives to achieve self sufficiency in rice, horticultural products and livestock production (USDA, 2010). So, it is necessary to adopt intense mechanized farming to achieve the self-sufficiency in basic food demand with reducing agricultural labor force and agricultural land of the country.

In case of Bangladesh, the agricultural labor intensity (4.69 in the year 2003) is reasonable even though to achieve the required food sufficiency for growing population in recent years. It is predicted that for Bangladesh, there is urgent need to produce additional 5 Million tons of food from the continuously decreasing agricultural lands to fulfill the food demand until the year 2015.

For all these reasons, mechanization of agricultural activities is inevitable for Asian countries. In early 1950's, many Asian countries started farm mechanization by using tractors to increase productivity. In last few years, the growth of mechanization has accelerated. Tractor intensity is measured by the number of tractors per thousand hectares of arable land. Though the tractor intensity in Asia differs from country to country, all countries have experienced an increase in tractor intensity. This section gives main focus on the extent of mechanization in the selected Asian countries.

1.3.2 Impact of agricultural mechanization on regional economy

Following the accelerated process of industrialization, urbanization and modernization, agriculture lagged behind the industry. The gap in economic and social development between urban and rural areas becomes increasingly obvious. For example, although the net farmer's income growth rate in China was the highest in the period 1985-2007, the gap in economic and social development between urban and rural areas in 2007, was still the biggest of the past 30 years (in 1978-2.6:1, 1984-1.8:1, 2005-3.28:1, 2007-3.33:1). (China country report, 2008).

Due to the differences in living conditions between urban and rural areas, farmers are leaving the land to look for job in cities. Machines become a necessary alternative. This trend will not reverse even if under the pressure of the financial crisis.

Although, most countries in this region have abundant overall labor force in agriculture, non-availability of manpower during peak crop season is a growing problem. Nepal, for example, is a developing agricultural country with poor infrastructure (road, electricity, market, communication etc.). Agriculture provides 71.3% of total employment in 2003/04. Because of the unavailability of employment opportunities in secondary and tertiary industries, the majority of farmers in the country are forced into subsistence agriculture. Moreover, due to low investment capacity and lack of infrastructure and market opportunities, the majority of farmers are continuing traditional technology in their production system. Its rural youths migrate abroad and to nearby cities in search of jobs, which causes insufficient agricultural labor in peak agricultural season (Nepal country report, 2009).

1.3.3 Impact of agricultural mechanization on agriculture

In the Asia-Pacific region, the promotion of agricultural mechanization has brought about a rapid change in the agricultural sector. Many small and medium sized agricultural machines have been produced and are widely used in the region.

Agricultural mechanization plays an increasingly important role in agricultural production in the Asia-Pacific region. It reduces drudgery, increases the safety and comfort of the working environment; it enhances productivity, cropping intensity and production. It increases income for agricultural workers and then improves social equality and overall living standards. If properly used, it also conserves and properly utilizes natural resources and reduces the cost of production. It allows for timelier farm operations, effectively deals with climate change, produces better quality agricultural commodities, etc.

It is necessary, therefore, to use modern equipment in agriculture and to use modern science and technology to re-invent agriculture. The region needs, inevitably, to accelerate the development of agricultural mechanization.

1.3.4 Overview of agricultural machinery manufacturing in this region

1.3.4.1 Agriculture machinery industry

Asia has become a big player in agricultural machinery manufacture. According to FAO, 30.48 per cent of the tractors sold worldwide in 2004 were produced in Asia, with India topping the list. Indian-made tractors were supplied to as much as one third of all farm tractors in the world with 0.31 million units (2006-2007), 0.35 million (2007-2008) and 0.30 million (2008-2009). There are 13 tractor manufacturers and many other manufacturers producing diesel engines and agricultural tools as well. The total power availability of this country to farm lands increased from 0.295kw/ha in 1991 to 1.231kw/ha in 2001, with an annual increase of 41.7 per cent. China ranked second in this regard. This development momentum is expected to accrue even more growth potential in the future.

Agricultural machinery in Asia and the Pacific is characterized by diverse types, testing standards and facilities as a result of huge difference in topography, scale of farming and different levels of economic development across the region. In some Asian developing countries, local manufacturers are still in the “cut and weld” level of manufacturing technology.

In Bangladesh, due importance was not given to farm mechanization until the beginning of this century, and only a few manufacturers were established to fabricate simple, manually-operated machinery like weeders, threshers, winnowers, etc. With the growing needs for food, the decision-makers realized that Bangladesh agriculture will have no other alternative than to adopt mechanized cultivation to feed her ever growing population. This helped the growth of some agricultural manufacturing workshops in the country. Presently, more than 40,000 small and medium-sized local metal working workshops have grown up to manufacture agricultural machinery all over the country (Farouq et al., 2007). Many small workshops are manufacturing sub-standard machinery creating adverse impact among the farmers. These small workshop

owners, in general, do not use jigs and fixtures and produce different standard machines. They get the prototype from the designers / researchers and multiply them. While copying these machines, they do not use exact quality materials and specifications thus producing low quality machines. This kind of situation, unfortunately, not only happened in Bangladesh, but also in some other countries in this region.

Another problem in this region is that the implementation of farm machinery standards remains on a voluntary basis. Low or substandard machines continue to be peddled in the market while some machines are not suitable to the farming conditions of the users. At the same time, farm machines are beyond the reach of most farmers owing to high acquisition and maintenance costs.

1.3.4.2 Agriculture machinery safety

Agriculture is one of the most hazardous occupations in the world. In several Asia-Pacific countries, the fatal accident rate in agriculture is double the average for all other industries. Agricultural machinery safety needs to be valued across the region. Region-wide safety standards and guidelines on the production and operation of agricultural machines are imperative.

1.3.4.3 Agricultural machinery and environmental sustainability

Agricultural machinery has to minimize negative effects on the environment for long term sustainable agricultural development. Energy efficient machinery contributes to environmental protection and is cost-effective. Most of the agricultural machinery in the region, unfortunately, is energy-intensive. To effectively promote the application of energy-efficient and safe agricultural machinery requires concerted efforts across the region to adopt a holistic approach, from capacity building through transfer agri-technology to training of operators and mechanics, from experience-sharing and needs assessment study to development of common testing procedures and safety standards.

1.3.5 Summary

Mechanization has had a revolutionary impact on the development of agriculture and the improvement of farmer's livelihood in the Asia-Pacific region. At the same time, there is a huge gap in the mechanization of agriculture due to different levels of development, lack of technology transfer and various testing standards and procedures. Promoting agricultural mechanization and enhancing its safety standards are key to the development of sustainable agriculture, a challenge that most developing countries in the region need to address. This report reviewed countries in the region including India, Bangladesh, the Republic of Korea, China, Philippines and Thailand, presenting different levels of agricultural mechanization from advanced to medium and low level, to assess the current status of agriculture and agricultural mechanization. The feasibility study on the proposed establishment of the Asian Pacific Network for Testing Agriculture Machinery (ANTAM), and country demand analysis and policy recommendations on how to establish an effective regional mechanism to promote the application of agriculture machinery, priority areas for capacity building through technology transfer and cooperation are the highlights of this study.

CHAPTER II
COUNTRY CASE STUDY

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Chapter II

COUNTRY CASE STUDY

This chapter includes major findings from the authors' field visits to six countries in Asia, supplemented with other related information from secondary sources. These six countries are Bangladesh, China, India, Republic of Korea, Philippines and Thailand.

A) BANGLADESH

1. General overview of agriculture

Agriculture remains the most important sector of the Bangladeshi economy, contributing 23.5 per cent to the national GDP and providing employment for 63 per cent of the population. The crop sector only contributes about 13.44 per cent to the national GDP. Approximately 82 per cent of the country's population lives in rural areas, virtually all of them making their living exclusively or substantially from agriculture. The agriculture production rate has been relatively steadier compared to the rapid growth in population of Bangladesh. Bangladesh is still importing an average of 2.0 million tons of food grains each year to meet minimum subsistence needs of the population.

Agriculture holdings in Bangladesh are generally small. As a result of the adoption of developed agricultural farming techniques with efficient use and saving of water through irrigation and crop protection, the gross production of agricultural commodities increased from approximately US$6.0 billion to US$15.0 billion from 1971 through 2007. Figure 2.1 and Figure 2.2 show gross and net total production in the country's agriculture sector.

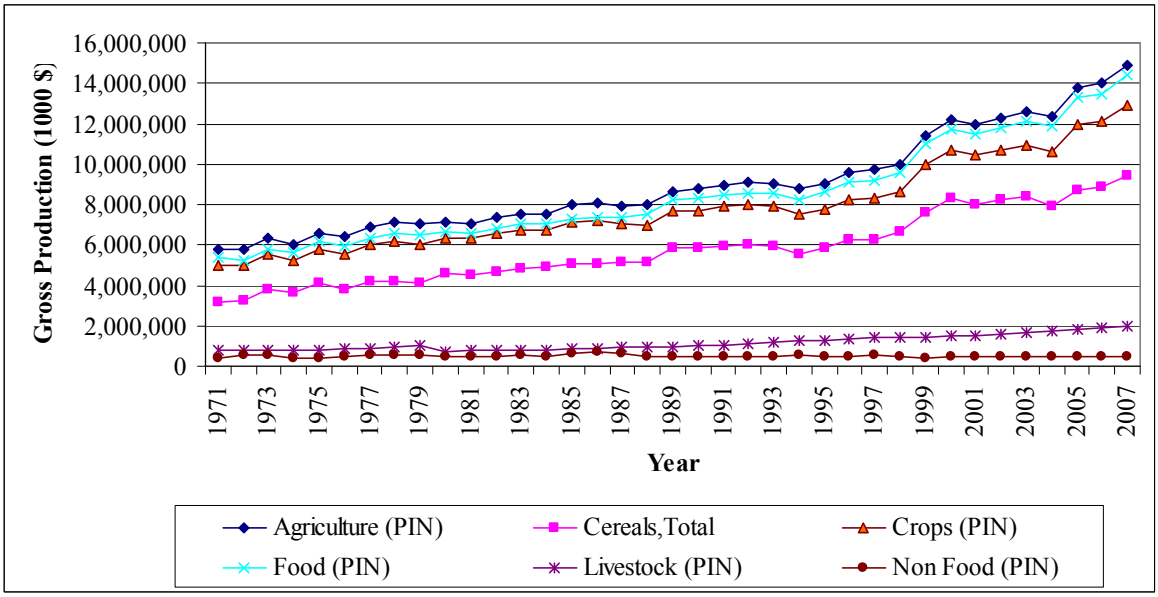


Figure 2.1: Gross production expressed as 1000 USD, Bangladesh (FAOSTAT)

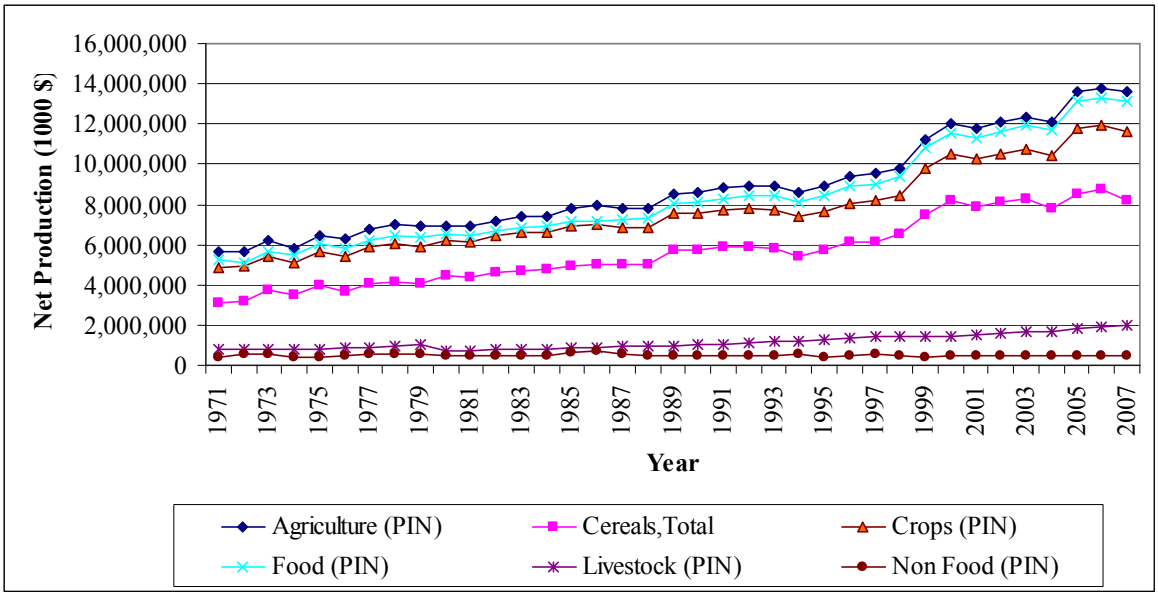


Figure 2.2: Net production expressed as 1000 USD, Bangladesh (FAOSTAT)

Agriculture is heavily dependent on the climate and associated weather patterns as well as natural factors and human and mechanized efforts. Major demand for food is fulfilled through the production and consumption of cereals like rice, wheat, vegetable crops, fruit crops, and food grain crops. Among these commodities, cereals contribute more to the national GDP with the production, consumption and export of the rice. Gross and net production of livestock and non-food products increased but at a very small rate ranging from US$1.0 billion to approximately US$2.0 billion.

Agriculture contributes about 20 per cent of the country's GDP, and the GDP of the agricultural sector is less than that in the industrial and services sectors because of increased demand for opportunities in non-agriculture activities. In addition income from the industrial sector is greater than agriculture with less human effort. Regardless, agriculture is still a major contributor to the country's GDP because processing and agricultural machinery industries are contributing to the GDP through industry and services. Therefore, agriculture is expected to remain as a base contributor to the country's GDP. Figure 2.3 and Figure 2.4 show shares of various sectors in Bangladesh's GDP.

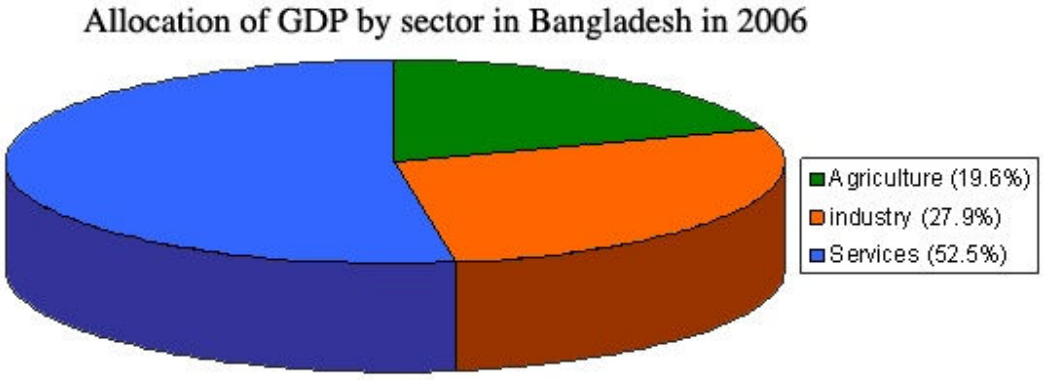


Figure 2.3: Allocation of GDP by sector in Bangladesh in 2006 (Earth Trends, 2009)

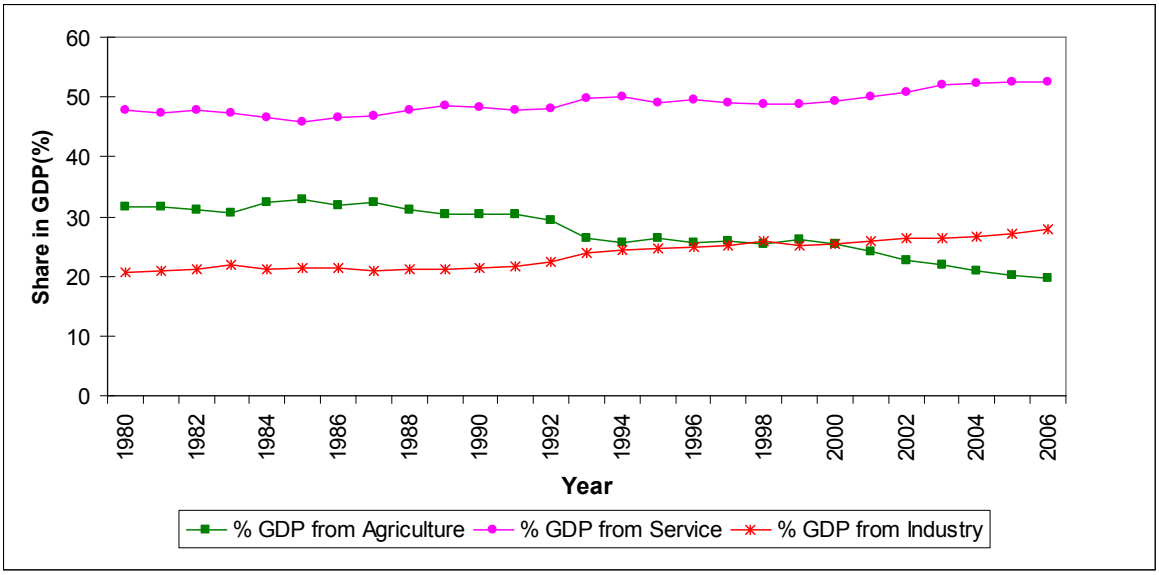


Figure 2.4: Share of different sectors in Bangladesh's GDP growth (Earth Trends, 2009)

Table 2.1 and Figure 2.5 show the annual production of the top twenty agricultural commodities in terms of value and tons in 2007 with rice as a major crop of Bangladesh with a value of US$7.98 billion. Fortunately, climatic conditions in Bangladesh are suitable for the growth and production of potato, which requires relatively mild temperatures during early growth stages and cool weather during tuber development. Therefore, potato ranks second in the production with a value of US$0.69 billion followed by milk and chilies. Not only vegetables but also fruits, tea, spices, meat and eggs are produced in large quantities. Figure 2.5 shows a similar trend of high production of rice followed by potato, milk, fruits, spices etc.

Table 2.1: Bangladesh's production of top twenty agricultural commodities in the year 2007 (FAOSTAT)

Rank	Commodity	Production (Int $1000)	Production (MT)
1	Rice, paddy	7981474	43057000
2	Potatoes	691163	5167000
3	Goat milk (whole, fresh)	607703	2016000
4	Chillies and peppers (dry)	457272	153955
5	Jute	312861	838682
6	Cow milk, whole, fresh	217538	818000
7	Vegetables, fresh, nes	205664	1096000
8	Mango, mangosteen, guava	186739	766930
9	Onions, dry	164802	894255
10	Spices (fresh)	151241	116725
11	Eggs (in shell)	144742	180000
12	Bananas	143154	1004520
13	Garlic	136388	176710
14	Sugar cane	119841	5769945
15	Wheat	108905	737000
16	Fruit, tropical (fresh)	105986	925965
17	Maize	96315	902150
18	Tobacco unmanufactured	71433	39180
19	Tea	63326	58500
20	Other bird eggs (in shell)	63163	76000

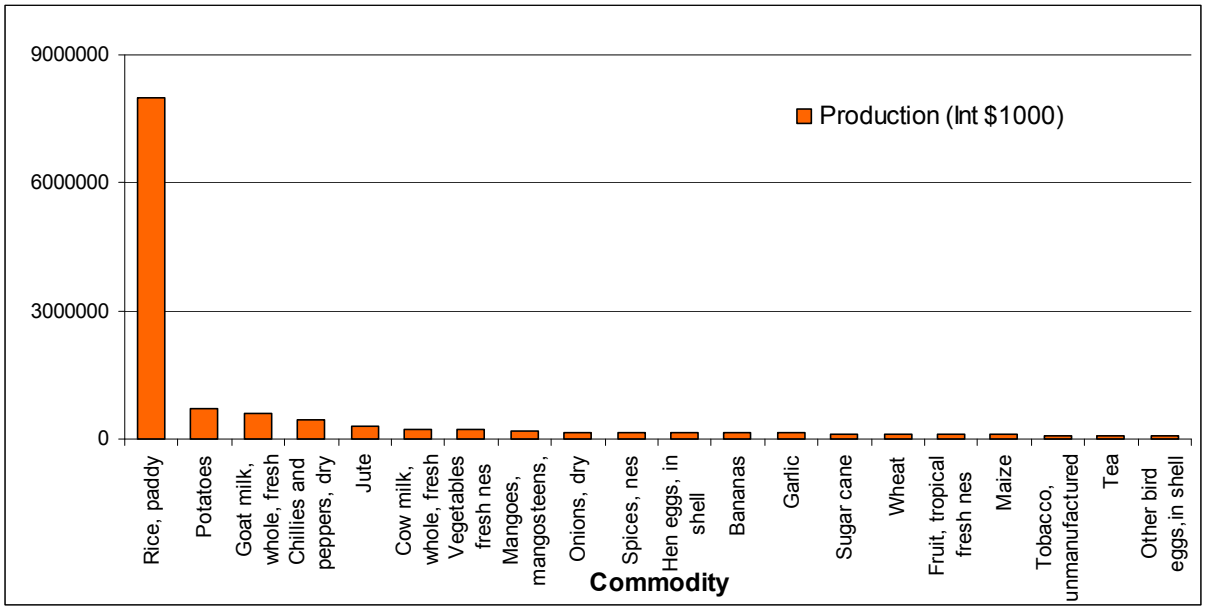


Figure 2.5: Bangladesh's production of top twenty agricultural commodities in the year 2007 (FAOSTAT)

The export value of Bangladesh's major agricultural commodities like cereals, pulses and fruits and vegetables after independence through 2007 are shown in Figure 2.6. It can be clearly seen from the Figure 6 that export of cereals, pulses and fruits and vegetables was zero until the early 1980s because of the unpromising nature of agriculture due to change in climate and rainfall patterns, and the natural calamities affecting the country lead to less production of these commodities every year. Trend of pulses showed that export value was zero except early 1980s, but was negligible for fruits and vegetables. Cereal export value increased from 1981 to 1983, then fell to zero before beginning to increase after 1997. However, after 1993 the trend of export value of fruits and vegetables remains increasing reaching US$70.48 million in 2007.

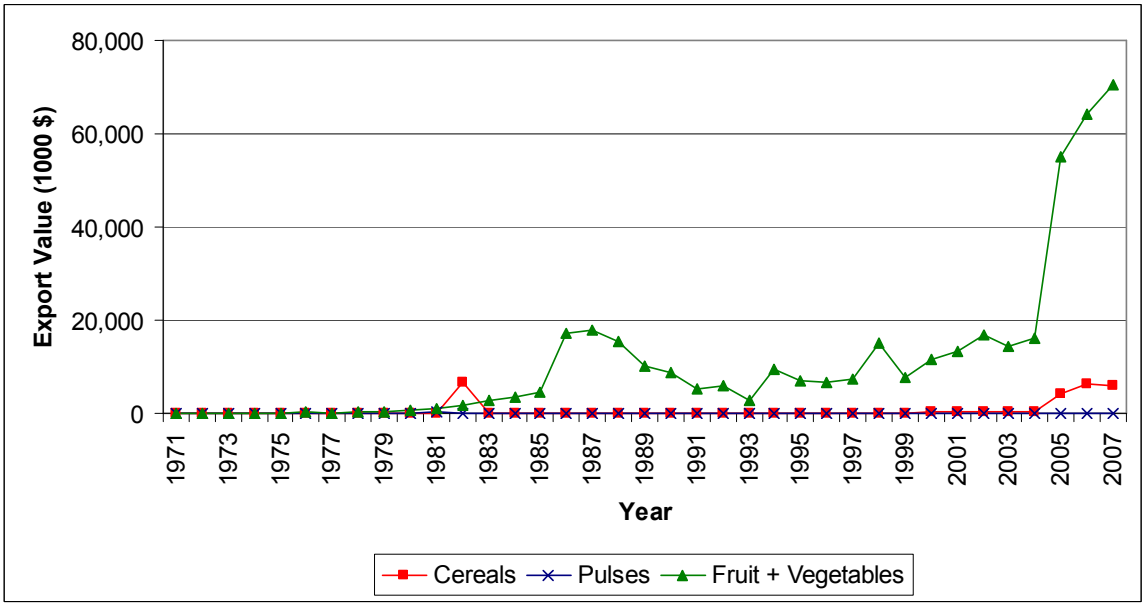


Figure 2.6: Bangladesh's export of major agricultural commodities from 1971 to 2007

Compared to export value, import of these commodities is greater (see Figure 2.7). Pulses were

not imported to Bangladesh until 1975, although unstable. After 1986, pulses import proportionally increased. According to FAOSTAT, the population of Bangladesh is increasing from 1971 until now, and less production and increased consumption of pulses resulted in an increase in its importation. Though fruits are not part of daily major consumption, its recognized importance through higher vitamin and mineral composition resulted in continuous increase in the import of fruits and vegetables. However, the trend of cereal import was not uniform, fluctuating year by year. The demand for cereals is changed yearly because of damage to agricultural produce by natural calamities, climate change and the unpromising nature of Bangladesh's agriculture. The import value of cereals reached a peak in 1999 with a value of US$934.25 million. After 2005 import values of all three commodities continued increasing.

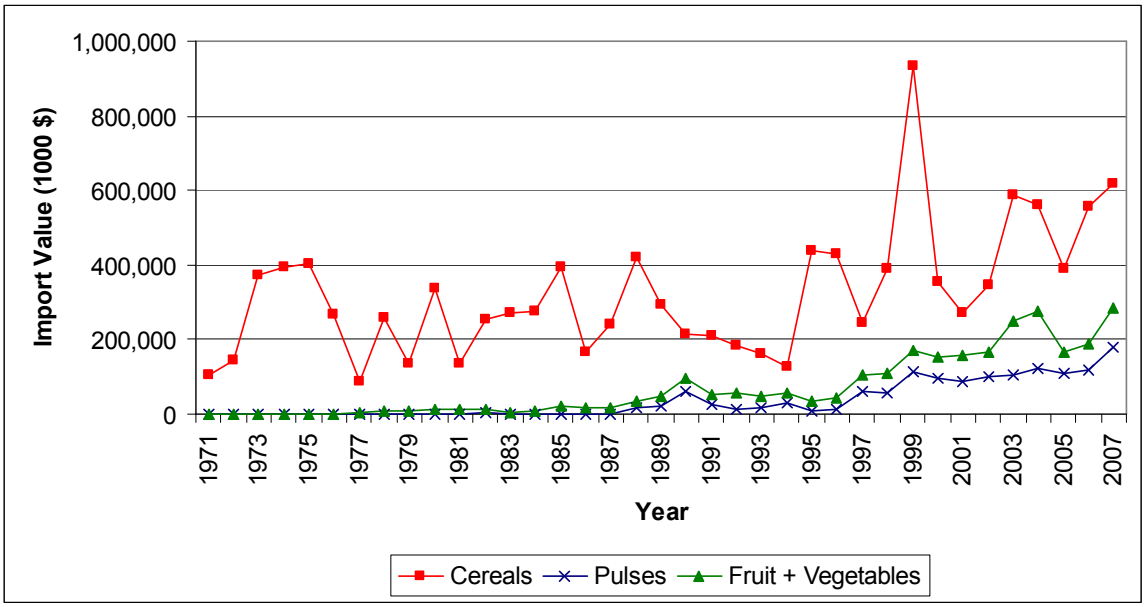


Figure 2.7: Bangladesh's import of major agricultural commodities from 1971 to 2007

Figure 2.8 shows the import-export relationship of total merchandise trade and total agricultural products. Import-export trade of total merchandise and export trade of total agricultural product were nearly the same until 1987 with some deviation until 1993. But the import of total agricultural product was increasing from 1971 to 2007 and reached a high with US$4.00 million.

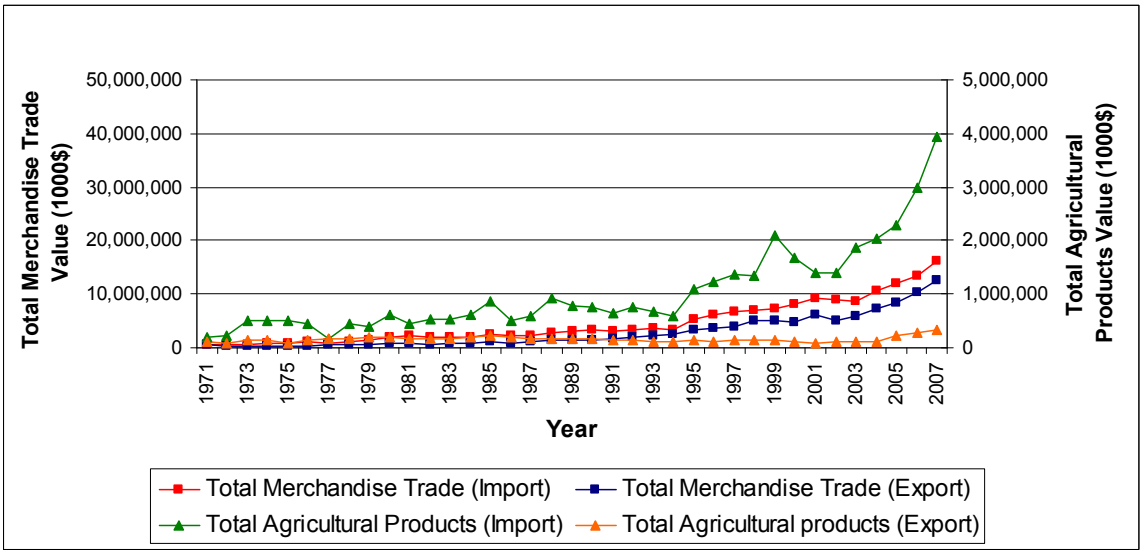


Figure 2.8: Bangladesh's total merchandise trade and total agricultural products trade in 1000 USD

Percentage of trade of import and export of total agricultural products to total merchandise trade is shown in the Figure 2.9. It is observed from Figure 9 that export trade was continuously decreasing from 1971 to 2007. However this decrease was nearly constant from 1995. At the same time after 1993 import trade was also nearly constant except in 1999 and 2002. It is clear that Bangladesh is not self sufficient in their production and lack selected commodities, which were imported from other countries. During 1974 import value percentage reached a peak with 77.09 per cent and was least in 2001 with 15.43 per cent. The percentage import exceeds by more than 8 times the export of total agricultural products to total merchandise trade.

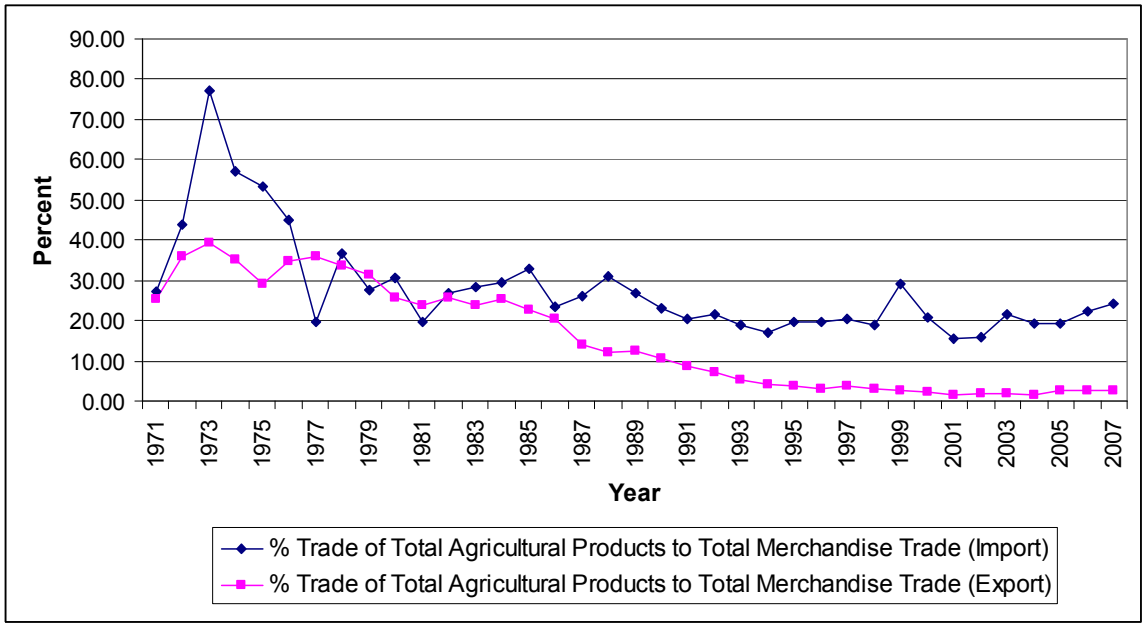


Figure 2.9: Total agricultural trade v/s total merchandise trade for Bangladesh (FAOSTAT)

Agricultural area occupies 62.85 per cent of the entire area of Bangladesh, with permanent crops, permanent meadows, pastures, forest area and inland water taking 3.33 per cent, 4.16 per cent, 6.01 per cent and 9.61 per cent, respectively. However arable land area and area equipped for irrigation is 55.35 per cent and 34.73 per cent, respectively, of total country area. Figure 2.10 shows land use in Bangladesh.

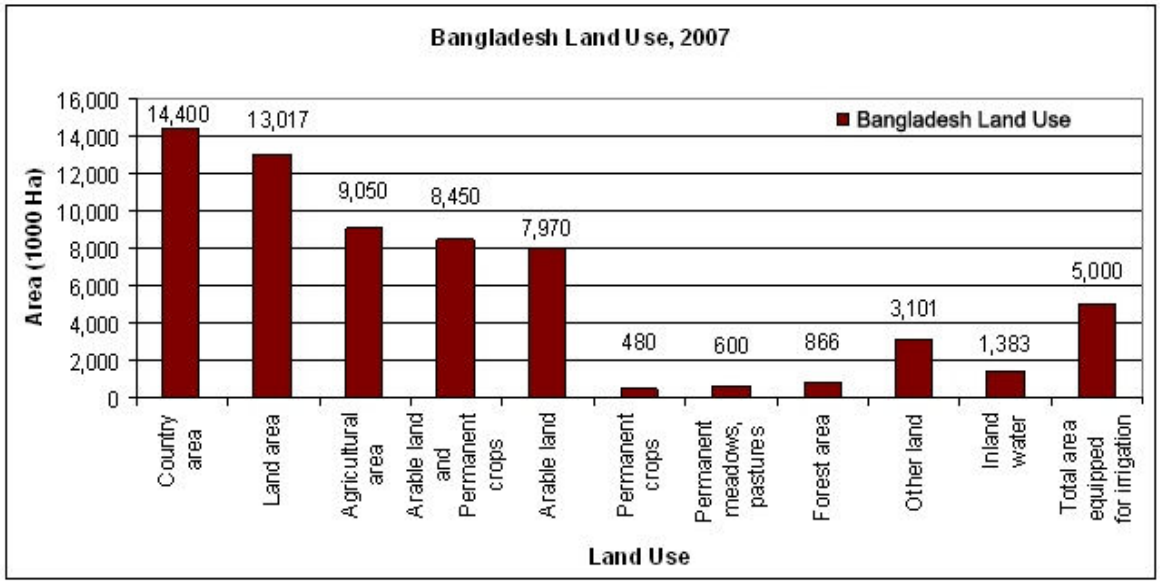


Figure 2.10: Available land use in Bangladesh in the year 2007 (FAOSTAT)

According to FAOSTAT, the population of Bangladesh in 2009 was 162.221 million. Figure 2.11 shows that the population of country will reach 195.1 million by 2025 and 222.5 million by 2050. This increasing population will increase demand for the food.

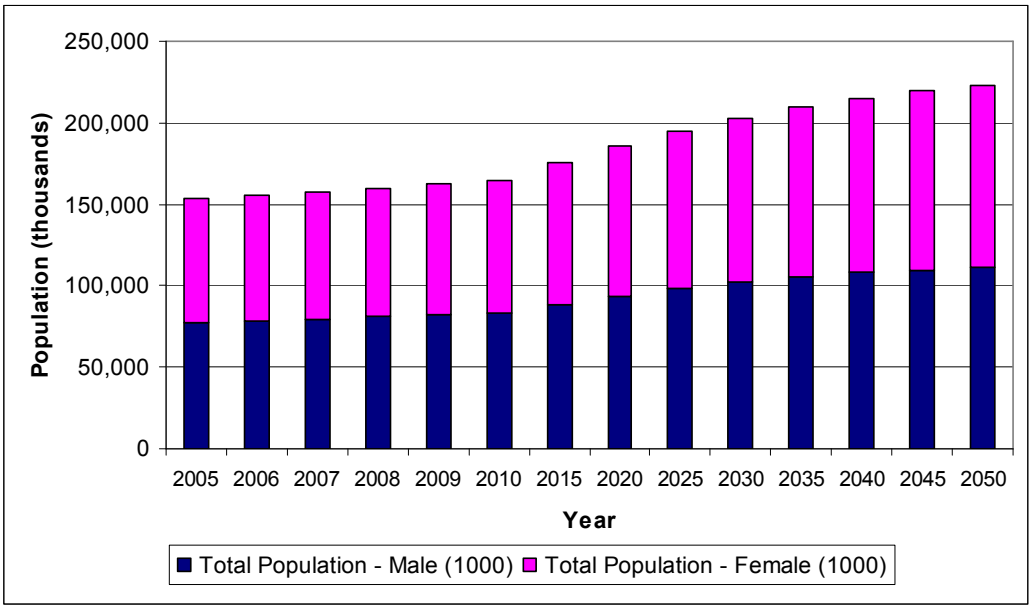


Figure 2.11: Total current and predicted population of Bangladesh over the period of 2005 to 2050 (FAOSTAT)

In the year 2005, the total agricultural population was 50.12 per cent of the total population (153.122 million) while in 2009 it was 46.33 per cent of the total population. It is predicted that the total agricultural population will decrease to 36.09 per cent of the total population (please see Figure 2.12). This clearly shows the need of agricultural mechanization in the country.

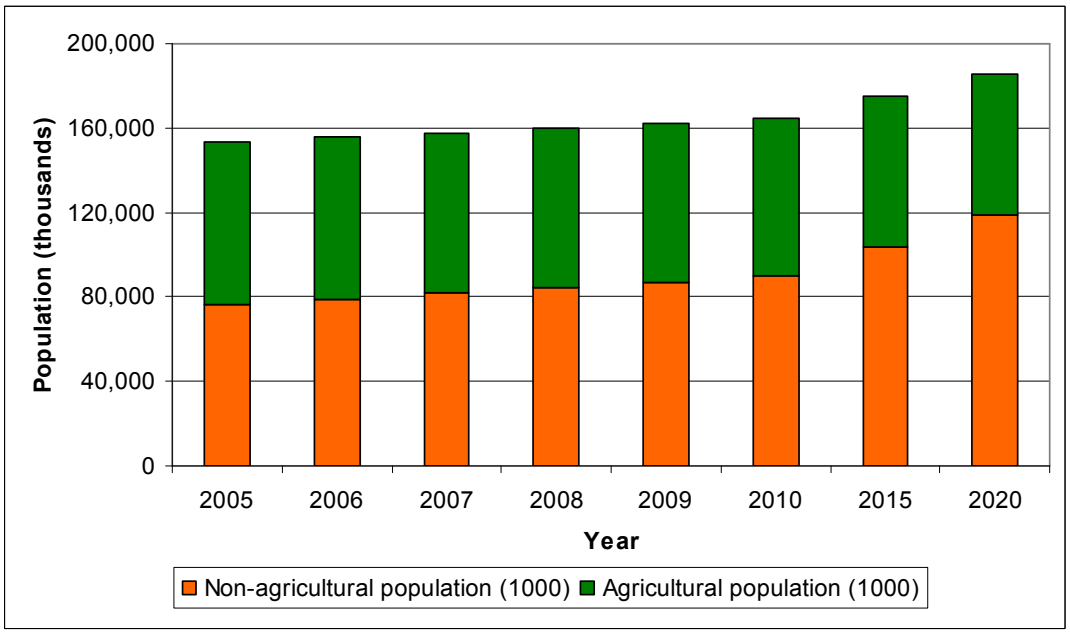


Figure 2.12: Current and predicted total agricultural and non-agricultural population of Bangladesh (FAOSTAT)

2. Agricultural Mechanization in Bangladesh

2.1 Popularization of agricultural machinery

Mechanization in Bangladesh agriculture started in the 1960s with the introduction of tractors, power tillers, deep tube wells, shallow tube wells and low lift pumps but of very limited quantities. After independence in 1971, introduction and adoption of mechanization accelerated, especially in irrigation development. Though the use of tractors, power tillers and other farm machinery, like threshers and weeders, increased with time, irrigation equipment increased at a much faster rate. Table 2.1 shows the population of the different farm machinery over the years.

Table 2.1: Population of different farm machinery over years (Roy and Singh, 2008)

Name of machine	Year				
	1977	1984	1989	1996	2006
Tractor	300	400	1,000	2000	12500
Power tiller	200	500	5,000	100,000	300,000
Maize sheller	-	-	-	100	850
Thresher(open drum)	-	500	3,000	10,000	130,000
Thresher(closed drum)	-	100	1,000	5,000	45,000
Deep tube well	4,461	15,519	22,448	24,506	28,289
Shallow tube well	3,045	67,103	223,588	325,360	1,182,525
Low lift pump	28,361	43,651	57,200	41,816	119,135

Other than the listed agricultural machinery, about 250 power tiller-operated seeders are in use. Farm machinery, such as, weeders, threshers, winnowers and centrifugal pumps are developed and manufactured locally with locally available materials. Manually-operated weeders and sprayers are used widely and summed to total about 200,000 and 1,000,000 units in 2008, respectively. A few hundred pedal and power operated winnowers are also being used in the country (Roy and Singh, 2008).

The extent of mechanization can be measured as the level of energy input. Figure 2.13 shows the available power in agriculture over the period of 1960 to 2007. From Figure 15 it is clear that the available power gradually increased from 0.24 kW/ha in 1960 to 0.32 kW/ha in 1984. After 1984 available power increased sharply reaching 1.17 kW/ha in 2007.

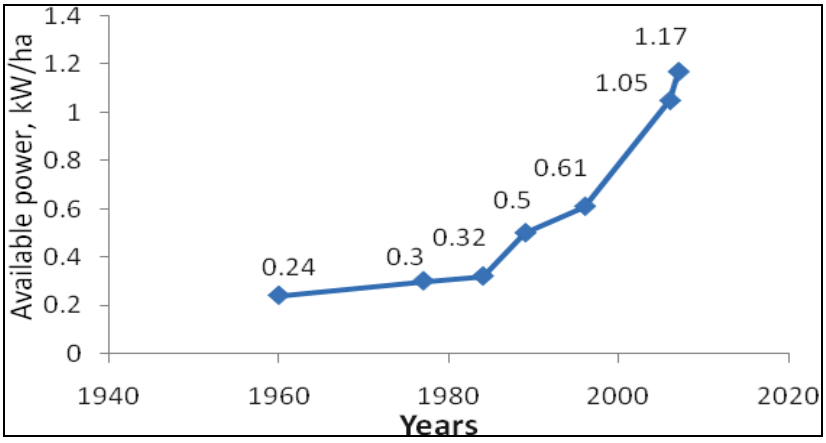


Figure 2.13: Available power in Bangladesh agriculture sector during 1960 - 2007 (Islam, 2008)

The Bangladesh agriculture sector is more focused on irrigation engineering and proper utilization of water resources than mechanized farming. Thus, most of the agricultural machinery used in the country is either imported or locally manufactured in workshops. Figure 2.14 shows Bangladesh's importation of agricultural tractors, harvesters and threshers, soil, dairy and other machinery.

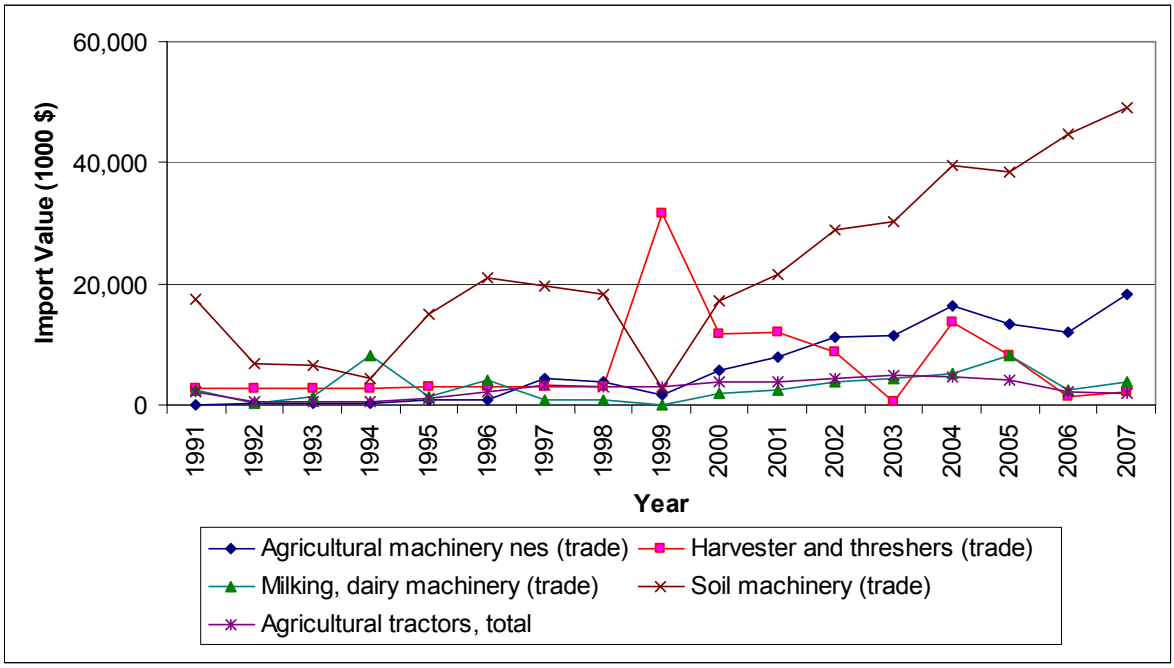


Figure 2.14: Bangladesh import of agricultural tractors, harvesters, threshers, soil, dairy and other machinery (FAOSTAT, 2010)

The import value of soil machinery is consistently higher and increasing compared to agricultural machinery such as, harvesters and threshers, milking and dairy machinery, agricultural tractors and other agricultural machinery and equipment. In 2007 the country imported about US$49.18 million worth of machinery. The import value of agricultural tractors and milking and dairy machinery was fairly consistent over the last two decades while the import value of harvesters and threshers fluctuated during the same period. Trade of other agricultural machinery not mentioned above has shown steady growth since 1999.

Figure 2.15 shows the main agricultural machinery imported by Bangladesh while Figure 2.16 shows the total import value in 1000 USD of the same imported agricultural machinery. From the figures it is clear that the import of main agricultural machinery is only demand based. Seeders and ploughs were the main imported agricultural equipment. Except in 2006, the import value of milking machines was about US$600,000. Balers were the least imported agricultural machinery followed by combine harvesters and threshers. With the exception of milking machinery, the import value of agricultural machinery was mostly below US$200,000.

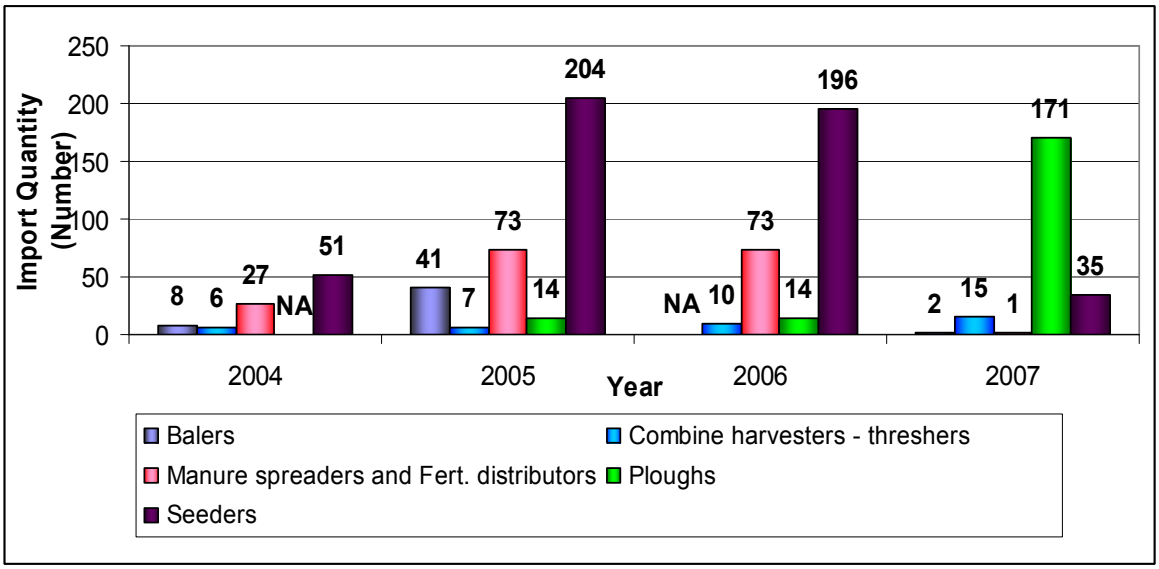


Figure 2.15: Bangladesh's main agricultural machinery import in quantity (no.) (FAOSTAT)

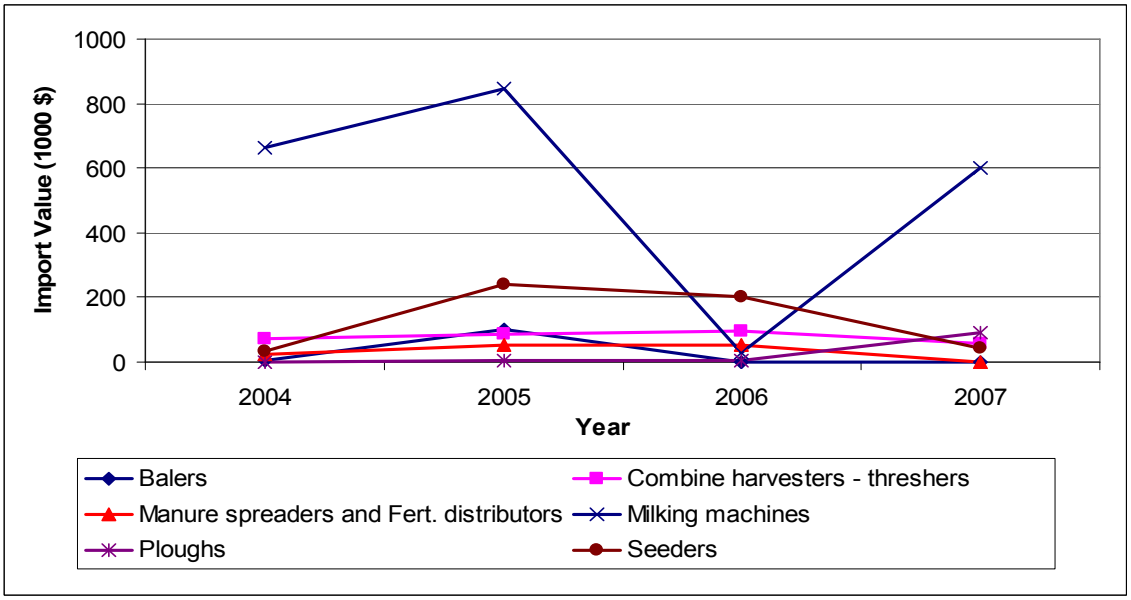


Figure 2.16: Bangladesh's main agricultural machinery import value (1000 US$) (FAOSTAT)

Bangladesh is not involved in any major export of agricultural machinery. Recently, in 2007, Bangladesh exported some of agricultural machinery as shown in Figure 2.17. The export of agricultural machinery is not extensive for the country. Most of the machines in Bangladesh are manufactured locally for local use.

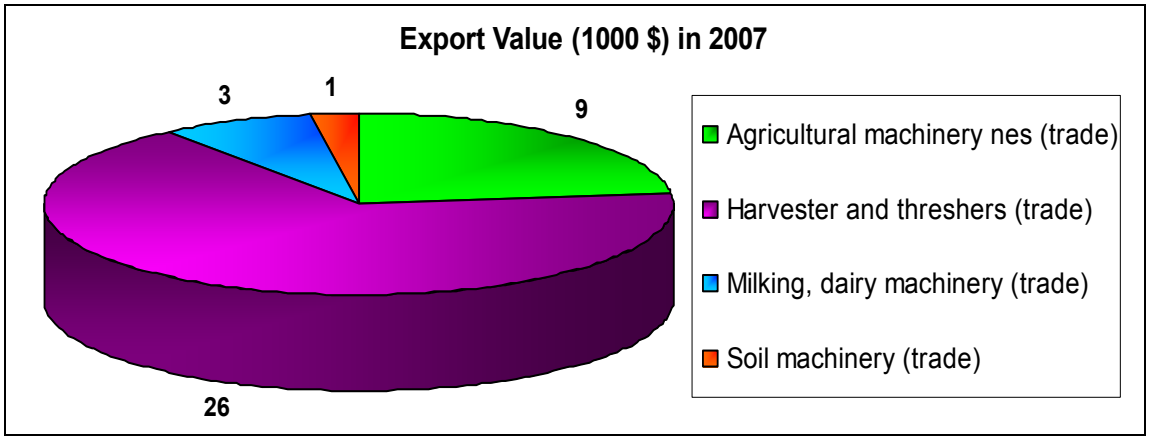


Figure 2.17: Bangladesh's export of harvesters, threshers, soil, dairy and other machinery in export value (1000 US$) (FAOSTAT)

2.2 Constraints to farm mechanization in Bangladesh

The adoption of mechanization in the Bangladesh agricultural sector is increasing but is imbalanced. The country has given first priority to mechanization of water pumping for irrigation. At present about 55 per cent of the total cultivable area is under irrigation, mainly by pumped ground water. The second priority was given to mechanizing tillage operations by using power tillers. Currently, about 80 per cent of the total tillage operation is carried out with power tillers and tractors. The use of power tillers for tillage operations is higher than tractors as average land holding is quite small. Also, rapid growth of mechanization was observed in threshing operations. The availability of farm power was increased from 0.3kW/ha in 1960 to 1.17 kW/ha in 2007. Looking at the increasing trend of farm power availability, it is expected that the power available at farm level will continue to increase further at a higher rate as many major agricultural operations have yet to be mechanized (Roy and Singh, 2008).

However, the adoption of farm mechanization in Bangladesh is hindered due to inherent problems such as small and fragmented land holdings, low buying capacity of farmers, lack of quality machines for farm operations, inadequate knowledge of machinery use and lack of extension of information and building awareness in farming communities (Islam, 2008).

2.2.1 Small and fragmented land holdings

The average farm holding has been decreasing continuously. In 1980 the average land holding was 0.91 ha which fell to 0.68 ha in 2000 (Roy and Singh, 2008). With a smaller farm area, farmers prefer to follow traditional methods of cultivation rather than use mechanized implements. The use of power tillers, reapers and other machinery on small farms faces the problem of frequent turning, which reduces the efficiency of the work and makes the operation tedious and boring.

2.2.2 Low buying capacity of farmers

Modern agricultural machines like tractors, combine harvesters and seeders are owned by only a few rich farmers. Most of the farmers are very poor and can not afford the high price of modern agricultural machinery and implements. They either follow traditional methods by using animal and human labor for most of the farm operations or hire the machinery from richer farmers in the locality having specific equipment.

2.2.3 Farm machinery quality

In Bangladesh greater importance has been given to irrigation than farm mechanization. Thus, only a very few manufacturers are producing simple, manually-operated machines like weeders,

threshers and winnowers. However, the vital need of the country to produce sufficient food for its growing population pointed to the need to adopt farm mechanization in recent years. At present about 40,000 small and medium-scale local manufacturers are running their facilities to manufacture most of the simple, manually operated machinery (Farouq et al., 2007). Due to no required testing or standardization, machines and equipment manufactured locally are not up to international standards.

Mostly manufacturers obtain a prototype of a particular machine from researchers which they then produce in bulk without paying attention to quality aspects. Institutions such as BARI (Bangladesh Agricultural Research Institute) and BAU (Bangladesh Agricultural University), develop machinery, but do not produce nor have current authority to control the manufacturer quality. Local manufacturers have mostly emerged out of the repair and maintenance sector, and lack facilities and knowledge to produce at a high standard and due so in under equipped facilities (Islam, 2010) Such sub-standard machinery create an adverse impact on farmers, which hinders the adoption of mechanization practices. The requirement of advanced machinery like tractors, power tillers and combines is fulfilled by importing machinery form other countries, mainly India. Which again are being imported without required testing or set standards.

2.2.4 Inadequate knowledge and skill

Due to the high level of illiteracy among farmers and a lack of facilities to obtain the required knowledge about machine use, operation and maintenance the growth rate of farm mechanization is low. Manufacturers do not provide after sales service to the users. Machines are kept idle for small or minor and easily repairable faults. Farmers have to pay a higher amount to get the machine repaired from local mechanics. Moreover, village mechanics are not adequately trained and are generally unaware of the mechanics of the machine.

The lack of knowledge and skill is not limited only to farmers but manufacturers as well. Most small manufacturers are in reality small workshops manufacturing equipment and in some cases machinery based on researcher blueprints. Both manufacture workers and repair have no expertise knowledge or training even when after sale services are available. What's more even machinery foreign companies frequently do not have own or representative facilities for 'after sales services'.

2.2.5 Lack of extension of information and building awareness

Much of the agricultural research in the country is not focused on farm mechanization. Whatever research is conducted is not extended to the farmers effectively. Lagging in awareness building and information extension among farmers hinders the mechanization adoption process.

2.2.6 Machinery import and tariff policies

In order to increase agricultural mechanization in Bangladesh, a policy decision was made following a devastating flood in 1988. The Bangladesh government abolished all standardization requirements for agricultural machinery, allowing for open market imports of all agricultural machinery and implements (Islam, 2010).

Further weight to the matter of this policy is added by the substantial tariff differences in agricultural machinery imports. While finished agricultural machinery falls under a no-tax import policy, spare parts for the same are being taxed at 35% (Baswas, 2010). Thus no-tax no standard requirement has a tendency to introduce low quality machinery into the country for which spare parts are taxed high.

3. Testing and Certification Facilities in Bangladesh

Bangladesh is still lagging in the effective and efficient adoption of agricultural mechanization due to the fragmented approach toward agricultural mechanization and a lack of coordination in research and development within and between the government and the private sector (Kabir, 2004). The Ministry of Agriculture has formed various branches to deal with different aspects of national

agriculture (Figure 2.18). However, there is no institutional arrangement to coordinate different institutions in respect of farm mechanization (Roy, 2003).

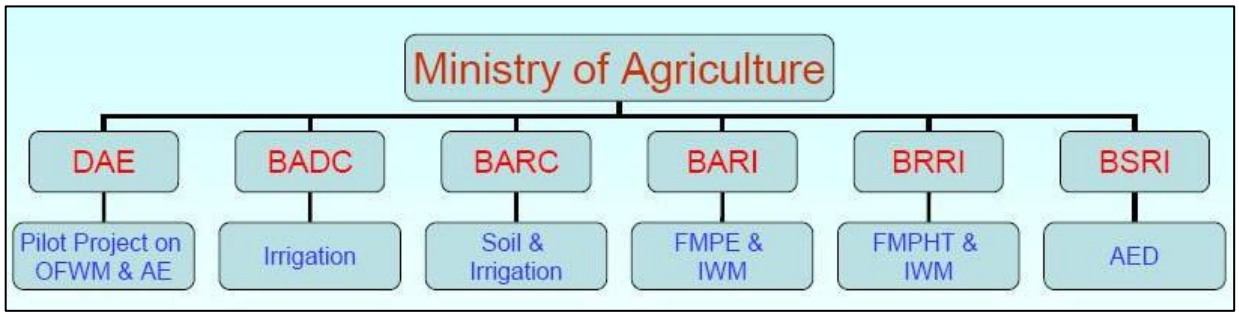


Figure 2.18: Organizational structure of Ministry of Agriculture, Bangladesh (Roy, 2003)

The domestic manufacturing of agricultural machinery comprises about 12 to 15 local manufacturers. With the help of BARI, BRRI, BSRI and other branches, some research and development work is carried out in the country.

Till 1998 testing and certification for machinery in Bangladesh was mandatory. For manufacturers it was compulsory to obtain certification from farm power and machinery department of Bangladesh Agricultural University and farm machinery division of BARI before passing on final certification decision by national committees. Meaning elementary facilities and capacities for machinery and equipment testing exist within these and other smaller institutions, which now play a role in researching and designing machinery for manufacturers (Islam, 2010 & Basawa, 2010).

3.1 Testing of agricultural machinery in Bangladesh

During 1970 to 1988, there were two national committees to test domestic and imported agricultural machines. The Agricultural Machinery Standardization Committee and Technical Sub Committee (TSC) to test country made and imported agricultural machinery. In the case of TSC, it tested the machines submitted by the manufacturers or importers both at field and laboratory levels and sent the results to the technical committee with some recommendations for good ones. The TSC in return claimed fees for testing the machines which the manufacturers or importers would have to pay at the time of submitting the machines (Basawa, 2010; Ahmed & Kabir 2005.)

These committees used to test all the machinery, especially irrigation equipment, pumps and sprayers. After the 1988 waver of testing and certification by the Bangladeshi government any national testing and certification procedure has stopped. Currently Bangladesh is importing agricultural machinery, which is certified by the country where it was manufactured.

In the core of testing and certification for agricultural machinery and equipment, policies, institutional framework and knowledge capacity remain. Bangladesh has some previous experience and fundamental facilities to reinstate testing and certification, with an evident need for further development and capacity building.

3.2 Future focus of the national institutes

The national institutes in Bangladesh are aware of the need to test and certify domestic as well as imported agricultural machinery. The main focus of the national institutions is to develop effective testing and certifying units for the sustainable and efficient growth of agricultural mechanization in the country.

- The institutes are planning to provide the test report to the buyers of domestic or imported agricultural machines.
- Testing (if not standardizing) of the domestic and imported machinery will be required for sellers before marketing of the machine.

- Support for the development of methodologies for the testing the agricultural machinery and to develop the standards.
- Strengthening of the standardization and testing facilities

All these developments are still in the initial phase and need a longer time to develop into a strong nationwide network.

B) PEOPLE'S REPUBLIC OF CHINA

1. General overview of agriculture

1.1 Social and economic condition and agricultural development

In the late 1970s, the Chinese Government instituted the policy of "reform and opening up." Since then, economic conditions have changed rapidly. China has become one of the most dynamic players in the global economy. China's GDP growth is illustrated in Figure 2.19. China's GDP in 2008 was 3 times more than that in 1998 according to the World Bank.

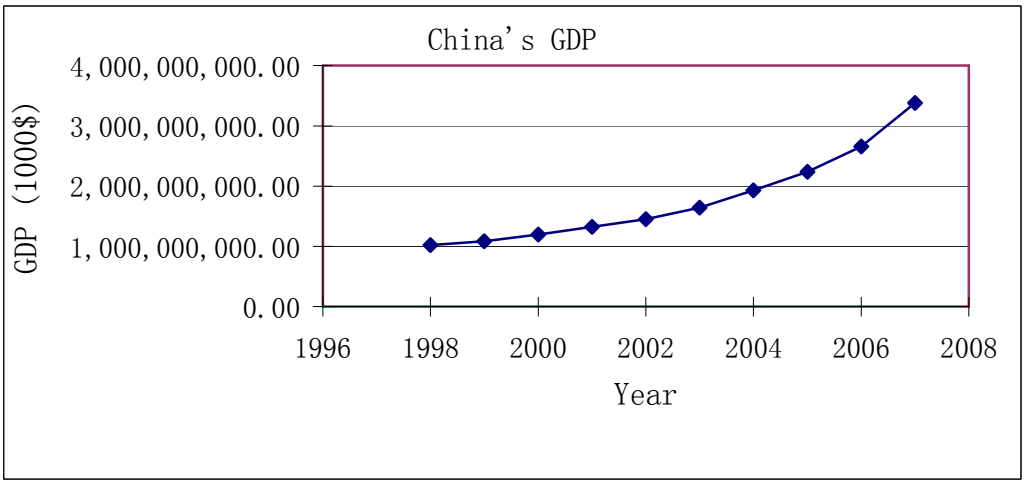


Figure 2.19: China's GDP growth in the decade from1998-2008（World Bank Database）

1.2 Industrialization and urbanization

Since the last two decades of the 20th century, China launched its plan of modernization. In 2002, China proposed the building of the so-called new type of industrialization. According to this plan, China will achieve the basic industrialization in 2020 (Ma Kai 2005). Actually, China's GDP reached US$ 4.3 trillion, with GDP per capita exceeding US$3,000 in 2008 (Maohua Wang 2009).

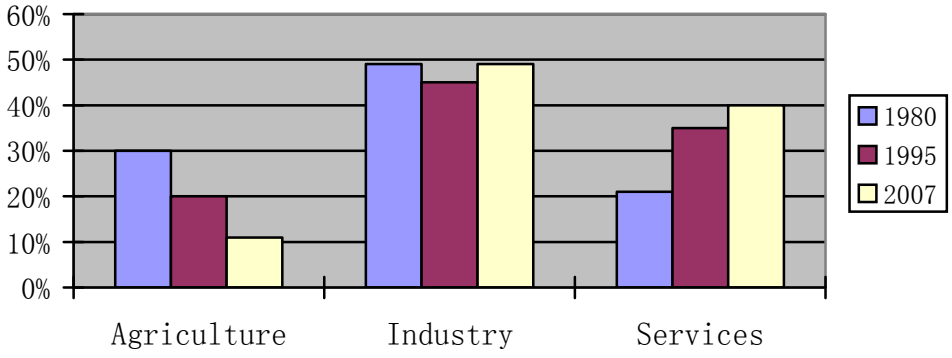


Figure 2.20: Share of GDP by sector in China

Rapid economic growth was accompanied by significant structural changes in China's economy. As can be seen in Figure 2.20, the share of agricultural sector in GDP accounted for 30 per cent in 1980, 20 per cent in 1995 and 11 per cent in 2007;, the industrial sector fluctuated between 45 per cent to 50 per cent from 1980 to 2007; and the share of the service sector increased from 13 per cent in 1970 to 21 per cent in 1980 and 40 per cent in 2007. The trend shows that the service sector is expanding quickly while the agriculture sector is shrinking. However, agriculture remains a key economic sector since it employs about 40 per cent of the total labor force in China. This trend is expected to persist in the coming years (Ji kun Huang, Scott Rozelle, 2009). Therefore, it is important for China to improve and enhance the development of its agricultural sector.

Structural changes also indicate the substantial impact on employment. The data from 1970 to 2007 demonstrates in Figure 2.21 that 80 per cent of the nation's workforce was employed in the agricultural sector in 1970 declining to 60 per cent in 1990 and 40 per cent in 2007. The share of employment in the industrial sector was stable at about 20–30 per cent during the 1990-2007 period. As far as the share of employment in the service sector is concerned, it increased rapidly from about 10 per cent in 1970 to more than 30 per cent in 2007 (Huang and Rozelle, 2009).

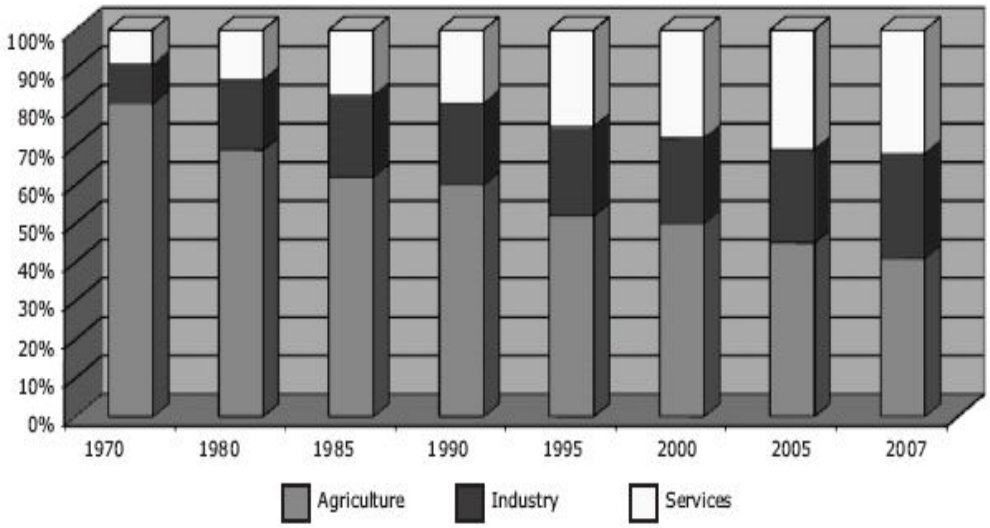


Figure 2.21: Employment by sector in China

The factors that contribute to China's structural changes include the rapid economic growth, urbanization, market liberalization and China's reform and opening-up policies. These changes pushed China to develop rapidly in the past three decades.

Figure2.22 and Figure 2.23 show the steady growth in the gross and net value of agricultural production including agriculture in total, cereals, other crops, livestock, food and non-food in the past half a century with the introduction of the Household Responsibility System (HRS), hybrid rice, high yield seeds for other crops, the use of fertilizers and plant protection techniques, which helped the country to improve the status of its agriculture.

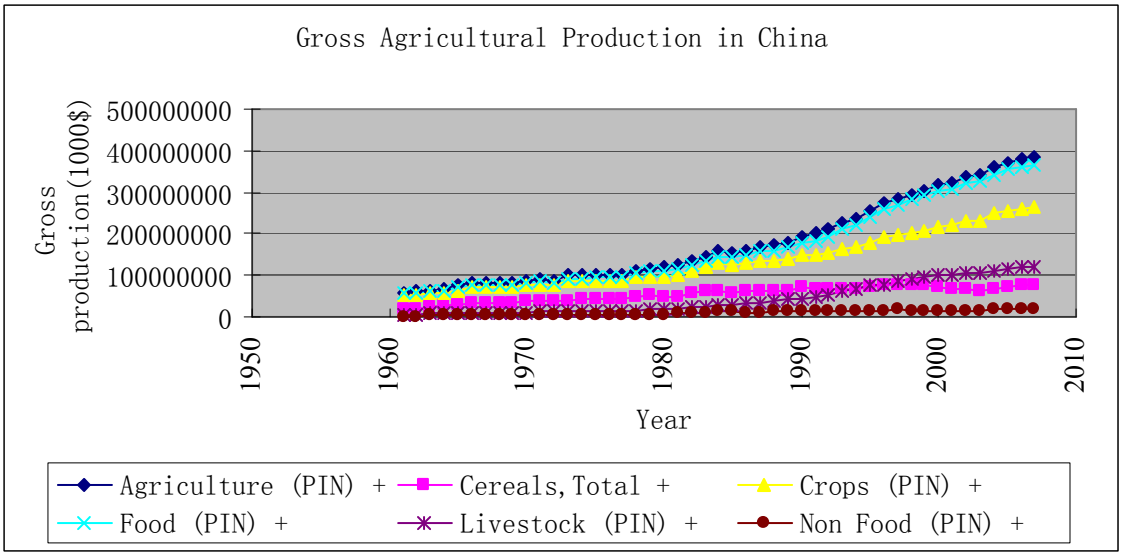


Figure 2.22: Gross production expressed as 1000 USD, China (FAOSTAT)

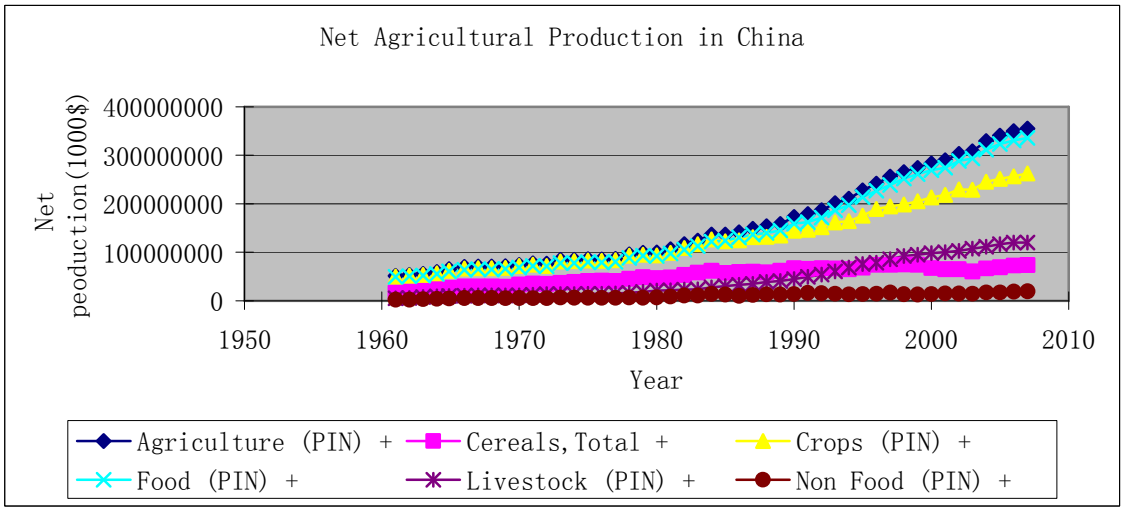


Figure 2.23: Net agricultural production as 1000 USD, China (FAOSTAT)

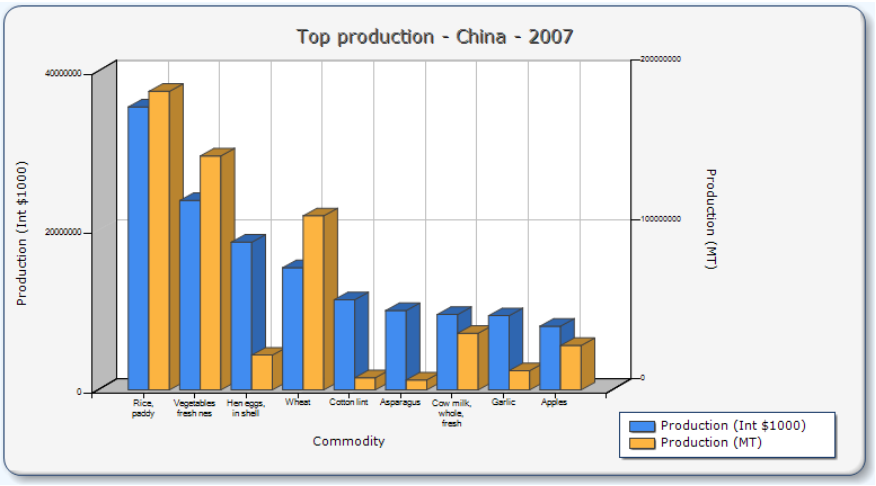


Figure 2.24: Production of some top agricultural commodities in China in 2007 (FAOSTAT)

Table 2.2 shows the production of top twenty agricultural commodities in 2007 while the production of some top agricultural commodities in China in 2007 is shown in Figure 2.24. Rice production, with a value of US$35.53 billion, was the highest, followed by fresh vegetable production (US$23.78 billion). Other agricultural products like wheat, cotton and fruits were also produced in large quantities.

Table 2.2: Production of top twenty agricultural commodities in China in 2007 (FAOSTAT)

Rank	Commodity	Production ($1000)	Production (MT)
1	Rice, paddy	35,526,760	187,397,460
2	Vegetables	23,777,510	146,902,838
3	Hen eggs, in shell	18,540,600	21,833,200
4	Wheat	15,348,160	109,298,296
5	Cotton lint	11,317,680	7,623,597
6	Asparagus	9,961,629	6,253,141
7	Cow milk, whole, fresh	9,460,634	35,574,326
8	Garlic	9,311,747	12,064,662
9	Apples	8,003,659	27,865,889
10	Tomatoes	7,960,108	33,596,881
11	Potatoes	6,743,942	64,837,389
12	Watermelons	6,583,176	62,256,973
13	Groundnuts, with shell	6,112,785	13,079,363
14	Maize	5,818,754	152,418,870
15	Cabbages and other brassicas	5,101,838	36,530,009
16	Spinach	4,907,504	12,012,005
17	Sweet potatoes	4,855,120	75,800,197
18	Chillies and peppers, green	4,840,326	14,026,272
19	Cucumbers and gherkins	4,590,038	28,049,900
20	Tobacco, un-manufactured	4,370,623	2,397,152

Developments in the export and import of major agricultural commodities are shown in Figure 2.25, Figure 2.26, Figure 2.27 and Table 2.3 respectively. The data indicates that in the past two decades China was very active in the international market. China both imported and exported many agricultural commodities. It can be found that the import and export of agricultural commodities increased drastically since the end of last century. The data in Figure 27 and Table 4 also show that the most important commodities for trade by value were soybean and soybean oil. However, the imported soybean was for producing oil. This means that the oil for food depends on import and the cereals including rice, wheat, maize are not important commodities in China's import and export since the least amount of cereals was imported or exported (Figures 28 and 29). The strategic target for the Chinese government is to achieve self-sufficiency in food production.

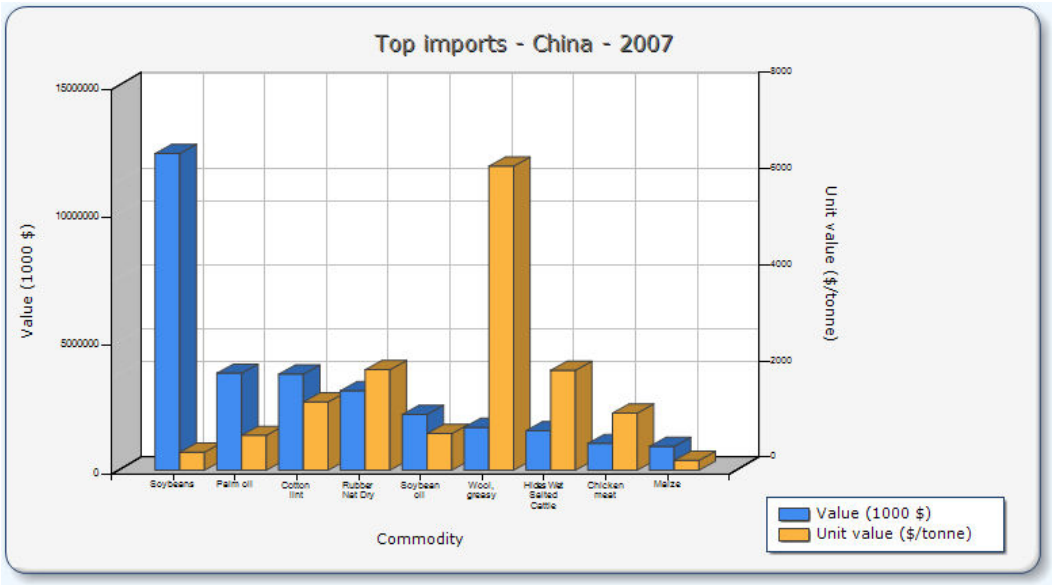


Figure 2.25: Top imported agricultural commodities in 2007

Table 2.3: Top 20 imported agricultural commodities in 2007

Rank	Commodity	Quantity (tonnes)	Value (1000 $)	Unit value ($/tonne)
1	Soybeans	33150449	12351826	373
2	Palm oil	5223369	3784334	725
3	Cotton lint	2638361	3746973	1420
4	Rubber Nat Dry	1481813	3099144	2091
5	Soybean oil	2857284	2176624	762
6	Wool, greasy	264220	1670971	6324
7	Hides Wet Salted Cattle	741467	1540504	2078
8	Chicken meat	875586	1040633	1189
9	Maize	4529508	928949	205
10	Beverage, Distilled Alcohol	75756	865990	11431
11	Food (prepared)	202329	765527	3784
12	Cassava Dried	4672184	667537	143
13	Tobacco, unprocessed	93865	514344	5480
14	Cigarettes	29158	443101	15197
15	Offal of Pigs, Edible	431374	405554	940
16	Wheat	1427548	403267	282
17	Infant Food	55180	385706	6990
18	Wine	169983	373773	2199
19	Meat-Cattle Boneless (Beef & Veal)	81859	361026	4410
20	Rapeseed	833191	351754	422

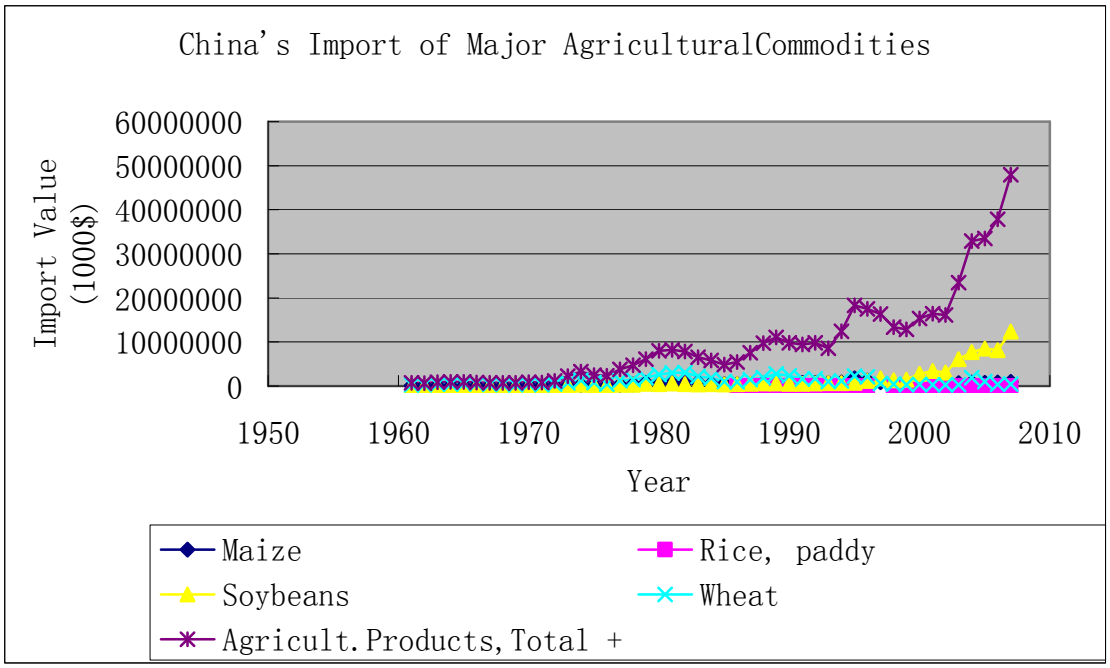


Figure 2.26: China's import of major agricultural commodities from 1961 to 2006 (FAOSTAT)

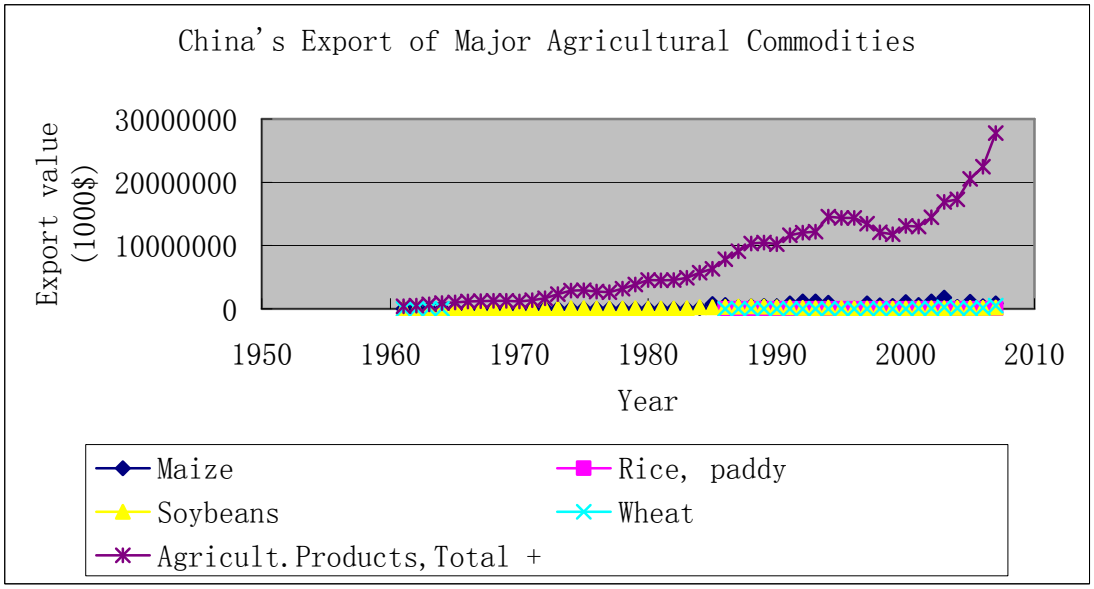


Figure 2.27: China's export of major agricultural commodities from 1961 to 2006 (FAOSTAT)

1.3 Issues surrounding agricultural development in China

In recent years, various factors including the economic globalization, entry to the WTO, and the commercialization of the agricultural products made a huge impact on Chinese agriculture while providing impetus to its development.

1.3.1 Grain and food security

With a huge population, feeding her people is the basic issue for the Chinese government. Grain and food security, therefore, are the most important issues in China. Grain price increased rapidly in the past decades. The increasing rates were 12 per cent, 24 per cent and 50 per cent in 2006, 2007 and 2008, respectively. The Consumer Price Index (CPI), in the first half of 2008, increased more than 7 per cent and food price increased 20 per cent compared with the same

period in 2007. CPI fluctuation was mainly caused by food price increases. The average CPI in 2008 increased 5.9 per cent which was 1.1 per cent higher than in 2007. This fact casts a big shadow on the grain and food security for China. One of the main reasons for the fast increase is the low working efficiency in agricultural production in China. Moreover, this is one of the main reasons for China to develop its agricultural mechanization as well.

1.3.2 Impact of global climate change

In the past 100 years the global average temperature increased 0.75℃. China's average temperature increased 1.10℃. In North Eastern and Northern China, the increment of temperature was 3.50℃C and the average rainfall in summer decreased 20mm.

The severe drought had hit at least eight provinces in China for several months in 2008. It affected about 20 million hectares of farmland and the growing of 10 million hectares of winter wheat leaving 4.37 million people and 2.1 million heads of livestock with drinking water shortage. It also caused the change of the pattern of crop structure, incidence of pest and disease, reduction of crop growing period, decreasing of yield as well as the change of crop production belt.

1.3.3 Impact of world financial crisis

The direct impact on China's agro-system during the world financial crisis was that millions of migrant workers lost their jobs in the cities. Export of agro-products was reduced and it was difficult to increase selling prices for agro-products. In order to strengthen the Chinese economy, the Chinese government established a policy "Maintaining economic growth, expanding domestic demand, restructuring economy, transforming growth pattern" to cope with the global crisis. A US$586 billion stimulus package was introduced to boost the country's domestic market, especially the rural market. China's financial system was relatively stable in recent years with an unhealthy asset rate of about 2.5 per cent. China's GDP increase was kept at 9.0 per cent and 8 per cent, respectively, in 2008 and 2009. Household savings by the end of 2008 was about US$2.9 trillion, which was 1.5 times higher than in 2008. The total foreign exchange reserves by the end of December 2008 was US$1.95 trillion, which increased 27.3 per cent.

Despite the Asian financial crisis in the late 1990s, an average annual growth rate of 8.2 per cent during the 1996–2000 period was maintained (see Table 2.4). China's economic growth accelerated at the beginning of the 21st century. Annual GDP growth rose from 7.3 per cent in 2001 to an average growth of 9.9 per cent during the 2001–2005 period and 11.8 per cent in 2006–2007 (see Table 2.4). The World Bank predicted growth in 2009 at 7.5 per cent (World Bank, December 2008).

Table 2.4: Annual growth rates of China's economy, 1970-2007 (%) (Huang, 2009)

	Pre-reform	**Reform Period**				
	1970-1978	**1979-1984**	**1985-1995**	**1996-2000**	**2001-2005**	**2006-2007**
GDP	4.9	8.8	9.7	8.2	9.9	11.8
Agriculture	2.7	7.1	4	3.4	4.3	4.4
Industry	6.8	8.2	12.8	9.6	11.4	13.2
Service	NA	11.6	9.7	8.3	10.1	12.4
Foreign trade	20.5	14.3	15.2	9.8	25.3	19.4
Import	---	12.7	13.4	9.5	24.9	16.2
Export	---	15.9	17.2	10.1	25.7	22.1
Population	1.8	1.4	1.37	0.91	0.63	0.5
Per Capita GDP	3.1	7.4	8.3	7.2	9	11.3

2. Agricultural mechanization in China

2.1 Need for agricultural mechanization

1）Urbanization and agricultural mechanization speed up transfer of agricultural labor force.

The Chinese experience in industrialization in the last decade shows that the rural labor force has become a principal force in industrialization and modernization. In 2005, China's population was 1.31 billion while the urbanization rate was 43 per cent. From 2005 to 2015 it is estimated there will be 200 million of the rural population moving into the cities. Migrant workers in secondary and tertiary industries will continue to rise. By 2020, China will achieve the basic industrialization and the initial modernization, the country's population will reach 1.45 billion and the urbanization rate will reach 60 per cent. According to a forecast by the State Council Development Research, China's rural population is expected to shrink from the current 900 million to 400 million over the next 30 years as farmers migrate to cities. It is estimated that agriculture will employ less than 30 per cent of the total labor force. Therefore, in this decade there will be large amount of labor force moving from agriculture to industry and the service sectors as indicated in Figure 2.28.

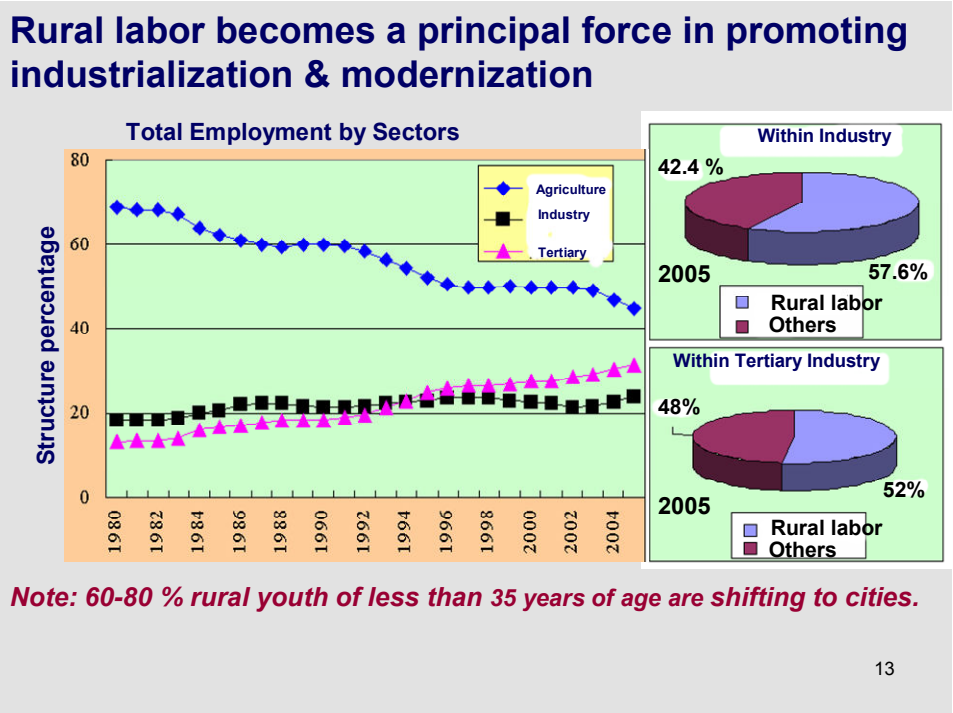


Figure 2.28: Labor shortage caused by industrialization (Shen, G F, Wang, M H, 2008)

2）Agricultural mechanization ensures security of food supply.

As with the rest of the Asian and Pacific countries, China is witnessing a population increase, and there is need to produce more food to feed her people. The agricultural labor force, as seen in Figure 30, was continuously decreasing. The traditional methods in agricultural production are insufficient to promote production growth.

Agricultural mechanization improves production capacity and promotes agricultural modernization, with increased grain output, improvement of production conditions, and effective use of land. For example, by using large-scale machines to conduct deep loosening of the soil can improve the soil water-holding capacity and increase crop yield by 10-15 per cent.

3) Agricultural mechanization is part of national economic development strategy.

In order to achieve the targets of national economic development, it is necessary to increase farmers' income. It is estimated that in 2020 farmers' income should reach 16,000 Yuan (approximately US$2,100). At the same time, the prices of agricultural inputs are also increasing, which drives up the cost of agricultural production. It is, therefore, crucial to speed up agricultural mechanization to increase the productivity to maintain or increase international competitiveness.

Labor cost is increasing progressively in China in recent years. The cost of sugarcane harvesting is a typical example. The labor cost for cutting one ton sugarcane was 20 Yuan in 2000 while it cost 60-80 Yuan in 2008-2009 during the harvesting season. Labor cost for main crop production in 2006 can be found in Table 2.5.

Table 2.5: Labor input cost for main crop production in 2006 (China Agricultural Yearbook 2007)

	Wheat	**Rice**	**Corn**	**Soybean**	**Rapeseed**	**Cotton**
Labor cost %	29.5 %	36 %	36.4 %	43.4 %	49.3 %	50.9 %

4) The Mid & Long-term Development Strategy by 2020 (Shen, G F, Wang, M H, 2008).

According to the study of an expert group, in order to achieve modernization, the following targets must be achieved by 2020:

- Agricultural mechanization level: 70 per cent
- Farming scale per agricultural labor force: 1.6 ha
- Total farm power: <1 billion kW
- Fuel consumption decreases: 30 per cent
- Extend areas of technology innovation to new machinery development for cash Crops, fruits and vegetables, livestock farming, post-harvest processing.

2.2 Status of agricultural mechanization in China

2.2.1 The total number of agricultural machinery grows fast

By 2008, the gross power of agricultural machinery and the amount of tractors and equipments can be seen in Table 2.6.

Table 2.6: Agricultural production basic conditions (China Agricultural Yearbook, 2009)

Item	**2000**	**2007**	**2008**
Total Agricultural Machinery Power (10 000 kW)	52573.6	76589.6	82190.4
Number of Large and Medium-sized Agricultural	974547	2062731	2995214
Tractors (unit)			
Capacity of Large and Medium-sized Agricultural	3161.1	6101.1	8186.5
Tractors (10 000 kW)			
Number of Small Tractors (10 000 units)	1264.4	1619.1	1722.4
Capacity of Small Tractors (10 000 kW)	11663.9	15729.2	16647.7
Number of Large and Medium-sized Tractor Towing	140.0	308.3	435.4
Farm Machinery (10 000 units)			
Small Tractor Towing Farm Machinery (10 000 units)	1788.8	2733.0	2794.5
Number of Diesel Engines (10 000 units)	688.1	861.5	898.4
Capacity of Diesel Engines (10 000 kW)	5232.6	6282.8	6561.7
Irrigated Area (1 000 hectares)	53820	56518	58472
Consumption of Chemical Fertilizers (10 000 tons)	4146.4	5107.8	5239.0
Number of Hydropower Stations in Rural Areas (unit)	29962	27664	44433
Generating Capacity of Hydropower Station in Rural Areas (10 000 kW)	698.5	1366.6	5127.4
Electricity Consumed in Rural Areas (100 million kWh)	2421.3	5509.9	5713.2
Total Sown Area (1 000 hectares)	156300	153464	156266
Grain Crops	108463	105638	106793
Cereal	85264	85777	86248
Rice	29962	28919	29241
Wheat	26653	23721	23617
Corn	23056	29478	29864
Beans	12660	11780	12118
Tubers	10538	8082	8427
Oil-bearing Crops	15400	11316	12825
Cotton	4041	5926	5754
Fiber Crops	262	263	221
Sugar Crops	1514	1802	1990
Tobacco	1437	1164	1326
Vegetables	15237	17329	17876
Area of Tea Plantations (1 000 hectares)	1089	1613	1719
Area of Orchards (1 000 hectares)	8932	10471	10734

The data shows that between 2000 and 2008 there was a substantial increase of the ownership of large and medium tractors, head-feed rice combines, rice transplanters, corn harvesters and conservation tillage equipment.

In 2008 in particular, in comparison to 2007, the total farm power was 820 mil. kW (766 mil.kW in 2007) with an increase of 4.4 per cent; the number of large and medium-scale tractors was 2.4 million units, 17 per cent increase; small-scale tractors 16.6 million units, a 2 per cent increase; combine harvesters 0.71 million units, 12 per cent increase; and rice transplanters 0.2 million units, 28 per cent increase. By 2015, the total power of China's agricultural machinery will reach 1 billion kW, and is expected to rise to 1.2 billion kW by 2020.

By product, tractor, harvesting machinery, field machinery and agricultural transport machinery except pumps all witnessed rapid growth in output in 2009. In the meantime, the ownership of large and medium-sized tractors increased from 975,000 sets in 2000 to 5.019 million sets in 2009, while the ownership of combine harvesters rose from 235,000 sets to 847,000 sets, at a compound annual growth rate (CAGR)of 20.2 per cent and 15.3 per cent, respectively. (Global and China Agricultural Machinery Industry Report, 2009-2010).

2.2.2 Agricultural mechanization level

In 2007, the general agricultural mechanization level, and the ratio of agricultural labor force to total social employment respectively reached 42.5 per cent and 38 per cent, indicating that China's agricultural mechanization had entered into the intermediate period (Global and China Agricultural Machinery Industry Report, 2009-2010).

According to the statistics of 2008 (Table 2.7), land preparation through mechanization, primarily tractor usage, reached 91 million hectares across the nation, accounting for 62.92 per cent of the total farmland. Fifty-nine million hectares of farmland were sowed by machines, and 47.5 million hectares were harvested by machines representing 37.74 per cent, and 31.19 per cent of the total cropland respectively. Farm mechanization level (powered tillage, sowing and harvesting) was on average 45.85 per cent (42.5 per cent in 2007), and mechanization level of rice harvesting was more than 50 per cent.

In 2009, the general agricultural mechanization level reached 48.8 per cent, and the mechanization of plowing, sowing and harvesting respectively achieved 64 per cent, 40 per cent and 37 per cent. Meanwhile, China's three major crops also achieved rapid development in terms of mechanization level. Wheat production has almost achieved complete mechanization, and the production of both rice and corn achieved over 54 per cent of mechanization. In 2009, the general agricultural mechanization level of wheat, rice and corn production was respectively 89 per cent, 54.9 per cent and 54.8 per cent (Global and China Agricultural Machinery Industry Report, 2009-2010).

Table 2.7: Statistics of agricultural mechanization (China Statistics Yearbook 2009)

Year	Total power (KW)	tractor (ten thousand)	combine harvester (sets)	tractor plowing (%)	mechanical sowing (%)	mechanical harvesting (%)	Total level of mechanization (%)
1978	117, 499, 000	193.04	19000	40.9	8.9	2.10	19.66
2001	551, 721, 000	1388.07	282900	47.41	26.06	17.99	32.18
2002	579, 299, 000	1430.56	310100	47.13	26.64	18.30	32.33
2003	603, 865, 000	1475.76	365000	46.87	26.71	19.02	32.47
2004	640, 279, 000	1566.79	410500	48.90	28.84	20.36	34.32
2005	683, 978, 000	1666.49	477000	50.15	30.26	22.63	35.93
2006	726, 359, 600	1728.34	567800	55.39	32.00	25.11	39.29
2007	768, 786, 500	1834.31	632400	58.89	34.43	28.62	42.47
2008	821, 904, 100	2021.91	743500	62.92	37.74	31.19	45.85

Mechanization development for cash crops such as rapeseeds, cotton, sugar cane, sugar beet, fruits and vegetables lags behind. The development of environmentally friendly bio-mass (straw, biomass and waste) treatment machinery becomes an attractive area for equipment innovation.

2.2.3 Service organizations of agricultural mechanization have expanded

After the launch of agricultural machinery subsidy policy, the total number of China's agricultural machinery cooperative organizations and large agricultural machinery owners increased to 39 million in 2009 from 30.818 million in 2003, and agricultural mechanization income also rose to 380 billion Yuan in 2009 from 226.96 billion Yuan in 2003 (Global and China Agricultural Machinery Industry Report, 2009-2010).

While government subsidies contribute to the rapid growth of agricultural machinery in China, agricultural mechanization also helps increase farmers' income and promote rural economic prosperity. The operation and maintenance service and sales of agricultural machinery have become an important part of the rural service sector.

2.2.4 Quality of agricultural machinery has been improved

Thanks to technology innovation of agricultural machinery, great progress has been made in rape seed harvesting, grass harvesting, sugarcane harvesting and water-saving irrigation implements, and duplex-operation-type equipments. The adaptability, security and reliability of agricultural machinery have been further enhanced. The quality of products can basically satisfy the need of actual production.

2.2.5 Agricultural accidents in China

Since the late 1970s, the economic reform promoted the rapid growth of agricultural mechanization in China. Agricultural machinery helps to reduce drudgery in the agricultural work. However, inappropriate use and handling of agricultural machinery can cause accidents and serious injuries, which lead to death. The rapid increase of the use of agricultural machinery also results in the surge of accidents associated with machinery. In 1978, 59,546 serious agricultural accidents were recorded in China, 15,326 people were injured with the death toll of 9,734. Safety of agricultural machinery poses a serious problem, which requires comprehensive testing regulations and systematic training of farmers on machine operation.

In 1986, statistics showed that the number of tractors increased 176 per cent over 1978 while the agricultural accidents reduced by 78.9 per cent. Agricultural accidents in 2007 can be found in Table 2.8, which shows that the situation has been much improved (Agricultural Mechanization Bureau, 2009, Institute of Nanjing Agricultural Mechanization, 2008).

Table 2.8: Agricultural machinery accidents in 2007

Accidents			**Accident Loss**		
Total	**Minor Accidents**	**Serious Accidents**	**Death**	**Injuries**	**Direct Economic Loss (10,000 Yuan)**
2, 296	2, 292	4	498	1, 454	1, 050.59

2.2.6 Supporting system of agricultural mechanization has been improved

Since 1980, a relatively comprehensive supporting system of agricultural mechanization, which includes management system, research institute, and education and training systems for agricultural mechanization, has been established (Table 2.9).

Table 2.9: Agricultural machinery systems (China Statistics Yearbook, 2008)

Agency	Quantity	Number of Persons	
		Total	Scientists and Engineers
Agricultural Machinery Management Organization	33,188	117,950	60,142
1) Provincial	31	787	141
2) Municipal	348	4669	1,854
3) Prefecture	2,768	33,576	15,646
4) Village	30, 041	78,918	42,501
Agricultural Machinery Testing & Certification Organization	55	1,312	960
1) Provincial	30	1,066	791
2) Municipal	25	246	169
Agro-technical extension agency	2,473	2,473	21,481
1) Provincial	30	30	656
2) Municipal	297	297	3,641
3) Prefecture	2,146	2,146	17,184
Agricultural machinery Safety Supervision Organization	2,897	2,897	35,695
1) Provincial	30	30	464
2) Municipal	352	352	3,720
3) Prefecture	2,515	2,515	31,511

2.3 Agricultural machinery industry

2.3.1 Rapid development of agricultural machinery industry

Boosted by a series of policy incentives to support the agricultural machinery sector and subsidies for the purchase of farm machinery, the agricultural machinery industry in China witnessed rapid development in the past few years (Table 2.10 and Table 2.11). In 2006, there were about 8,000 agricultural machinery manufacturers in China including the state-owned, private and joint ventures, of which 1,757 were large enterprises with annual sales of more than five million Yuan (Table 2.10). Since 2006, agricultural machinery sector in China has maintained a growth rate of over 20 per cent. In 2008, the total output value of agricultural machinery in China was US$25 billion, a 30.4 per cent increase over the previous year. A total of 209,000 sets of large and medium-sized tractors were produced with an increase of 19.44 per cent over 2008, but small-sized tractors witnessed a reduction of 6.19 per cent. There were 298,700 sets of cereal harvesters produced, a 19.98 per cent increase over the previous year. The gross output of large agricultural machinery makers totaled 230 billion Yuan in 2009. According to the document on agricultural machinery development issued by the State Council in July 2010, China is at a crucial stage in its development from traditional labor-intensive farm production to more reliance on farm machinery. Farm mechanization and increasing the use of agricultural machinery is essential for boosting agricultural production and increasing domestic consumption in rural areas.

Table 2.10: Agricultural machinery enterprises in 2006

Name	Amount
Number of enterprises	1,757
Gross output value of industry (100 million Yuan)	1,273.28
Sales income (100 million Yuan)	1,275.69
Total assets (100 million Yuan)	719.70
Total profits (100 million Yuan)	60.46

Employees (10,000)	36.60
Total profits (100 million Yuan)	60.46
Employees (10,000)	36.60

Table 2.11: Economic indicators of major agricultural machinery enterprises(Shen and Wang, 2008)

	2001		2002		2003		2004		2005		2006	
		Increase (%)		Increase (%)		Increase (%)		Increase (%)		Increase (%)		Increase (%)
Number of Enterprises	1,658		1,449		1,474		1,466		1,578		1,757	
Gross Output Value (100 million RMB)	551.03	0.76	621.68	12.82	733.88	18.05	823.03	12.15	1087.22	32.10	1273.28	17.11
Sales Income (100 million RMB)	481.99	-13.54	551.77	14.48	678.53	22.97	779.78	14.92	1060.51	36.00	1275.69	20.29
Total Profit (100 million RMB)	6.44	22.20	10.67	65.68	17.24	61.57	22.74	31.90	42.01	84.74	60.46	43.91

Agricultural machinery in China covers various sectors including agriculture, forestry, animal husbandry, sideline production and fishery. Owing to vastly different natural conditions and varying levels of economic development across the country, there are large categories of agricultural machinery with various types. There are 3,000 kinds of agricultural machinery of various types. For example, there are 14 categories of agricultural machinery for field crops production. The outputs of major agricultural machinery in China in 2005 and in 2006 are shown in Table 2.12.

Table 2.12: Output of major agricultural machinery in China in 2005 & 2006 (Jan.-Jun.)

Name of Products	Unit	Output in 2005	Output in 2006 (Jan.-Jun.)
Big and medium-sized tractor	set	162,414	113,329
Small-sized tractor	set	1,746,499	1,011,636
Diesel engine	10,000kW	34,795	21,638
Harvesting machinery	set	209,699	206,382
Farm transportation machinery	set	1,757,076	952,146
Grain processing machinery	set	960,754	702,076
Feed processing machinery	set	129,874	83,624
Pump	set	29,043,401	17,219,601

Source: China Agricultural Statistical Yearbook

The integrated system of agricultural machinery manufacturing in China has been formed which covers research, manufacturing, sales, services and etc. R&D systems incorporate enterprises, research institutes and universities. Big enterprises have established technology centers, medium- and small- sized enterprises set up research departments, which are mainly engaged in new products design. These technology centers and research departments of the enterprises gradually have become the main bodies of the new products development.

Currently, more than 20 provinces in China have established research institutes of agricultural machinery, which have become the backbone of technology innovation and research and product development. In universities, there are research institutes specialized in technology research, agricultural machinery design and training.

Apart from China Agricultural Machinery Testing Center under the Ministry of Agriculture, there are provincial and municipal agricultural machinery testing organizations all over China. General Administration of Quality Supervision and Inspection of the People's Republic of China

sets up 12 national level quality inspection and testing centers for agricultural machinery products throughout China, and there are 20 prefecture-level agricultural machinery certification organizations. These organizations ensure the quality of agricultural machinery products.

Agricultural machinery sales and service systems have been put in place through the sales network of enterprises, agricultural machinery companies and major markets of agricultural machinery. Special sales services network of manufacturing enterprises has been gradually established, and there are sales agents for medium and small enterprises. There are nearly 20 large agricultural machinery markets, and about 100 medium- and small-scale markets across the country.

2.3.2 Agricultural machinery trade

Since 2000, China has experienced steady increase in export of agricultural machinery (Figure 2.29 , Figure 2.30 and Table 2.13). In 2008, import and export of agricultural machinery stood at US$1.238 billion and US$5.882 billion with an increase of 21.71 per cent and 51.36 per cent, respectively. However, major agricultural machinery products had different export performance. For example, in 2009, wheeled tractor and walking tractor, two traditional export products, both experienced a drop in exports; but harvesting machinery saw a growth in exports.

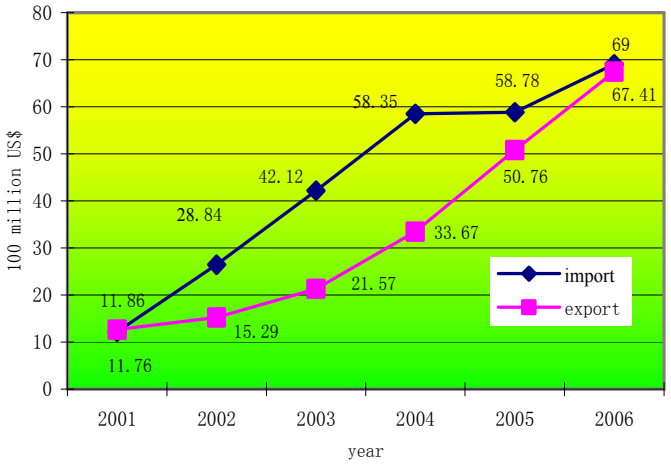


Figure 2.29: Import & export of agricultural equipment (including diesel engines and water pumps)

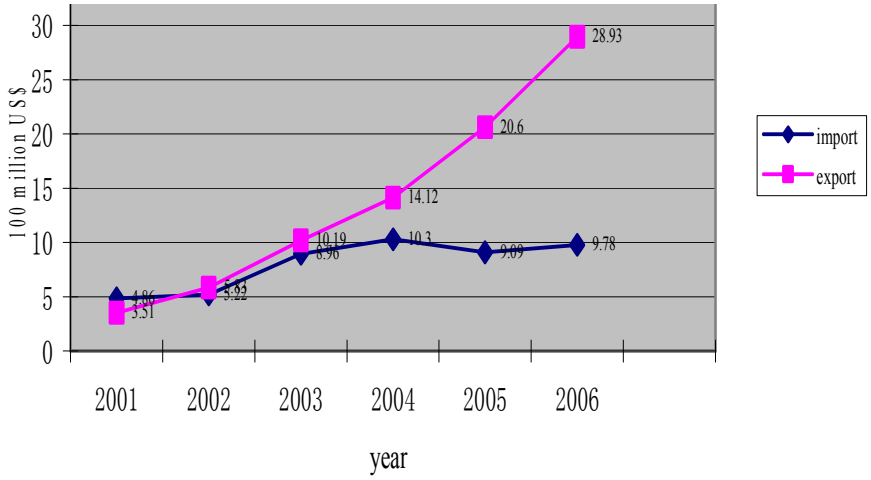


Figure 2.30: Import & export of agricultural equipment
(excluding diesel engines and water pumps) (Shen, G F, Wang, M H, 2008)

Table 2.13: Export of agricultural machinery in 2001-2006 (10,000 US$) (Shen and Wang, 2008)

	2001	2002	2003	2004	2005	2006	Total (100 mil US$)
Agricultural drainage and irrigation equipments and parts	30,608	41,765	58,001	88,401	118,466	163,464	50.18
Small diesel engine and parts	35,586	38,187	44,645	65,657	91,222	128,645	40.39
Diesel engine generator set and parts	8,160	11,056	29,398	56,595	104,237	129,640	33.91
Small petrol engines and parts	11,590	16,707	18,864	31,785	51,233	78,496	20.87
Tractors and parts	15,867	18,347	19,463	33,342	46,854	62,851	19.67
Crop combines and parts	4,426	8,776	19,295	20,177	27,908	34,445	11.51
Agricultural transport vehicles	2,822	3,394	6,146	14,018	32,442	46,946	10.84
Livestock equipment and parts	1,741	3,443	5,128	7,137	10,650	12,269	4.03
Agricultural implement and parts	2,972	3,799	5,729	6,335	7,609	8,655	3.51
Grain processing machines and parts	2,248	3,097	4,136	5,023	5,005	6,816	2.63
Plant protection machines and parts	1,132	2,369	2,786	4,723	7,742	13,117	2.50
Dairyman processing machines and parts	584	950	1,019	1,707	2,302	2,517	0.91
others	815	1,036	1,131	1,799	1,978	2,085	0.89
Total(10 million US$)	11.86	15.29	21.57	33.67	50.76	68.99	202.14

2.3.3 Major reasons behind rapid development

1) Government policy incentives

The Chinese government has introduced a series of policies to promote agriculture and rural development and to improve the wellbeing of farmers, showcased by the abolition of the agricultural tax and subsidies for grain production and purchase of agricultural machinery. For instance, both the central and local governments allocate funds (see Table 2.14) to subsidize farmers' purchase of agricultural machinery at a rate of about 30 per cent.

Table 2.14: Amount of subsidies provided by the governments at different levels (Unit: Million Yuan)

Year	2004	2005	2006	2007	2008	2009
Central Government	70	300	600	2000	4000	13000
Local Government	410	800	1006	1345		

(Shen, G F, Wang, M H, 2008, Nanjing Agricultural Mechanization Research Institute, 2008, CAAMM, 2010)

2) Pooling agricultural machinery resources

With the ownership of agricultural machinery, farmers also use their machines to provide services in land preparation, planting and harvesting to others in addition to their own use. Utilization of agricultural machinery brings tangible economic benefits to the farmers with rapid increase of farmers providing such kind of paid services. In 2007, there were 36 million households with agricultural machinery and more than 43 million people engaged in providing services with the annual operation income of 271.8 billion Yuan. Rural households specializing in agricultural machinery services also help expand the scale and scope of agricultural machinery services (Nanjing Agricultural Mechanization Research Institute, 2007, 2008).

3) Structural adjustment of agriculture helps expand the agricultural machinery market.

The structural adjustment of the agriculture sector in China is underway shifting priorities from grain production to other field crops production, forestry, sideline production and fishery, and from traditional grain production to agricultural industrialization. As the restructuring intensifies, the demand for agricultural machinery will increase both in quantity and variety. This will expand the market of agricultural machinery.

2.3.4 Problems concerning agricultural machinery industry in China

The majority of agricultural machinery produced in China is small-sized with medium or low level of technological inputs. Many large equipments and technology intensive machinery still need to be imported. The industry structure needs to be adjusted. Currently, most of the companies are small-sized with low production capacity. In comparison with overseas companies, large companies are not competitive on the global market. Table 2.15 illustrates the difference between Chinese companies and their counterparts overseas. Agricultural reform in China calls for enhanced capacity of R&D, technology innovation, comprehensive product mix, and the production of quality, energy-efficient and environmentally friendly agricultural machinery.

Table 2.15: Comparison between Chinese and Overseas Agricultural Machinery Manufacturers in 2006 (billion US$) (Shen and Wang, 2008)

Name	Sales Income	Profit	Sales Income/Person (10,000 US$)	Profit/Person (10,000 US$)
John Deere	22.148	1.694	47.58	3.64
CNH	12.998	0.292	51.38	1.15
Shifeng (China)	1.627	0.071	6.025	0.264
First Tractor Co. Ltd. (China)	1.176	0.018	4.629	0.071

The worldwide financial crisis that erupted in 2008 caused huge impact on Chinese export market including the agricultural machinery export market. In 2009, from January to November, the total imports and exports of agricultural machinery were US$5.916 billion, a decrease of 16.92 per cent compared with the same period the previous year with exports of US$4.529 billion and import US$1.387 billion, respectively. In particular, exports of agricultural machinery saw a decrease of 23.01 per cent over the previous year. However, because of government strong support, the Chinese domestic market for agricultural machinery kept accelerating (CAAMM, 2010).

3. Testing and certification facilities in China

The agricultural machinery testing system has played an important role in promoting agricultural mechanization in China. At present, there is nationwide agricultural machinery testing network comprising testing stations at the central level affiliated with the Ministry of Agriculture and at the provincial level. China Agricultural Machinery Testing Centre, established in 1951, was a national-level testing station with a mandate to conduct official testing and certification of agricultural machinery and implements; establish standard testing codes; provide technical training; establish a catalogue of quality agricultural machinery for promotion; and receive complaints about product quality. Local testing stations have been established in 31 provinces, municipalities and autonomous regions across the country. Since 1999, in addition to functioning as a quality watchdog, agricultural machinery testing in China has paid increasing attention to the adaptability, safety, energy efficiency, environmental impact and after-sales service of agricultural machinery. In November 2004, *Law on Promotion of Agricultural Mechanization of the People's Republic of China* was promulgated, providing further legislative guidance for testing and certification of agricultural machinery in China.

Testing in China primarily focuses on machinery for staple crops. Machinery that is tested includes tractors, equipment and implements for conservation agriculture, water-saving irrigation,

plant protection, food processing, stock breeding and their sideline products, internal-combustion engine and agricultural transport vehicles and etc. While ensuring compulsory compliance with standard codes and performance indicators, greater attention has been given to the noise and emission level and the operation safety of machinery in an effort to minimize adverse impact on the environment and hazards to human health.

C) INDIA

1. General Overview of Agriculture

Agriculture remains the main economic sector for India. In 2009 the contribution of agriculture and allied sectors to total GDP was 17.1 per cent, while the industry and service sectors contributed 28.2 and 54.6 per cent, respectively (Figure 2.31).

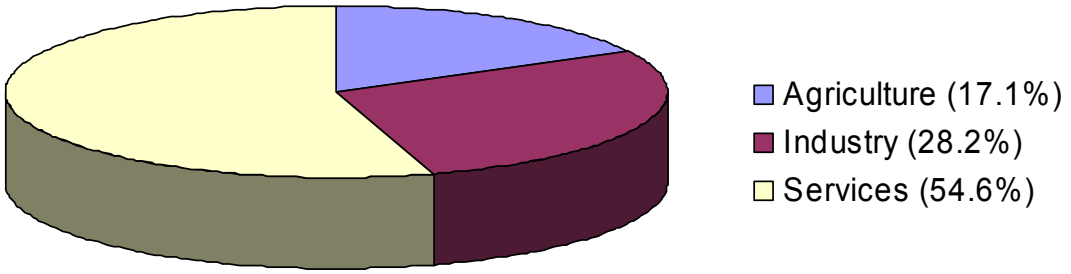


Figure 2.31: Allocation of GDP by sector for India in the year 2009 (CIA – The World Fact Book, 2009)

The share of agriculture in Indian GDP shows a decreasing trend due to rapidly developing industrial and service sectors, but it is still the important sector as it supplies bulk of wage goods and various raw materials required by the non-agricultural sectors. As one of the largest agrarian economies, agriculture holds the basis of socio-economic lifestyle of the country. The various agro-climatic zones of the country facilitate the production of various agricultural and agro-based allied products required by industry and service sectors. Thus, it is essential to improve and enhance the development of country's agricultural sector.

The Indian Green Revolution started in 1965 with the introduction of high yielding varieties of seeds, use of fertilizers, plant protection techniques and irrigation which helped the nation to be self sufficient in food grain and to improve the status of Indian agriculture. Figure 2.32 and Figure 2.33 exhibit the steady, consistent growth in gross and net production of agriculture, livestock, food and non-food, respectively.

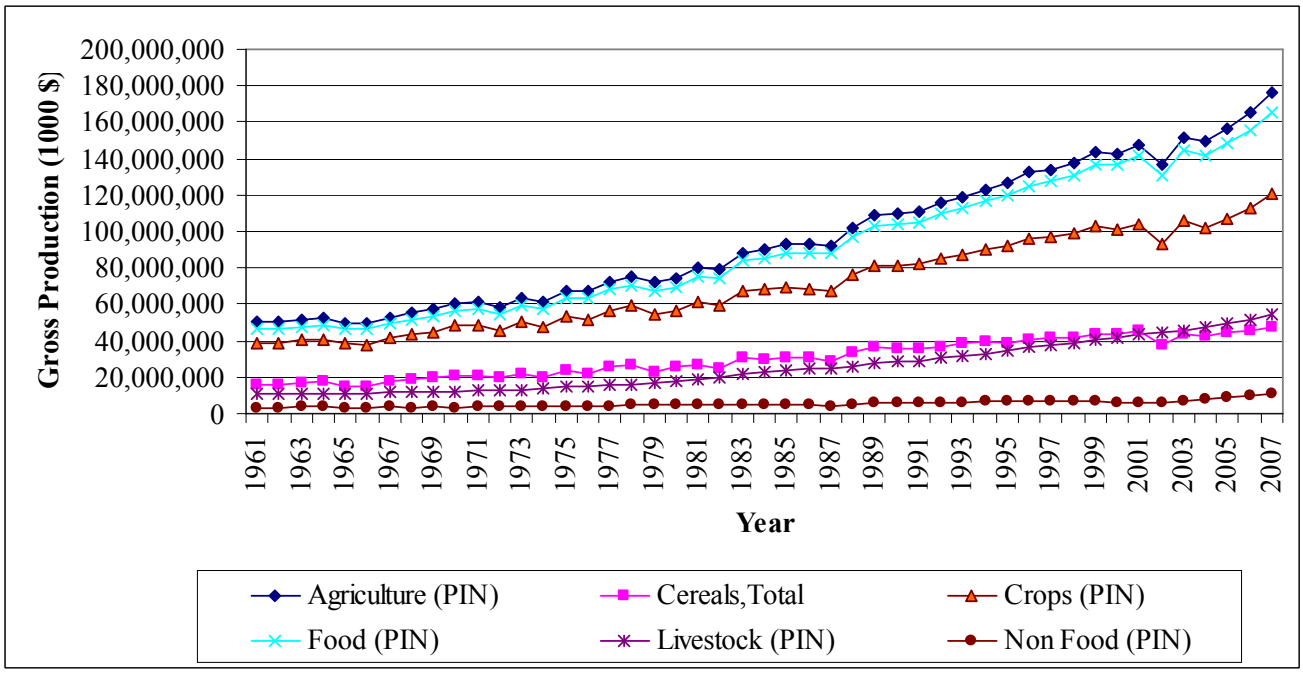


Figure 2.32: Gross production in India, expressed as 1000 USD (FAOSTAT)

Figure 2.33: Net production in India, expressed as 1000 USD (FAOSTAT)

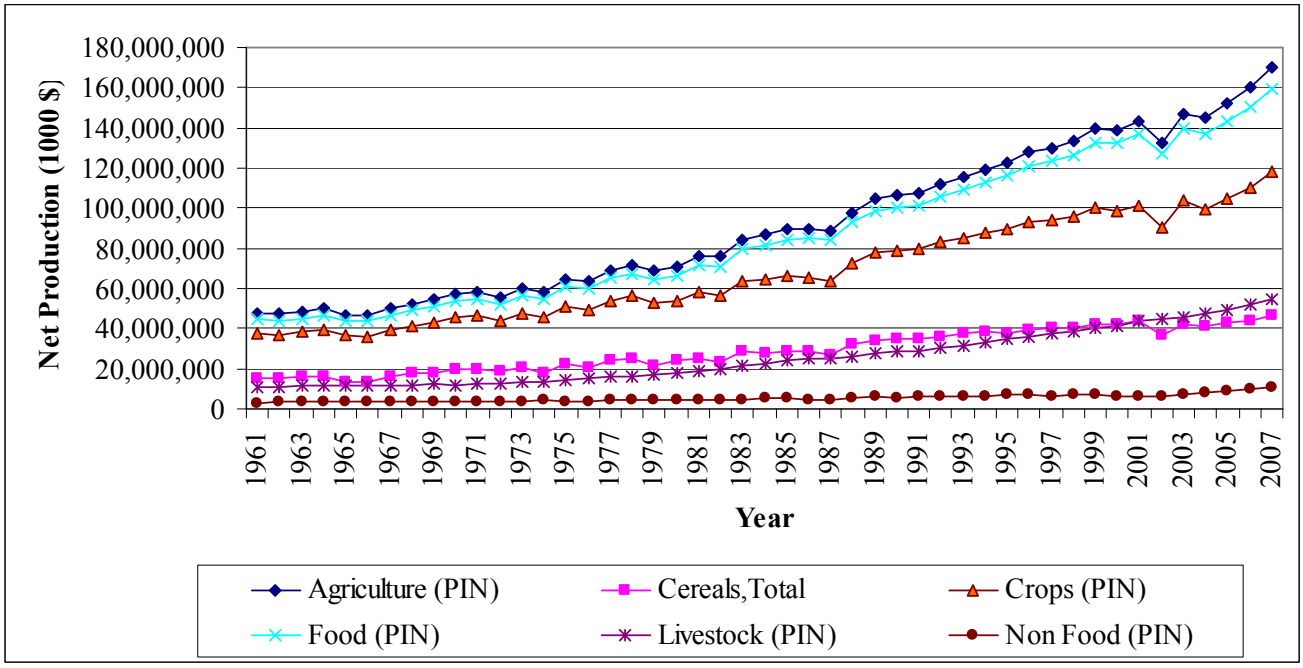


Table 2.16 and Figure 2.34 show the production of top twenty agricultural commodities in the year 2007. The highest production value of US$29.97 billion was achieved by rice production followed by buffalo (US$29.58 billion) and dairy cattle (US$11.41 billion) milk production. The successful Green and White Revolutions1 in Indian agriculture contributed to the current highest production of rice,

[1] The Government of India launched a massive dairy development program popularly known as Operation Flood (OF) from 1971 to 1996 to greatly increase milk production, making India the world's largest milk producer.

wheat, sugarcane and dairy cattle and buffalo milk. Apart from these major crops, other agricultural products like fruits, vegetables and pulses are also produced in large quantities.

Table 2.16: Production of top twenty agricultural commodities in the year 2007 (FAOSTAT)

Rank	Commodity	Production (Int $1000)	Production (MT)
1	Rice, paddy	29968800	144570000
2	Buffalo milk, whole, fresh	29575400	55913000
3	Cow milk, whole, fresh	11406170	43481000
4	Wheat	11242260	75806700
5	Sugar cane	6833297	355519700
6	Cotton lint	6531712	4400000
7	Vegetables fresh	5463880	29117400
8	Groundnuts, with shell	4205879	9182500
9	Chillies and peppers, dry	3564204	1244000
10	Mangoes, mangosteens, guavas	3287358	13501000
11	Bananas	3101930	23204800
12	Potatoes	2856034	28599600
13	Soybeans	2264313	10968000
14	Hen eggs, in shell	2176778	2930000
15	Rapeseed	2100884	7438000
16	Chick peas	2100050	6333700
17	Millet	2074595	12673000
18	Tomatoes	2034234	10054600
19	Onions, dry	1507179	12156200
20	Okra	1443749	3497200

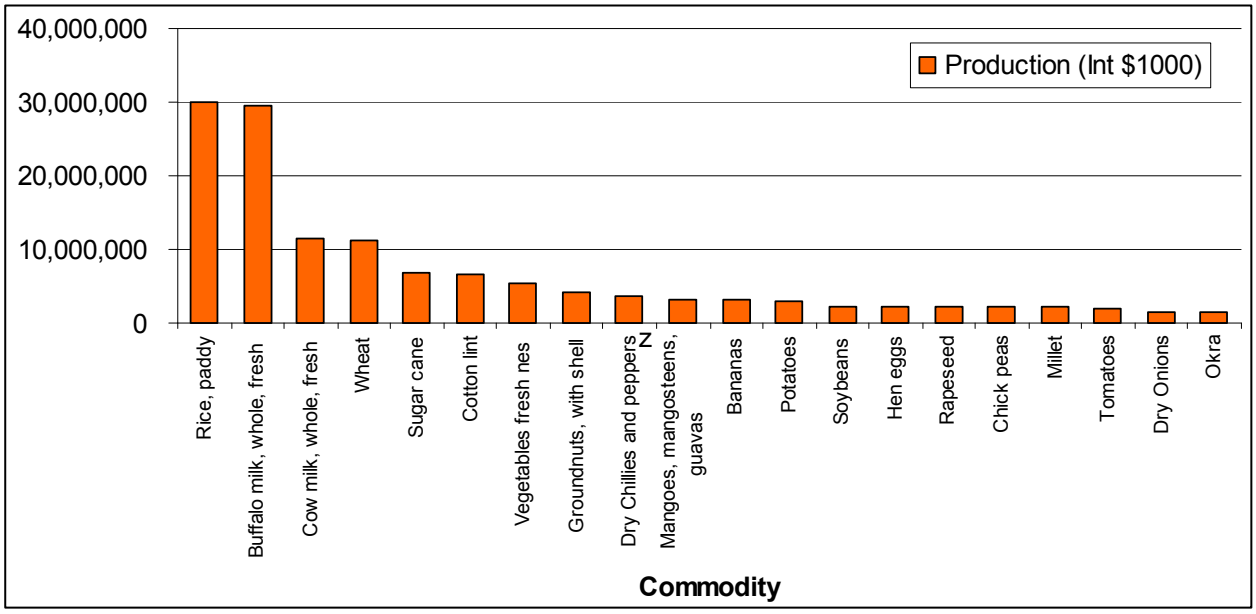


Figure 2.34: India's production of top twenty agricultural commodities in 2007 (FAOSTAT)

Figure 2.35 and Figure 2.36 attempt to relate GDP per capita and food production per capita during 1961 to 2006. In the early 1960s national GDP was mainly based on output from the agriculture sector. After the introduction of Green revolution in the year 1965, signs of progress in the GDP were seen. The contribution of the agriculture sector to national GDP was maintained in the 1970s. The short-term political instability in late 1970s affected the overall GDP per capita, but food production per capita remained largely unaffected. From the mid-1970s the share of agriculture in GDP started

decreasing while the share of non-agricultural sector increased. In the 1980s GDP per capita and food production per capita both showed overall positive growth. In the early 1990s the Indian economy accepted the economic liberalization which resulted in positive growth in all sectors.

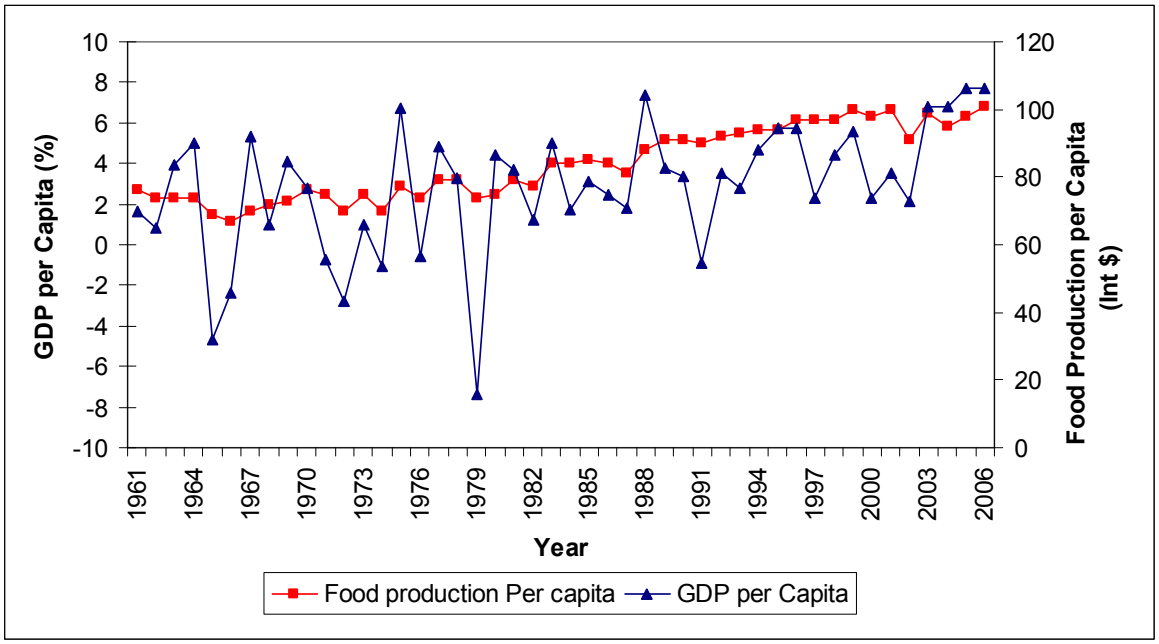


Figure 2.35: Food production per capita and GDP per capita for India (FAOSTAT)

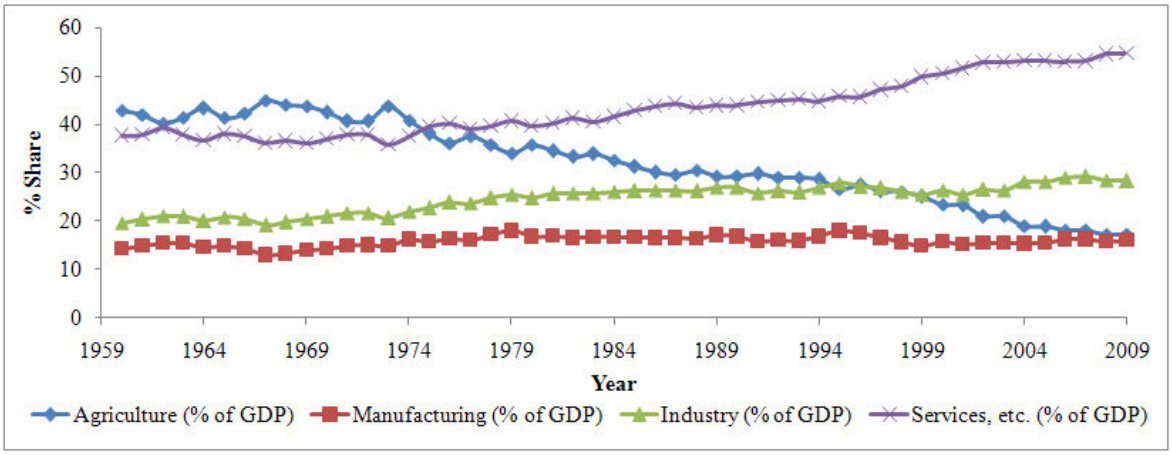


Figure 2.36: Share of different sectors in India's GDP growth (World Bank, 2010)

At present, Indian GDP is mainly based on the service (54.6 per cent) and industry (28.2 per cent) sectors, but agriculture with 17.1 per cent is still playing an important role through the supply of raw materials. Food production per capita showed more or less steady growth. Food production per capita reached US$101 in 2006, up from US$76 in 1961.

The trend in the export of major agricultural commodities like cereals, fruits, vegetables, and pulses is presented in Figure 2.37. After the Green revolution India achieved self sufficiency in food production and the export of agricultural commodities came into greater prominence. From early 1980s India experienced slow and steady growth in the export of cereals, fruits and vegetables. After economic liberalization in early 1990s the export of agricultural commodities increased drastically. In 2007, the country's cereal exports reached US$3.59 billion while the export of fruits and vegetables reached US$1.74 billion with minimal export of pulses.

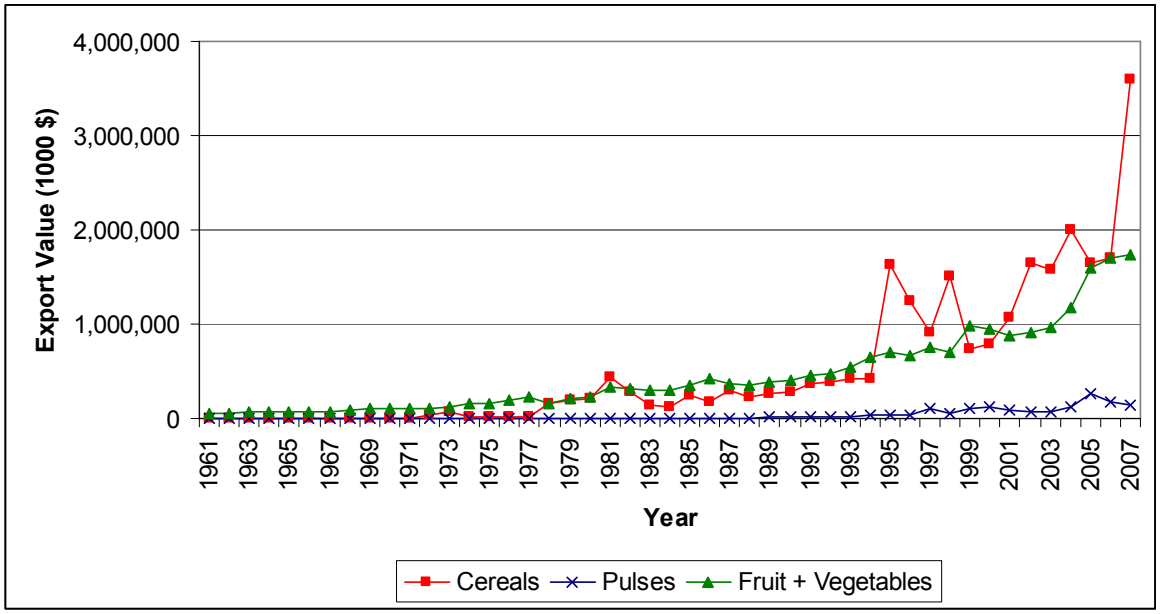


Figure 2.37: India's export of major agricultural commodities from 1961 to 2007 (FAOSTAT)

The import of agricultural commodities by India over the period of 1961 to 2007 is plotted in Figure 2.38. In the early 1960s the import of cereals was higher, which reduced after the Green revolution in the mid-1960s. There was a sudden increase in the import of cereals (US$1.5 billion) in the early 1970s but stabilized within a short period of time. In the 1980s and 1990s the import of cereals fluctuated, but compared with the export of the cereals during the same period, the import value of cereal was almost half. In the last decade, except in 2006 (US$1.3 billion) and in 2007 (US$0.65 billion), cereal import decreased.

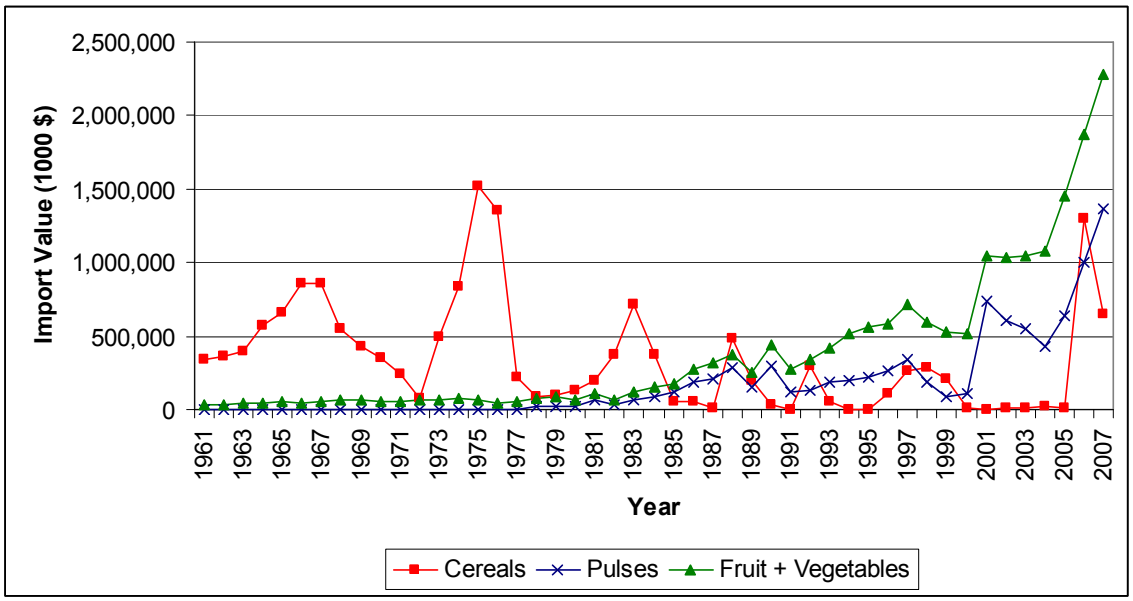


Figure 2.38: India's import of major agricultural commodities from 1961 to 2007 (FAOSTAT)

The steady and low import values were observed in the case of import of fruits, vegetables and pulses during 1960s and 1970s. From early 1980s onwards, the import of fruits, vegetables and pulses increased. After early 1990s when the country accepted economical liberalization and as a result of increased domestic demand with increased population, the import of fruits, vegetables and pulses

increased considerably. In 2007 the import of pulses reached US$1.37 billion while import of fruits and vegetables was US$2.28 billion.

Figure 2.39 shows the total merchandise and agricultural import-export trends of the country. It is clearly evident that the import and export of the country was comparatively low during the 1960s. From the mid-1970s the agricultural and overall merchandise trade increased. After the economic liberalization in the early 1990s the trading of agricultural and non-agricultural goods increased.

Figure 2.40 shows the trading of total agricultural products as a per cent of total merchandise trade. It clearly shows that the per cent of total agricultural products in total merchandise trade has been decreasing. However, the export percent of agricultural product trade is always higher than the import per cent of agricultural products. In 2007, the import of agricultural commodities was only 3.6 per cent of the total merchandise import, while the percent export of agricultural commodities was 11.4 per cent.

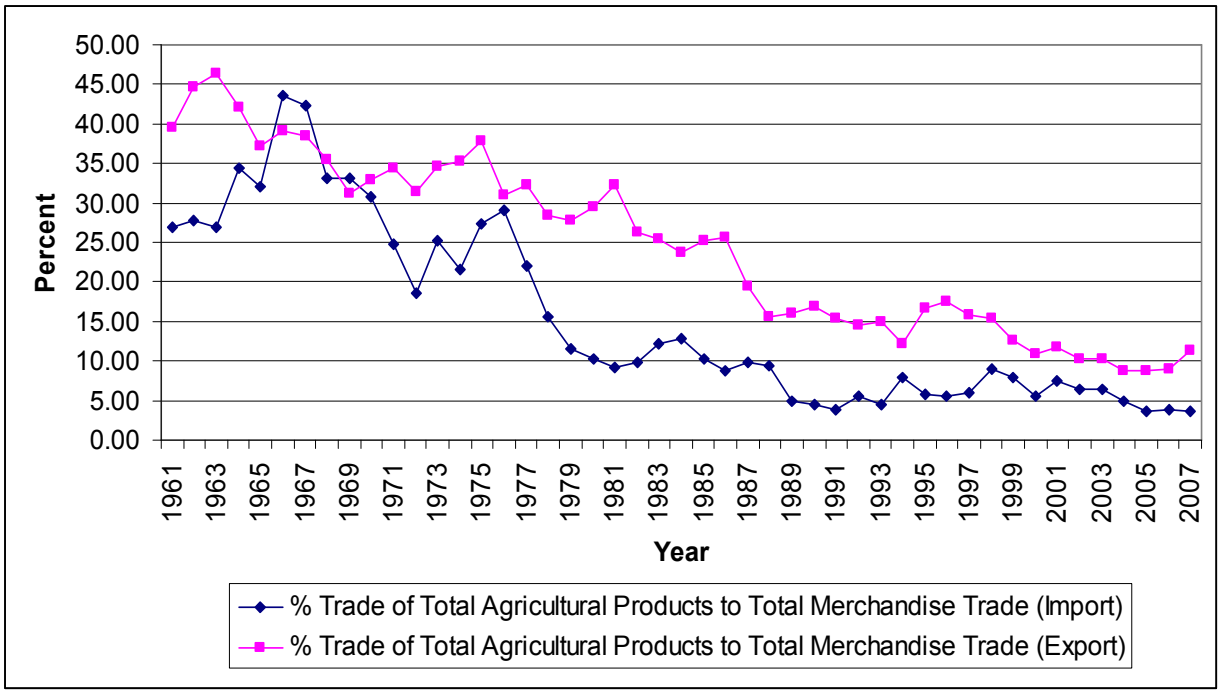


Figure 2.39: Merchandise trade as per cent of the total agricultural trade (FAOSTAT)

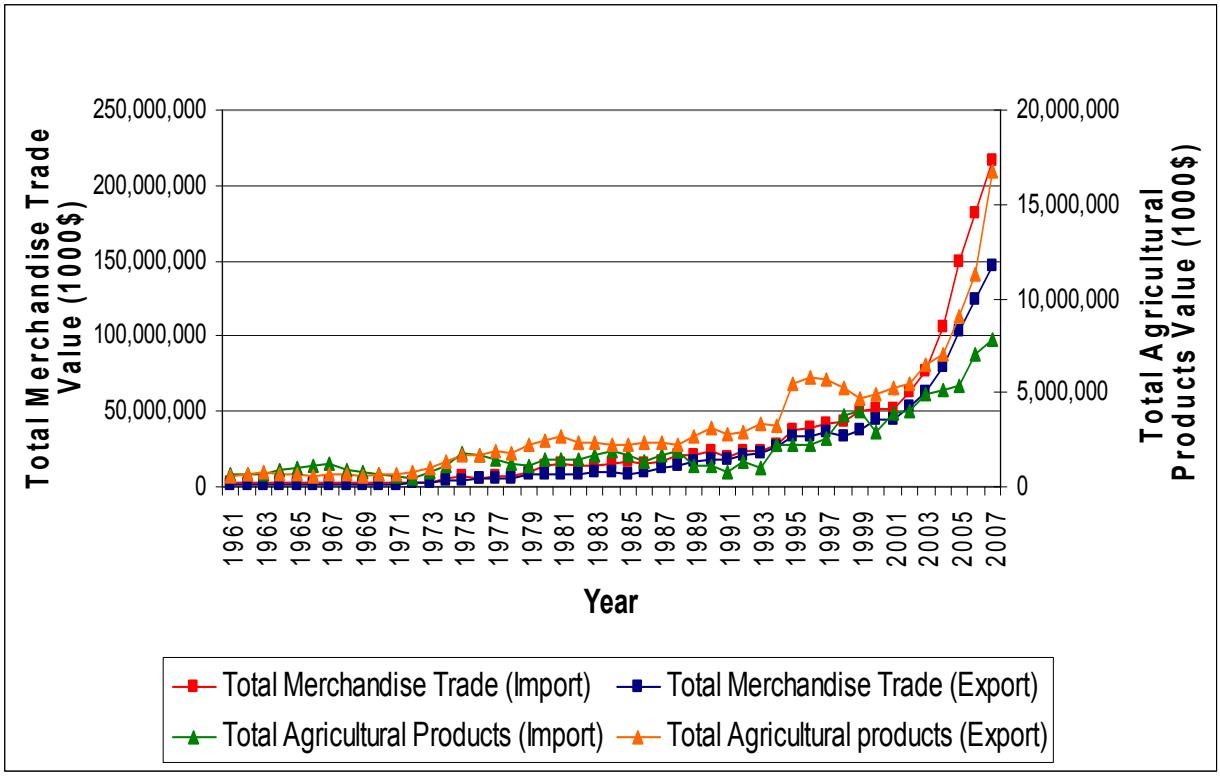


Figure 2.40: Total merchandise trade and total agricultural products trade in 1000 USD (FAOSTAT)

1.3 Available land utilization

India is a country with an area of 328.73 million hectares, out of which 297.32 million ha (90.45 per cent) is land area and 31.4 million ha (9.55 per cent) is inland water. In 2007, out of the total land area, 60.51 per cent (179.9 million ha) was utilized for agriculture, 22.79 per cent (67.76 million ha) was under forests and 16.7 per cent (49.66 million ha) was utilized for other land use purposes.

Out of the total agricultural area, 88.19 per cent (158.65 million ha) is arable land, about 6.03 per cent (10.85 million ha) is occupied with permanent crops, while 5.78 per cent (10.4 million ha) is under permanent meadows and pastures. The country has about 57.3 million ha of land (36.12 per cent of total arable land) equipped with irrigation facilities. There is still great need of irrigation engineering activities and planning to increase the arable area under irrigation (Figure 2.41).

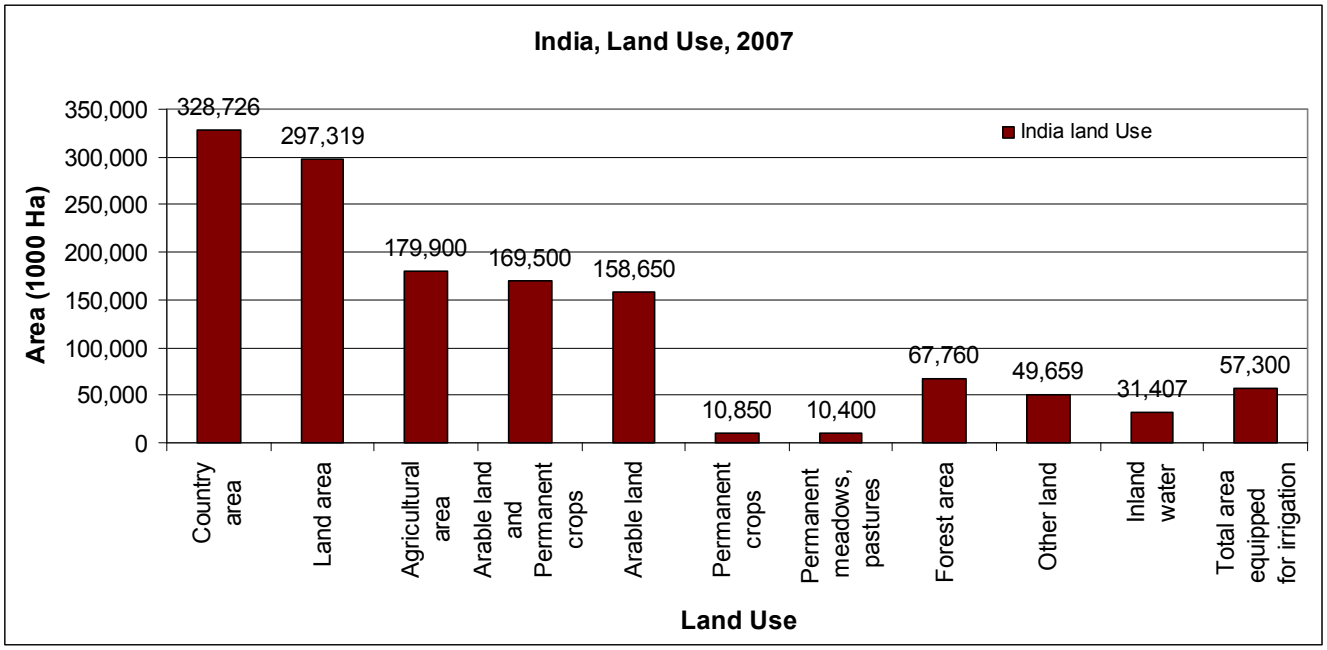


Figure 2.41: Available land use in India in the year 2007 (FAOSTAT)

Organic farming is one of the techniques adopted for sustainable agricultural production. Figure 44 shows the organic land area as a per cent of total agricultural area in the country. The concept of organic farming is gaining popularity in India. Figure 2.42 clearly shows the significant increase in organic land area. The organic land area as a per cent of total agricultural area has nearly doubled in the recent few years. Though the figures are less than 1.0 per cent, considering huge agricultural area of the country the coverage of organic agriculture is fairly significant. In 2005 the land under organic production was about 185,937 ha, which increased to 432,259 ha in 2006. In 2007 the organic land area reached 1,030,311 ha. However, more promotional activities are needed to promote farmers to realize the benefits of organic production practices.

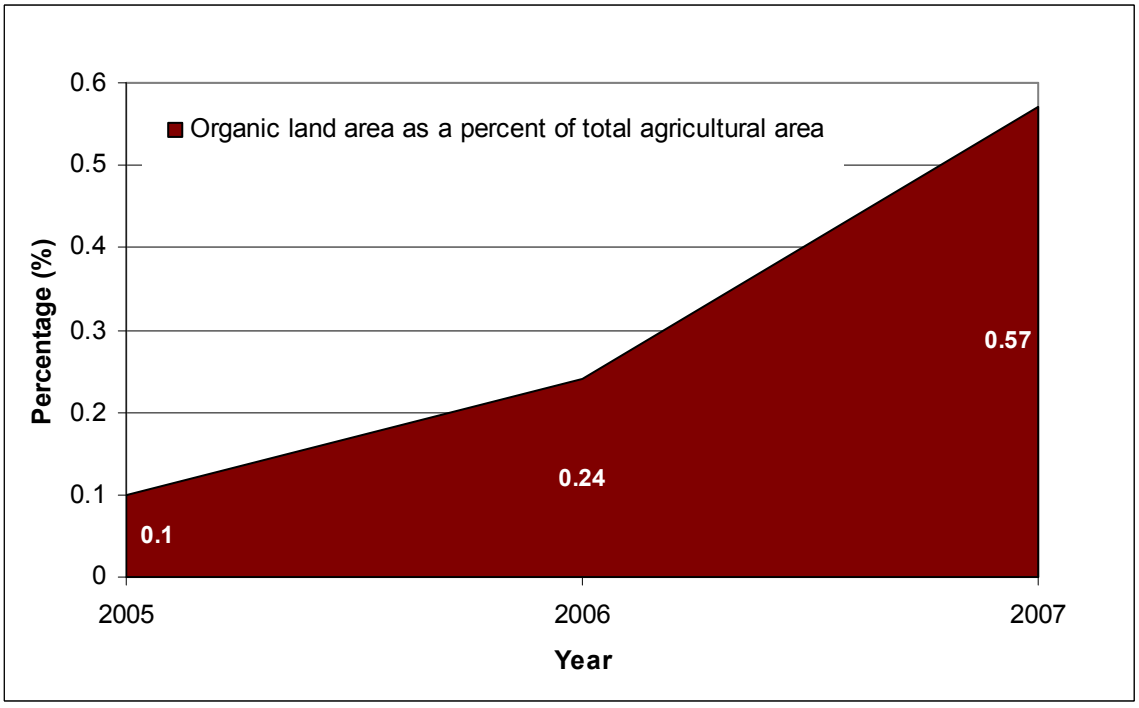


Figure 2.42: Organic land area as per cent of total agricultural area (Earth Trends)

1.4 Population: rural and urban habitation

India is the 2nd largest populous country in the world. As per the FAO database the total population of the country in 2009 was 1.198 billion, out of which 618.9 million (51.66 per cent) are male and 579.0 million (48.34 per cent) female. Predictions show that India's population will exceed China in 2030 and will be the highest populous country in the world (FAOSTAT). Figure 2.43 shows the total current and predicted population of India. It is predicted that total population of the country will reach about 1.431 billion in 2025 and 1.614 billion in 2050, which will trigger increasing demand for higher food production.

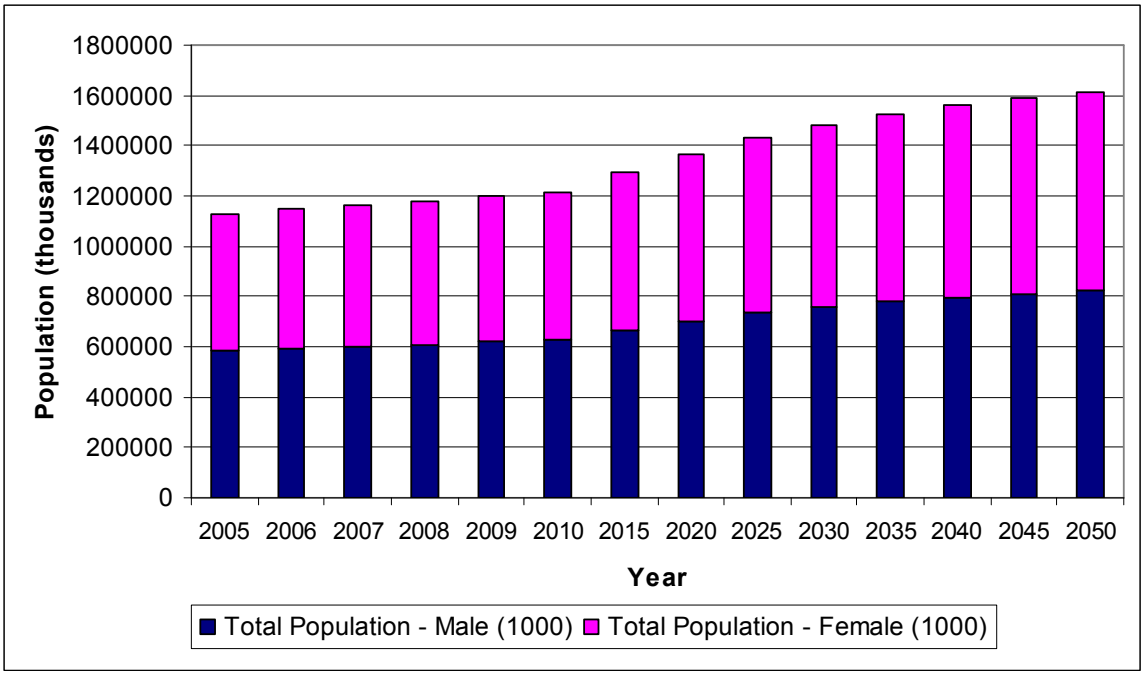


Figure 2.43: Total current and predicted population of India over the period of 2005 to 2050

As per 2009 statistics, out of the total population in the country, 70.24 per cent (841.5 million) were living in rural areas while 29.76 per cent (356.5 million) were in urban areas. It is predicted that the population in rural areas will decrease up to 62.83 per cent in 2025 and 44.83 per cent in 2050 (Figure 2.44 and Figure 2.45).

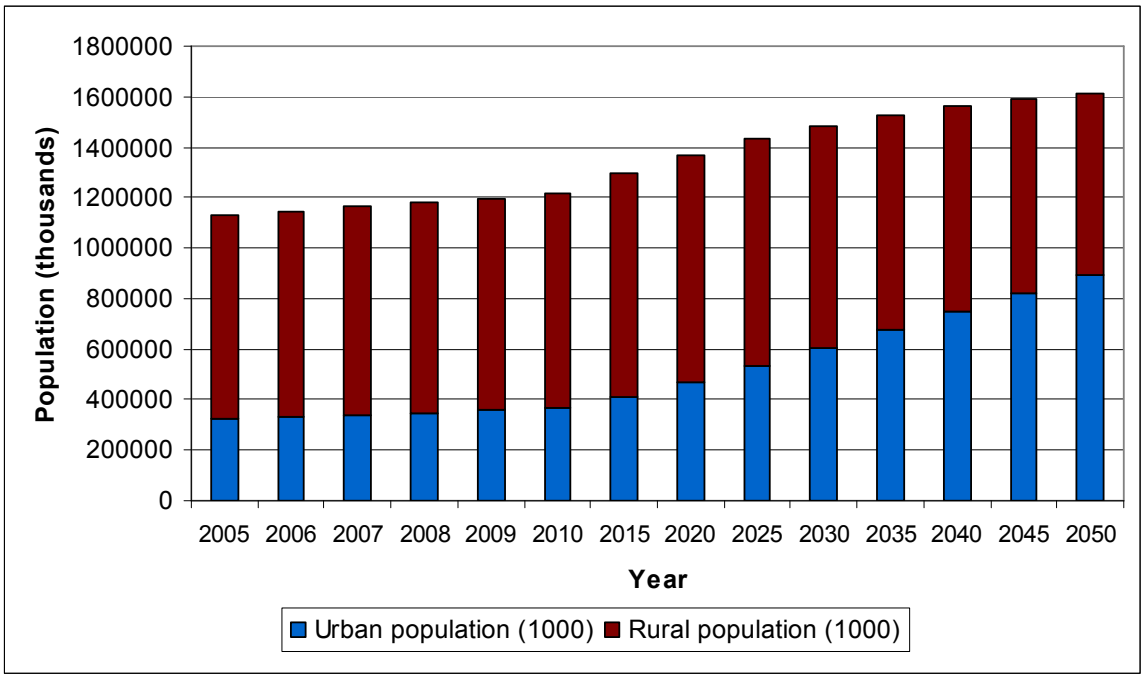


Figure 2.44: The current and predicted rural and urban population of India (FAOSTAT)

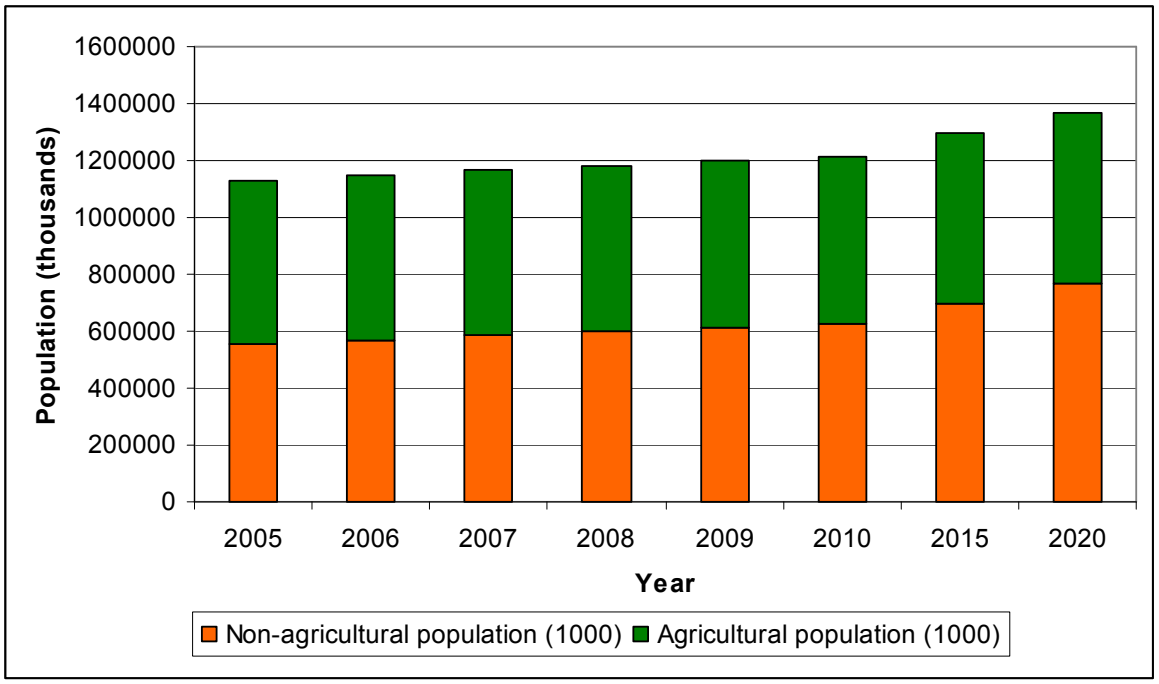


Figure 2.45: Current and predicted agricultural and non-agricultural population of India (FAOSTAT)

In 2005, the agricultural population was 50.74 per cent of the total population (573.6 million) while in 2009 it was 48.84 per cent of the total population. It is predicted that the agricultural population will decrease to 43.62 per cent of the total population. This clearly shows the need for agricultural mechanization in the country. Table 2.17 shows the population of agricultural workers and average annual growth rate.

Table 2.17: Population of agricultural workers and its average annual growth rate in India

Year	Total population	Average annual growth rate (per cent)	Rural population	Agricultural workers		
				Cultivators	Agricultural laborers	Total
1951	361.1	1.25	298.6 (82.7)	69.9 (71.9)	27.3 (28.1)	97.2 (100)
1961	439.2	1.96	360.3 (82.0)	99.6 (76.0)	31.5 (24.0)	131.1 (100)
1971	548.2	2.22	439.0 (80.1)	78.2 (62.2)	47.5 (37.8)	125.7 (100)
1981	683.3	2.20	523.9 (76.7)	92.5 (62.5)	55.5 (37.5)	148.0 (100)
1991	846.4	2.14	628.9 (74.3)	110.7 (59.7)	74.6 (40.3)	185.3 (100)
2001	1028.7	1.95	742.6 (72.2)	127.3 (54.4)	106.8 (45.6)	234.1 (100)

Source: CIAE (2010)

2. Agricultural Mechanization in India

2.1 Agricultural machinery in India

The adoption of agricultural mechanization in India is increasing continuously. Mechanization facilitates farmers to undertake agricultural activities with less drudgery and higher efficiency. In 2007, the country had about 3.149 million agricultural tractors and 0.477 million combine harvesters and threshers. From Figure 2.46 it is clear that the country is experiencing rapid and expansive growth in the use of tractors while the use of harvester and threshers is showing steady growth. This demonstrates an increasing awareness and popularity of mechanized farming in the country. At present in India, tractors are being used for tillage on about 22.78 per cent of the total land area and sowing about 21.30 per cent of total area (Kulkarni, 2009).

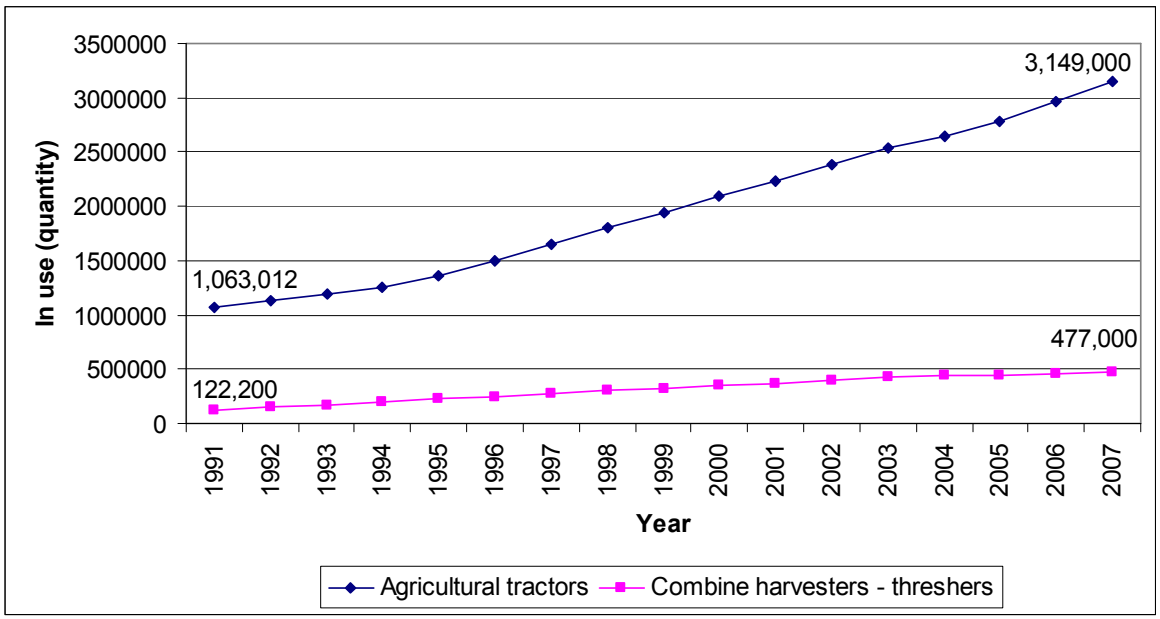


Figure 2.46: Population of agricultural tractors and combine harvesters in India (FAOSTAT)

Import trading of agricultural tractors and other agricultural machinery in the Indian agri-industry sector

is shown in Figure 2.47 and Figure 2.48, respectively. The overall demand for agricultural machinery increased in the last decade. India's import of agricultural tractors was seen comparatively lower than the import of other agricultural machinery. The import value of agricultural tractors was below US$2.0 million, except in 2005, 2006 and 2007. In 2006, the import value of US$7.355 million was the highest in the last two decades. Also in the last two decades, the import quantity of agricultural tractors was less than 500, except in 1995, 2005 and 2006. The tractor manufacturing industry in India generally fulfills the country's demand for agricultural tractors.

Harvesters and threshers are the major agricultural machinery being imported by India. From 2001 onwards, the demand for harvesters increased significantly. The total import value of harvesters and threshers reached US$51.12 million in 2007. Moreover, the import demand for milking and dairy machinery, soil machinery and other agricultural mechanized equipment realized steady growth. In 2007, the import value of milking and dairy machinery reached US$18.46 million, while in the same year, imported soil machinery and other agricultural machinery were worth US$17.34 million, US$15.52 million, respectively.

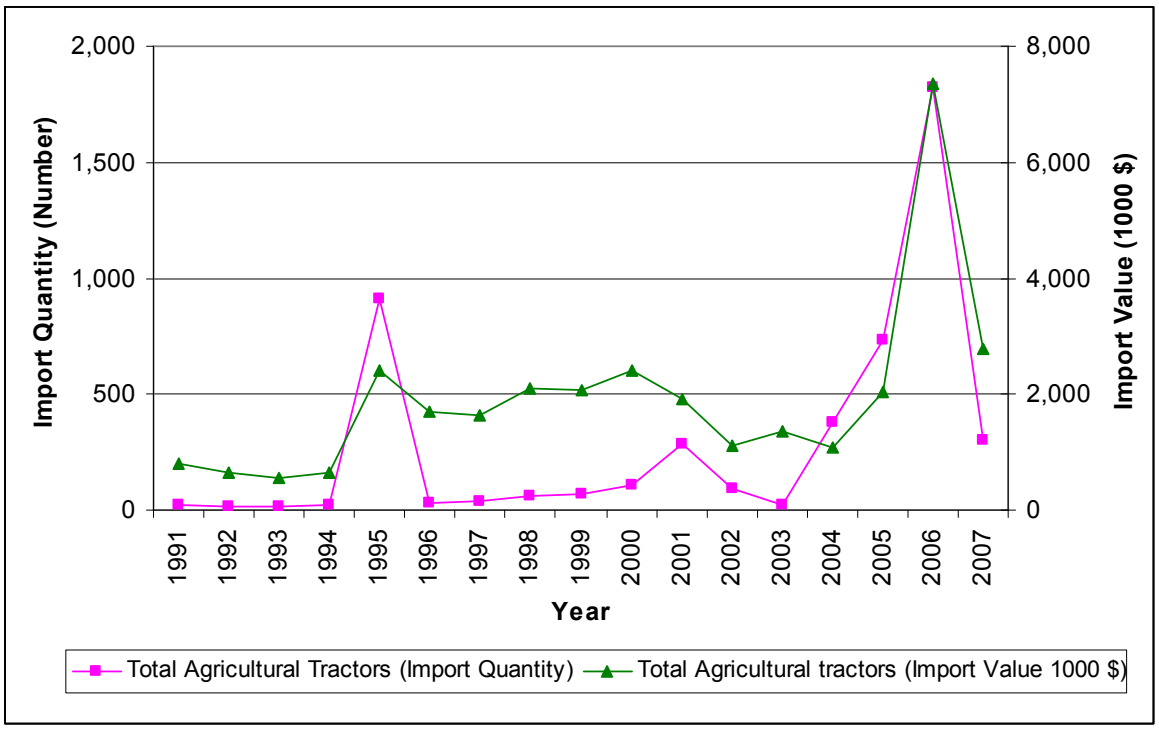


Figure 2.47: India's import of agricultural tractors in quantity and value (1000 $)(FAOSTAT)

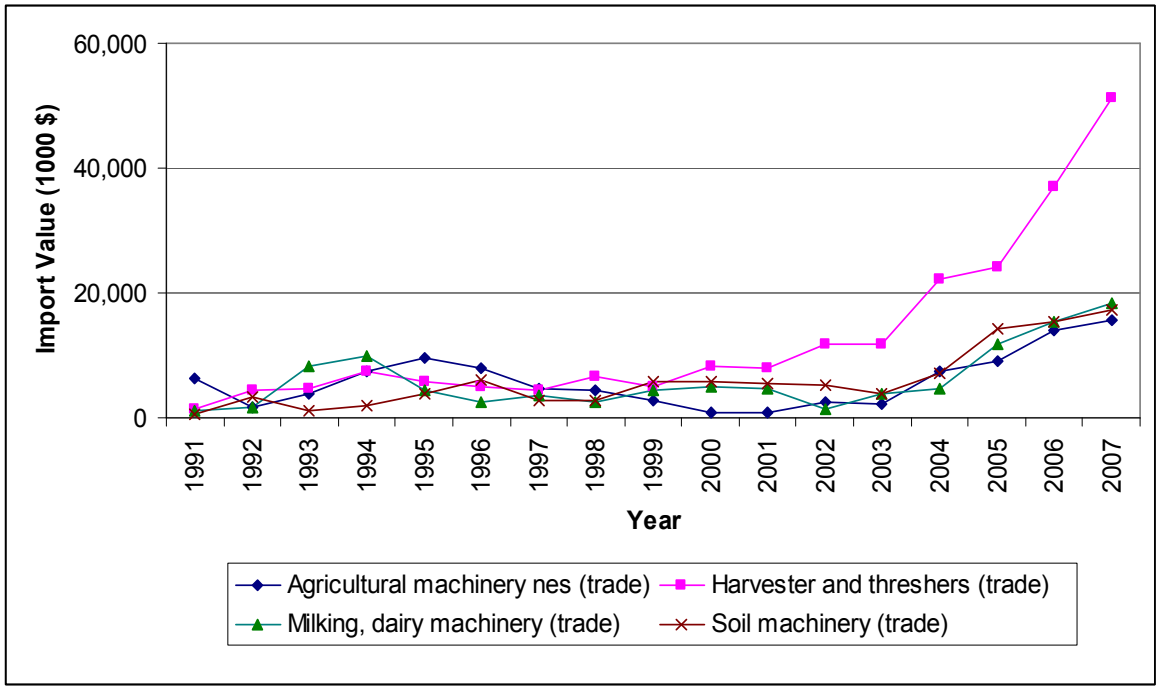


Figure 2.48: India's import of harvesters and threshers, soil, dairy and other machinery (FAOSTAT)

Export trading of agricultural tractors and other agricultural machinery in India's agri-industry sector is shown in Figure 2.49 and Figure 2.50, respectively. India exports a large number of agricultural tractors to other countries. Since 2000, the export of agricultural tractors experienced enormous growth. In 2000, only 3,841 tractors were exported which generated an export value of US$16.77 million while in 2007, the country exported about 36,992 agricultural tractors, which contributed US$342.0 million to agricultural machinery export of the country.

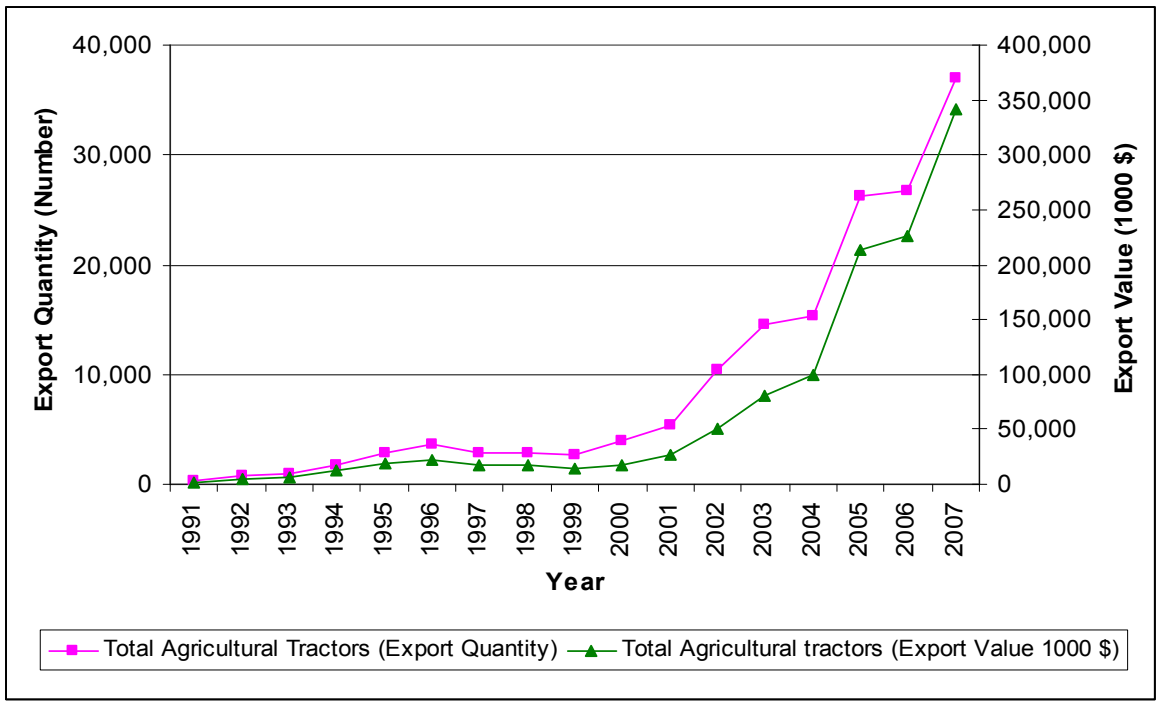


Figure 2.49: India's export of agricultural tractors in quantity and value (1000 $) (FAOSTAT)

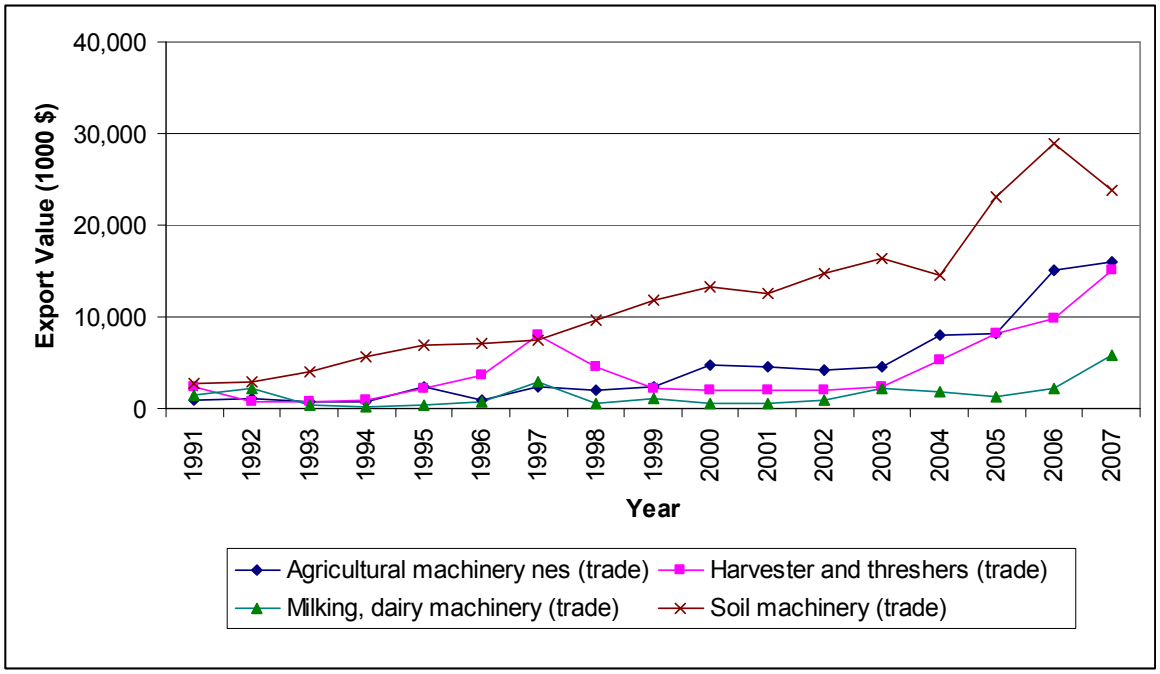


Figure 2.50: India's export of harvesters and threshers, soil, dairy and other machinery (FAOSTAT)

Figure 2.51 shows classified export of different types of agricultural tractors. The regular 4-wheel tractor was regarded as the major contributor of India's total tractor export, followed by track-laying tractors. The export of pedestrian controlled tractors (walking tractors or power tillers) was observed very low as compared with other 4-wheel tractors and track-laying tractors. In 2007, 31,649 agricultural tractors, 4,915 track-laying tractors and 428 pedestrian controlled tractors were exported. Figure 2.52 shows the projected estimation of total tractor production in India from 2007 to 2016.

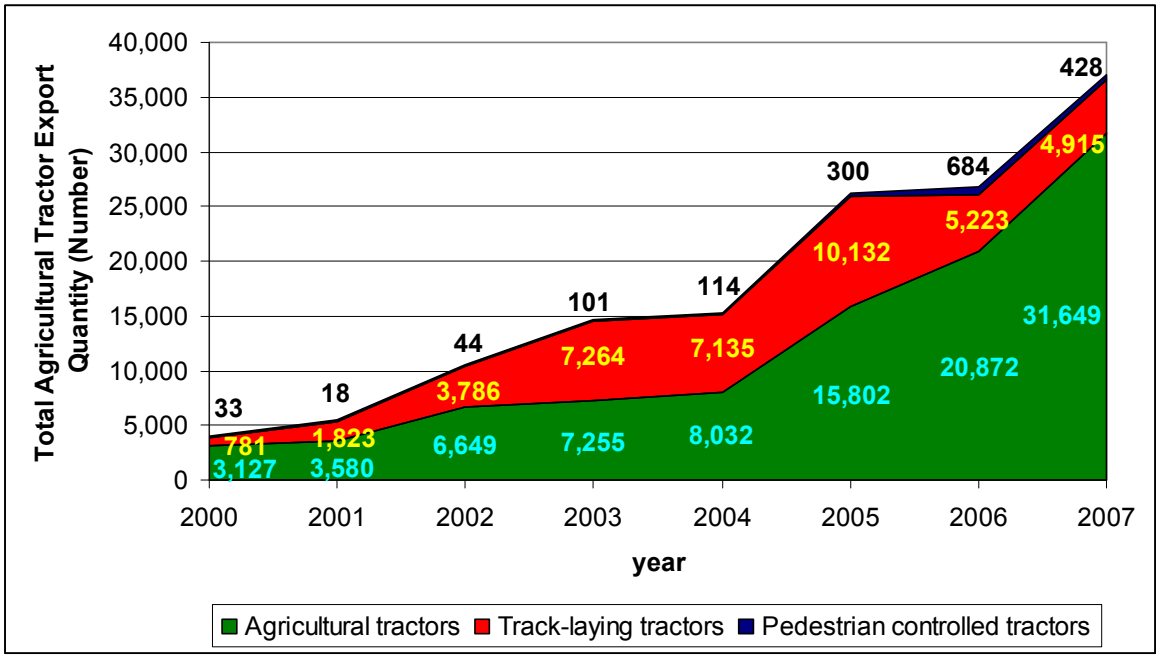


Figure 2.51: India's export of different types of agricultural tractors (FAOSTAT)

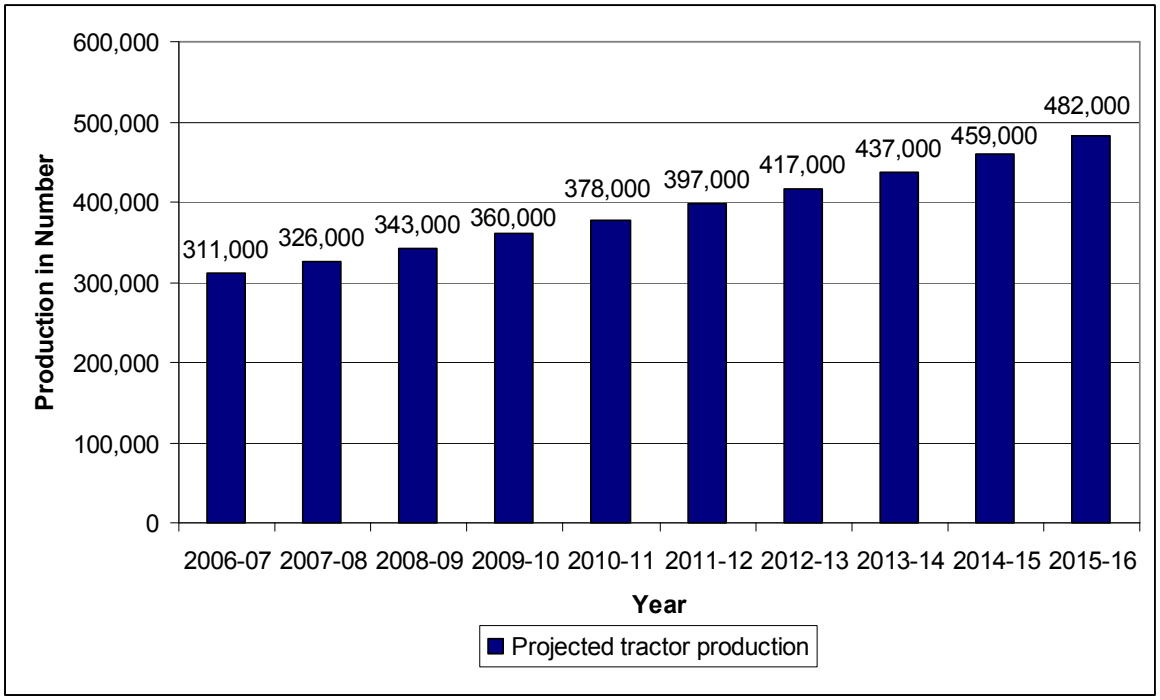


Figure 2.52: Projection of tractor production from 2006-07 to 2015-16 (Agricultural Engineering Data Book, 2008)

India's export of other agricultural machinery such as harvesters and threshers, milk and dairy machinery, soil and other machinery was much lower than the export of agricultural tractors. The export of soil machinery has steadily increased during the last two decades. Since 2003 onwards, the export of harvesters, threshers and other agricultural machinery showed consistent growth with an export value of about US$15.0 million and US$16 million, respectively in 2007. Milk and dairy machinery recorded the least export value over the last two decades. Consequently, there is a scope to improve the export of overall agricultural machinery of the country.

Table 2.18 shows the total production and sale of tractors and power tillers in India from 1982-83 to 2006-07. It is clear that the production and sale of agricultural tractors and power tillers has increased considerably within the last 25 years. The production and sale of agricultural tractors found much higher than that of power tillers in the country. In the last 25 years the sale of power tillers increased by only about 11,000 units, while the sale of tractors increased by about 200,000 units.

Table 2.18: Production and sale of tractors and power tillers in India

Year	Production (units)		Sale (units)	
	Tractors	Power tillers	Tractors	Power tillers
1982-83	63,155	2,248	63,073	2,221
1983-84	75,872	2,751	74,318	2,901
1984-85	84,876	4,244	80,317	4,222
1985-86	75,550	3,706	76,886	3,754
1986-87	80,369	3,325	80,164	3,209
1987-88	92,092	3,005	93,157	3,097
1988-89	109,987	4,798	110,323	4,678
1989-90	121,624	5,334	122,098	5,442
1990-91	139,233	6,228	139,831	6,316
1991-92	151,759	7,580	150,582	7,528
1992-93	147,016	3,648	144,330	8,642
1993-94	136,971	9,034	138,879	9,449
1994-95	164,029	8,334	164,841	8,376
1995-96	191,311	10,500	191,329	10,045

1996-97	221,689	11,210	220,937	11,000
1997-98	255,327	12,750	251,198	12,200
1998-99	261,609	14,480	262,322	14,488
1999-00	278,556	16,891	273,181	16,891
2000-01	255,690	17,315	254,825	16,018
2001-02	219,620	14,837	225,280	13,563
2002-03	168,742	14,438	173,098	14,613
2003-04	190,687	15,850	190,336	15,665
2004-05	249,077	-	247,693	18,985
2005-06	296,080	-	292,908	22,303
2006-07	319,014	-	263,146	13,375

Source: Agricultural Engineering Data Book (CIAE, 2008)

Table 2.19 summarizes the population of various agricultural machinery used in India for the year 2003. The machinery used includes manual- and animal-operated implements, tractors and other power operated equipment, plant protection equipments and irrigation equipments.

Table 2.19: Population of agricultural machinery in India in 2003

Sr. No.	Implement	Number in hundreds
Manually Operated Implements		
1	Seed cum fertilizer drill	24,948
2	Seed drill	191,365
3	Chaff cutter	5,367
4	Wheel hoe	21,417
5	Sprayer/duster	50,512
6	Rice planter	299,532
7	Thresher	90,959
8	Horticultural tools	501,540
Animal Operated Equipments		
1	Cultivator	60,986
2	Disc harrow	26,500
3	Seed/fertilizer drill	51,032
4	Leveller	119,713
5	Wetland puddler	35,467
6	Sugarcane crusher	4,344
7	Cart	101,012
8	Ghanis (oil expeller)	1,934
Tractor and other Power Operated Equipment		
1	Mould board	7,494
2	Cultivator	17,716
3	Disc harrow	9,325
4	Rotavator	1,328
5	Seed/fertilizer drill	10,110
6	Planter	1,140

7	Leveler	8,776
8	Potato digger	2,953
9	Tractor operated combine harvester	1,152
10	Self propelled combine harvester	3,086
11	Power operated paddy thresher	1,609
12	Power operated wheat thresher	7,261
13	Power operated multi-crop thresher	6,809
14	Maize sheller	1,185
15	Sugarcane crusher	1,897
16	Reaper	101,663
17	Rice planter	1,643
18	Trailers	11,162
Plant Protection Equipment		
1	Manually operated sprayers/dusters	40,245
2	Power operated sprayer/dusters	6,078
3	Tractor operated sprayer/dusters	1,719
Irrigation Equipment		
1	Manual	8,621
2	Animal	2,705
3	Diesel Engine	72,376
4	Electric Pump	84,461
5	Drip	4,352
6	Sprinkler	7,355

Source: Livestock census, 2003

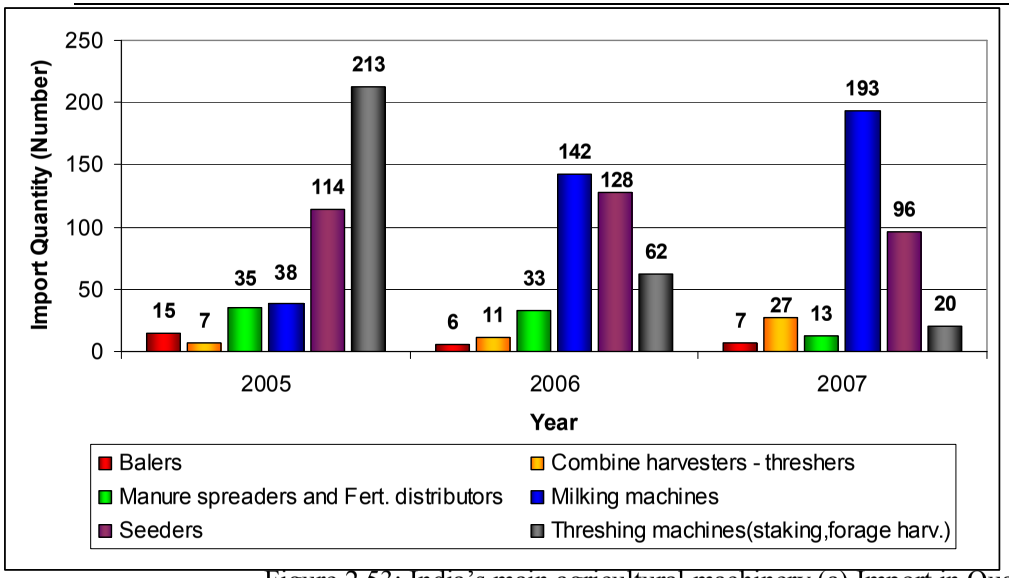
Figure 2.53 and Figure 2.54 show the import and export of main agricultural machinery, excluding tractors. Balers, manure spreaders and fertilizer distributors, milking machines, seeders, combine harvesters and threshing machines were the main agricultural machinery involved in trading. There was no specific trend noticed in the import and export of these agricultural machinery. The import and export of these agricultural machinery followed mostly a demand and supply based policy rather than focusing on business trading.

In case of India's agri-machinery import over the period 2000 to 2007 (Figure 55(b)), demand for ploughs and milking machines was higher than other imported agricultural machinery. The import value of other machinery such as seeders, balers, threshing machines, combine harvesters, manure spreaders and fertilizer applicators was less than US$0.5 million. The export share of Indian agri-machinery over the period of 2000 to 2007 is shown in Figure 56(b). Combine harvesters and ploughs were the top two exported agri-machinery products of the country. The export value of ploughs was always almost above US$1.0 million, while for the combine harvesters the export value was mostly above US$0.5 million. The export of seeders, balers, manure spreaders and fertilizer applicators, milking and threshing machines was always below US$0.25 million with few exceptions for milking machine export.

Table 2.20 gives the annual population of diesel and electric irrigation pumps used in India. The table shows that until late 60s the use of irrigation equipment was limited but from the early 70s the use of

irrigation pumps and equipment increased considerably and still growing continuously. In 2006, about 14.34 million irrigation pumps were recorded as pumps in use.

Table 2.21 shows the diesel and electricity consumptions in cultivation of some major crops in India. The highest amount of diesel found to be used in Potato production (81.69 litres / ha) while the highest amount of electricity being consumed in sugarcane production (425.74 kWh / ha). When compared with production, the highest amount of diesel consumption was observed in mustard production (0.034 litres / kg) while the highest amount of electricity was used in wheat production (0.078 kWh / kg).



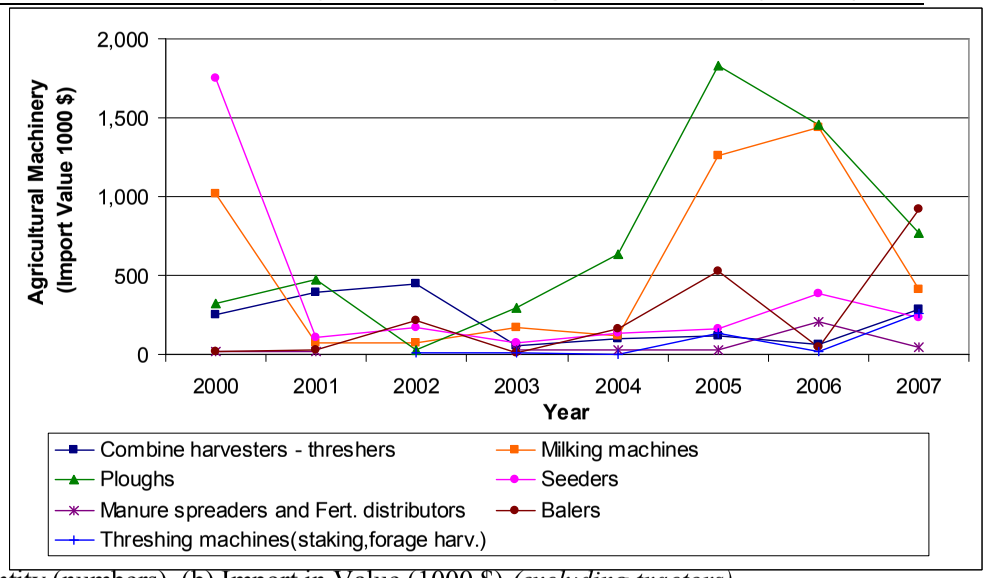
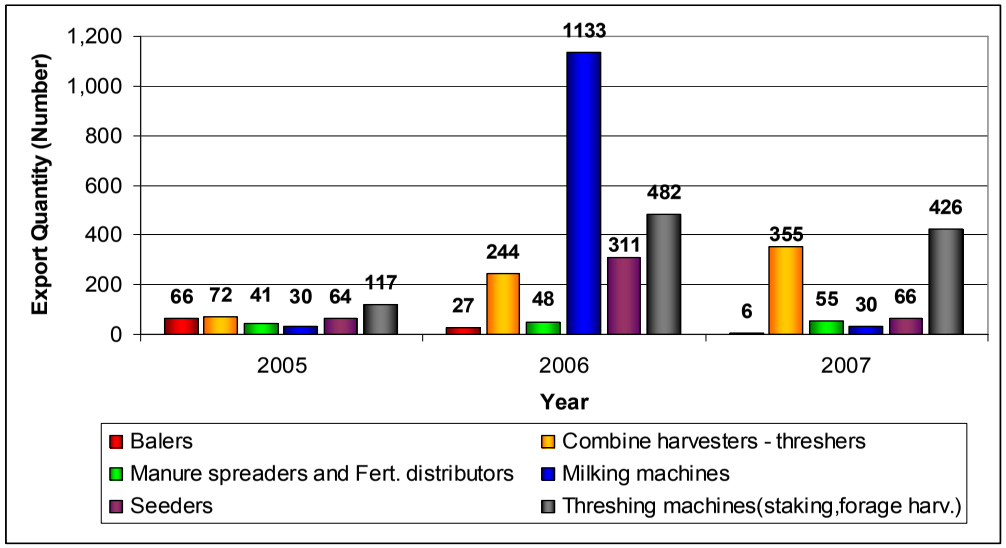


Figure 2.53: India's main agricultural machinery (a) Import in Quantity (numbers), (b) Import in Value (1000 $) *(excluding tractors)*



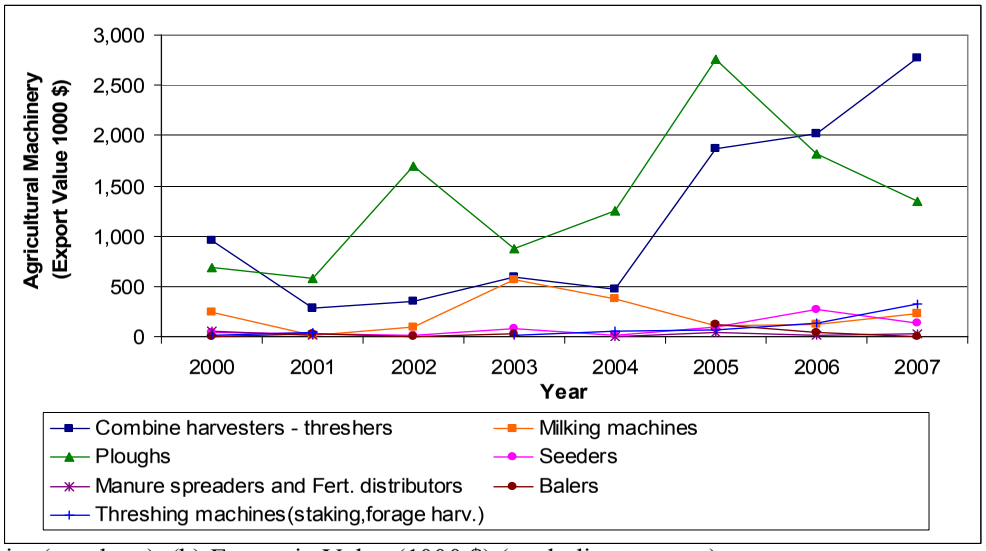


Figure 2.54: India's main agricultural machinery (a) Export in Quantity (numbers), (b) Export in Value (1000 $) (excluding tractors)

Table 2.20: Year-wise population of irrigation pumps (Diesel and Electric)

Year	Number
1951	109,000
1956	170,000
1961	390,000
1966	886,000
1972	3,164,000
1977	4,797,000
1982	6,669,000
1987	12,317,000
1995	10,619,584
1996	11,104,090
1997	11,565,342
1998	11,849,406
1999	12,216,650
2000	12,514,244
2001	12,823,480
2002	13,043,926
2003	13,792,427
2004	14,115,373
2005	14,045,290
2006	14,338,785

Source: CIAE (2008)

Table 2.21: Diesel and electricity consumptions in cultivation of some major crops in India

Crop	Diesel (l/ha)	Electricity (kWh/ha)	Diesel (l/kg)	Electricity (kWh/kg)
Paddy	39.11	96.32	0.012	0.031
Wheat	54.42	224.99	0.019	0.078
Maize	38.18	41.11	0.018	0.019
Sorghum	0.00	19.81	0.00	0.021
Green gram	1.42	12.42	0.003	0.024
Black gram	2.14	8.53	0.005	0.021
Gram	18.99	57.85	0.018	0.056
Mustard	32.69	44.01	0.034	0.046
Soybean	24.67	18.47	0.023	0.017
Sugarcane	55.49	425.74	0.001	0.007
Cotton	14.78	36.97	0.016	0.039
Potato	81.69	198.09	0.005	0.013

Source: CIAE (2008)

Figure 2.55 shows the production (in hundreds) of power driven pumps and stationary diesel engines. Except for a few exceptions, the use of power-driven pumps for irrigation purposes was higher than the use of stationary diesel engines for pumping and irrigation.

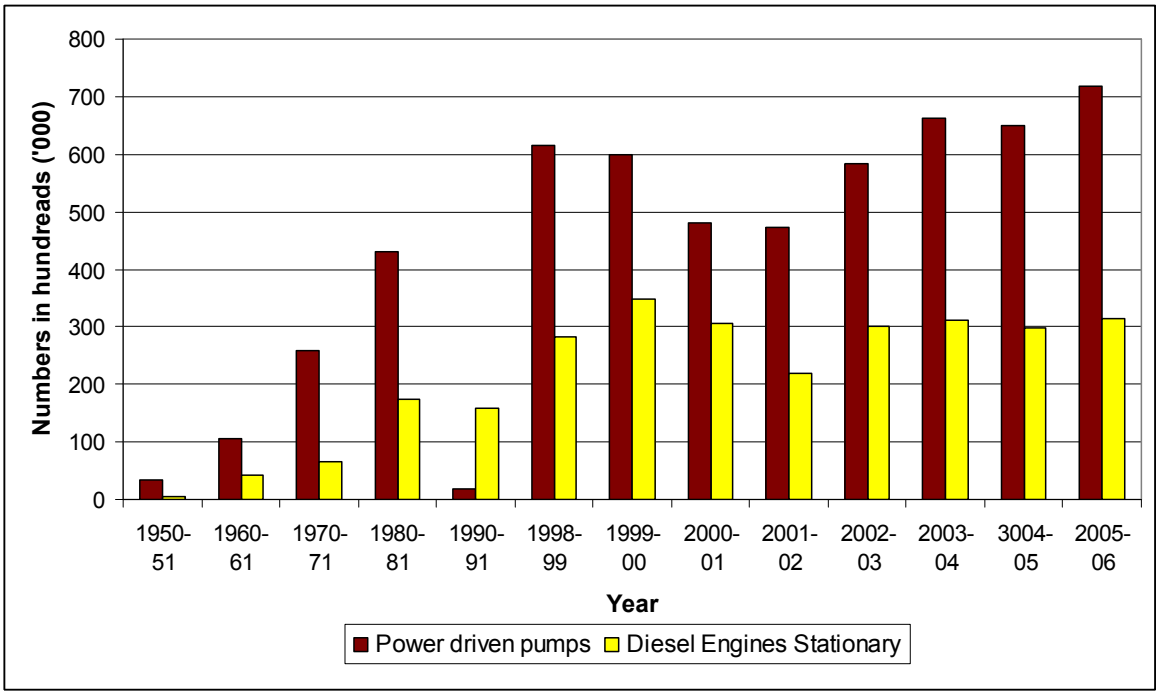


Figure 2.55: Production of pumps and diesel engines (CIAE, 2008)

2.2 Future prospectus of farm mechanization in India: potentials and constraints

In India about 40.3 per cent tillage operations are mechanized, either by using tractors or animal-drawn implements. Though the adoption of tractors and power tillers for tillage activities is increasing, it is still lower than animal-drawn implements and machinery. The growth rate of tractor and power tiller use for tillage operations is higher. On the other hand, there is some reduction in use of draft animals for tillage operations (Kulakarni, 2009). The introduction of new equipments such as precise planter, seed cum fertilizer drill, harvesting and threshing machinery increased the level of farm mechanization in the country. About 47.8 per cent of wheat threshing reported to be done by using threshers while about 4.4 per cent paddy processed with specially designed paddy threshers. Table 2.22 shows the growth of selected power machinery (numbers in hundreds) in Indian agriculture. It is clear from the table that the use of selected agricultural machinery has been increased over time while reaper showed highest growth per year.

Table 2.22: Growth of power machinery (numbers in 1000)

Machinery/Year	1994	1998	2002	2006
Leveller	670	786	863	913
Planter	102	109	113	116
Reaper	2,782	6,779	9,602	11,595
Potato digger	158	239	287	315
Maize sheller	78	101	116	126
Sugarcane crusher	210	196	190	188

Source: Livestock Census (2003)

The adoption of mechanization in irrigation and plant protection methods was also increased steadily. At present, mechanization of irrigation and plant protection operations is about 37.0 per cent and 34.2 per cent, respectively. The use of combine harvesters and reapers was quite low as compared with other mechanized operations. This may be because the use of combines is mainly helpful for the larger land holding farmers and not for the small land holding farmers. As per the record, during the 2000-01 period, about 63.0 per cent of total agricultural land holding was less than 4.0 ha. Thus, the majority of farmers had to prefer threshers than the combine harvesters. Table 2.23 show the level of farm mechanization in India while Table 2.24 shows the contribution of different power sources in Indian agriculture.

Table 2.23: Level of farm mechanization in India (Kulakarni, 2009)

Operation	Percentage
Tillage	**40.3**
(a) Tractor	15.6
(b) Animal	24.7
Sowing with drills and planters	**28.9**
(a) Tractor	8.3
(b) Animal	20.6
Threshers for wheat	47.8
Paddy and other	4.4
Harvesting	
(a) Reapers	0.56
(b) Combines	0.37
Irrigation	**37.0**
Plant protection	**34.2**

Table 2.24: Contribution of different power sources in Indian agriculture (Kulakarni, 2009)

Year	Agricultural labor (%)	Drought animal (%)	Tractor (%)	Stationary engine (%)	Total power (kW/ha)
1981-82	10.92	27.23	19.95	41.57	0.471
2005-06	5.77	8.02	46.70	41.12	1.502
2011-12*	5.09	6.37	51.08	37.46	1.910

*Estimated

Agriculture has to grow at 4 per cent annually for India to maintain a sustainable annual GDP growth of 8-9 per cent (Ali, 2007). Rural people migrate to urban areas for employment and better amenities as such opportunities are not adequately available in rural areas. This causes a reduction in the agricultural labor intensity of the country. In 2003, the agriculture labor intensity was recorded at only 1.61. The current power use in Indian agriculture is classified as mechanical (65 per cent), electrical (21 per cent), animal (8 per cent) and human (6 per cent).

Table 2.25 shows the population of power sources and their availability in India. The available power for agriculture increased steadily, except animal power, which showed slight decrease over the time. It is obvious that the use of agricultural machinery such as tractors and power tillers, diesel engines and electric motors has increased, which substituted the traditional animal power used in Indian agriculture.

Table 2.25: Population of power sources and their contribution to power availability in India (CIAE, 2008)

Year	Agricultural workers		Draught animals		Tractor		Power tiller		Diesel engine		Electric motor	
	Population (000')	Power (kW/ha)	Population (000')	Power (kW/ha)	Population (000')	Power (kW/ha)	Population (000')	Power (kW/ha)	Population (000')	Power (kW/ha)	Population (000')	Power (kW/ha)
1971-72	125,666	0.045	78,416	0.133	119.39	0.02	16.418	0.759	1,442.82	0.053	1,535.52	0.041
1975-76	133,751	0.048	77,519	0.135	207.43	0.04	23.486	1.110	2,075.45	0.078	2,063.59	0.056
1981-82	146,766	0.051	76,208	0.128	513.38	0.09	32.400	1.562	3,061.01	0.112	3,202.67	0.084
1985-85	161,089	0.057	75,356	0.129	746.55	0.14	40.303	1.971	3,742.20	0.139	4,192.07	0.111
1991-92	185,238	0.065	74,110	0.126	1,243.60	0.23	60.325	3.020	4,799.79	0.177	6,018.95	0.159
1995-96	200,979	0.071	73,300	0.124	1,734.32	0.32	82.130	4.098	5,528.47	0.203	7,464.12	0.196
2000-01	222,551	0.079	72,309	0.122	2,599.72	0.48	122.488	6.112	6,465.58	0.238	9,524.71	0.250
2005-06*	246,438	0.087	71,341	0.120	3,819.49	0.70	181.079	9.035	7,431.58	0.273	11,866.07	0.311

*Projection source: CIAE Bhopal Reference: IASRI, New Delhi, Agricultural Data Book 2006

Table 2.26: Percentage share of various power sources (CIAE, 2008)

Year	Agricultural workers	Draught animals	Tractor	Power tiller	Diesel engine	Electric motor	Total power kW/ha
1971-72	15.11	45.26	7.49	0.26	18.11	13.77	0.295
1981-82	10.92	27.23	19.95	0.33	23.79	17.78	0.471
1991-92	8.62	16.55	30.21	0.40	23.32	20.90	0.759
2000-01*	6.49	9.89	41.96	0.54	19.86	21.26	1.231
2005-06*	5.77	8.02	46.70	0.60	18.17	20.73	1.502

*http://www.indiaagristat.com

Table 2.26 gives the percentage share of different power sources in Indian agriculture over the years. The total power available for agriculture was increased steadily. Due to the increasing trend for the adaptation of mechanization in agriculture the power from agricultural workers and animals was reduced whereas mechanized power in the form of tractors and power tillers was increased. The growing use of electric motors for irrigation purposes lowered the dependence on diesel engines.

Though the adoption of farm mechanization is increasing in India, it is mostly region-specific. Farm mechanization has a very low growth rate in the regions where farming is done on hilly and sloppy land. Chronological change in area of operational land holdings is presented in Table 2.27. The data shows that the land holdings above 4 ha are continuously decreasing. The decreasing trend in operational land holdings may obstruct the growth of agricultural mechanization in future.

Table 2.27: The area of operational holdings by type of holdings in India (Kulkarni, 2009)

Major Size Classes	Area '000 ha		
	1980-81	**1990-91**	**2000-01**
Marginal, > 1ha	19.735 (12%)	24,894 (15%)	30,088 (18.82%)
Small, 1-2 ha	23.169 (14.2%)	28,827 (17.4%)	32,260 (20.18%)
Semi-medium, 2-4 ha	34.645 (21.2%)	38.375 (23.2%)	38,305 (23.96%)
Medium, 4-10 ha	48.470 (29.6)	44,752 (27.1%)	38,125 (23.84%)
Large, >10 ha	37.705 (23.0%)	28,659 (17.3%)	21,124 (13.21%)
All size classes	1,63,724 (100%)	1,65,507 (100%)	1,59,903 (100%)

Though the level of mechanization in agriculture is increasing, there are some farmers who prefer to continue with their traditional way of cultivation due to less purchasing power. Many farmers cannot afford the high cost agricultural machinery. Lack of knowledge of machines being used and required maintenance, lack of information about bank credit and small land holdings are some of the factors that force farmers to follow the traditional ways of agricultural operations.

Post-harvest processing is another area of interest for mechanized operations. The present levels of post-production losses are 5-15 per cent in durables, 20-30 per cent in semi-perishables and 30-40 per cent in perishables products. About 50 per cent of these losses could be prevented using appropriate post-harvest approaches. So there is still large scope for the mechanization in post harvest processing of agricultural commodities. Also, rice cultivation in the country is still lagging in the adoption of mechanization. So, there is an equal scope for extending mechanization to rice cultivation as well.

2.3 Farm accidents in India

Ergonomics is the scientific study of a person, his / her working environment and interactions within a person and the working environment. The working environment includes available working tools and materials, working methods and organization of the work, ambient conditions and physical environment of work. Human power is the most important farm power involved in agriculture. Apart from the human work labor force, human power is needed to operate animal-drawn equipments, tractors, power tillers, self-propelled and power operated machines. Thus, the application of ergonomic principles, standards and guidelines to the regular agricultural activities and machinery will help in increasing the efficiency and productivity of workers without imperiling their health and safety.

Table 2.28 gives the population dynamics of Indian agricultural workers. Large number of agricultural workers confirms the significant role of farm workers in Indian agriculture. Hence, due attention toward the health and safety of the farm workers is essential to provide them a comfortable working environment, better safety enabling them to achieve higher production efficiency.

Table 2.28: Population dynamics of Indian agricultural workers (numbers in million) (CIAE, 2010)

Sr. No.	Particulars	2001	2007	2012	2020
1	Country's population	1029	1130	1210	1300
2	Number of workers as % of population	39	41	42	45
3	Total number of workers	402	463	508	605
4	% of agricultural workers to total workers	58.2	52.0	47.5	40.0
5	Number of agricultural workers	234	241	241	242
6	% of females in agricultural work force	39	42	45	50
	a) Number of male agricultural workers	143	140	132	121
	b) Number of female agricultural workers	91	101	109	121

The adoption of farm machinery and mechanized agricultural practices augmented the overall productivity of farms but at the same time mechanization made agricultural operations more vulnerable to increased causalities and injuries due to accidents. Table 2.29 shows the category-wise distribution of agricultural accident data collected from 1600 villages in seven states of India. The report revealed that out of total farm accidents about 30.5 per cent are due to farm machinery, while 34.2 per cent accident occurred due to hand tools and 35.3 per cent accidents were reported due to other sources like snake and animal bites, falling into open wells, lightening and heat stroke. As high as 5.6 per cent of accidents were reported fatal in nature while 94.4 per cent accidents were non-fatal.

Table 2.29: Agricultural accident data collected from 1600 villages in seven states (CIAE, 2010)

Sr. No.	Source	No. of accidents			% of total accidents
		Fatal	Non-fatal	Total	
1	Farm machinery	39	659	698	30.5
2	Hand tools	1	782	783	34.2
3	Other sources (snake bites, animal bites, falling in open well/pond, lightening, heat stroke etc.)	84	725	809	35.3
	Total	124	2166	2290	100
		(5.6%)	(94.4%)	(100%)	

Table 2.30 gives the estimated farm machinery and tool-related accidents in Indian agriculture for the year 2001. Out of the total estimated accidents about 7.2 per cent were reported as fatal in nature and 92.8 per cent were non-fatal in nature. Farm machinery was considered as the cause for 78.4 per cent of the total accidents while 21.6 per cent accidents were reported due to hand tools.

Table 2.30: Estimates for farm machinery and tools related accidents in Indian agriculture for the year 2001 (CIAE, 2003)

Sr. No.	Category of accidents	Type of accidents		
		Fatal	Non fatal	Total
1	Farm machinery related accidents	19,095	1,90,045	2,09,140
2	Hand tools related accidents	-	57,671	57,671
Total		**19,095**	**2,47,716**	**2,66,811**

Table 2.31 gives the source-wise distribution of farm machinery accidents. The highest number of accidents (31 per cent) was due to the tractor and tractor-operated implements, followed by animal-drawn equipment (22 per cent), threshers (14 per cent), electric motors / pump sets (12 per cent), chaff cutters (9 per cent), power tillers (6 per cent), sprayers (4 per cent) and other machinery (2 per cent). Out of the total fatal accidents, tractor and tractor-operated implements were responsible for 44 per cent of the total fatalities. About 31 per cent fatalities were reported due to electric motors / pump sets followed by sprayers (13 per cent), power tillers (10 per cent) and threshers (2 per cent). The statistics mentioned here clearly show the necessity of immediate attention for tractor and tractor-operated implements, electric motors, sprayers, power tillers and threshers.

Table 2.31: Source-wise and severity-wise distribution of farm machinery accidents (CIAE, 2010)

Sr. No.	Source	No. of accidents			% of total accidents
		Fatal	Non-fatal	Total	
1	Tractor and tractor-operated implements	17	196	213	31
2	Threshers (including winnowers)	1	96	97	14
3	Chaff cutters (Manual + power operated)	0	65	65	9
4	Sprayers (Manual + power sprayers)	5	25	30	4
5	Cane crushers	0	6	6	1
6	Electric motors/pump sets	12	74	86	12
7	Power tillers	4	34	38	6
8	Animal drawn equipment	0	156	156	22
9	Other equipment	0	7	7	1
	Total	**39**	**659**	**698**	**100**
		(5.6%)	**(94.4%)**	**(100%)**	

Table 2.32 shows the source-wise accident incidence rates per thousand machines per year in selected villages during the years 1995-99 in different states of India. The highest incidence rate per 1000 machines was recorded for tractors in the Orissa state (55 per cent) followed by self propelled machines in Madhya Pradesh (50 per cent). In case of cane crushers, threshers / maize shellers and sprayers the highest incidence rate per 1000 machines was reported in Tamil Nadu

state (61.3 per cent, 41.85 per cent and 14.47 per cent, respectively). The Punjab state had a lower accident incidence rate in all types of agricultural machinery.

The highest incidence rate per 1000 workers was recorded in snake and animal bites followed by agricultural chemicals and pesticides and falling in open well / pond. Sun stroke and lightening constituted comparatively minor reasons for the accident incidence.

Table 2.32: Source-wise accident incidence rates in selected villages during the years 1995-99 in different states in India (CIAE, 2003)

Sources of Accident	Incidence rate/1000 Machines/Year			
	Madhya Pradesh	Orissa	Tamil Nadu	Punjab
Accident Prone Agricultural Machinery				
Self propelled machines	50.0	0	0	5.13
Tractors	25.83	55.00	14.33	1.24
Threshers/maize shellers	9.40	2.02	41.85	2.09
Manual/powered chaff cutters	1.91	3.50	8.94	0.94
Sprayers	0.45	0.97	14.47	1.73
Grain mill/rice hullers	17.39	21.28	0	0
Electric motor and pump sets	1.27	2.50	0	0.54
Cane crushers	0	13.33	61.30	1.31
Power tillers	0	42.85	0	0
Winnowers	0	1.60	0	0
Animal drawn puddlers	0	5.10	0	0
Animal carts	0	0	0	0.25
Diesel engine	0	0	0	0.09
Hand tools	0.08	0.39	0.20	0.01
Others				
	Incidence rate/1000 Workers/Year			
Snake/animal bites	0.07	0.26	0.05	0.17
Wells/tube wells	0.05	0	0	0.11
Agricultural chemicals/pesticides	0.02	0.19	0.31	0.04
Overhead electric wires	0	0.07	0	0.06
Sun stroke	0	0.16	0	0
Lightening	0	0.20	0	0

2.4 Economic loss due to agricultural accidents

The cost due to fatal injuries can be estimated by using YPLL (years of productive life loss) method. Lehtola et al. (1994) used this method and calculated the total cost of one human life as INR 1,100,000 (US$23,900). Estimates suggest that each year there would be about 45,000 fatalities and 755,000 non-fatal injuries in India. The average cost per non-fatal injury was calculated as INR 5,700 (US$124). The overall cost due to agricultural accidents worked out as INR 54 billion (US$1.174 billion) per year (CIAE, 2010).

2.5 Comparison of agricultural accidents in India with other countries

There are scientific studies published related to agricultural accidents in developed and developing countries. McKnight (1984) reported that about 75 per cent of agricultural fatalities in United States were due to tractor accidents and 50 per cent of those were caused due to overturning tractors. Murphy (1990) reported that tractor-related incidents in United States accounted for one-third to one-half of all farm injuries and 5 to 10 per cent of total non-fatal injuries.

Lehtola et al. (1994) analyzed agricultural tractor fatalities published in newspapers from Iowa State in five years period. The overturning of tractors caused 56 per cent of total fatalities. Moreover, about 59 per cent incidents of overturns occurred in field and farmyards, whereas, 37 per cent incidents of overturns occurred on public roadways with no other vehicle involved. About 17 per cent fatalities of overturns were associated with children as victims. No fatalities were reported for tractors equipped with roll over protective structure (ROPS).

Zhou and Roseman (1994) studied the occurrence of agricultural injuries among 1000 farm operators in Alabama. It was reported that most frequently limbs of farm operators were affected during accidents and the causes were machinery (28.6 per cent), falls (23.2 per cent) and animals (12.5 per cent).

In a study for farm accidents carried out in New Zealand, Langley et al. (1997) reported that about 18.6 per cent of total farm accidents were associated with tractors out of which 55 per cent of fatalities were due to the overturning of tractors. In Turkey, the agricultural fatality rate was 16 per 100,000 workers per year while in United States the same was recorded as 25.4 per 100,000 workers.

It is evident that agricultural mechanization in western countries is more developed and advanced than the developing countries like India. The average farm power available per hectare in developed western countries is about 13 kW, while in India it is only 1.3 kW. For achieving the double food production to feed the country's increasing population, India has to increase its farm power availability to 3.5 kW/ha. Therefore, if attention to safety is not given, the fatality rate in agriculture may increase causing enormous loss to the Indian agriculture community.

3. Testing and Certification Facilities for Agricultural Machinery in India

3.1 Status of agricultural machinery industries in India

The agricultural machinery manufacturing in India, like most of the developing agricultural countries, is a complex structure consisting of village artisans, tiny units, small-scale industries to State Agro-Industrial Development Corporations and organized tractor, engine and processing equipment industries. The traditional hand tools, basic agricultural equipment and animal-drawn implements are still manufactured in villages and with small-scale industries. The sophisticated, modern agricultural machinery and equipment are manufactured by well-organized agricultural machinery industry sector. The manufacturing at small-scale industries is generally not associated with R&D facilities. Production in these industries is based on the information and prototypes provided by the public and research institutions, including local universities. However, they use to upgrade their products with their experience, but most of the time, no specific standards followed for manufacturing.

India is recognized as one of the leading countries in the world for the development and manufacture of agricultural implements and equipments. The organized agricultural machinery manufacturing industries function in an ordered dealership network. The facility of after-sales service through the dealers determines reliability towards the company and the machines. Most of these industries are coupled with R&D facilities to upgrade their product and process technologies. Table 2.33 shows the status of the agricultural machinery industry in India in 1997.

Table 2.33: Status of agricultural machinery industries in India (CIAE, 1997)

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

3.2 Institutions involved in testing and evaluation

The adoption of agricultural machinery is greatly dependent on the quality of the product and after-sales service offered by the manufacturer. The organized industrial sector has own R&D facilities and testing units to maintain the quality of the product as per the BIS (Bureau of Indian Standards) specification. Most of the agricultural machinery being manufactured in small-scale industries leave gap for under-quality manufacturing due to variations in technology adopted by them.

All newly developed equipment undergo the testing and evaluation process for ensuring quality, reliability, durability, functional ease, comfort in operation and cost of operation. Testing is conducted with well-defined BIS, ISO, or OECD standards while evaluation is carried out to measure the performance under simulated or field conditions. Thus, testing and evaluation of the product is necessary to maintain the quality production of the machinery.

1) Bureau of Indian Standards (BIS)

India has its own certifying agency called the Bureau of Indian Standards, or BIS. The institute

has a well-organized nationwide network of regional testing centers and laboratories to certify and ensure the quality and safety of the manufacture and marketing of the agricultural and industrial goods in the country. The test codes and specifications of agricultural machinery and appliances are documented by the BIS, which periodically undergoes amendments to upgrade the standards as per the requirements. The bureau issues ISI (Indian Standards Institution) certificate to those goods and services which satisfy the prescribed test code and specifications as per the BIS standards.

The bureau has salutary authority to examine the quality of a product manufactured and / or marketed in the country. BIS offers quality certificates to the agricultural machines manufactured by the organized sector like tractors, earth moving machinery, irrigation equipment, plant protection equipment, dairy equipment, processing machinery.

2) Farm machinery training and testing centers

The Indian Government established 'Farm machinery training and testing centers' for testing the agricultural machinery and to train the respective individuals for skillful use and maintenance of the machinery. There are regional testing centers for farm machinery and equipment. These centers are located at Budni, Madhya Pradesh (Central Region); Hissar, Haryana (Northern region), Assam (Eastern region); Anantpur, Andhra Pradesh (Southern region); and Tamil Nadu (Southern region).

Central Farm Machinery Training and Testing Institute, Budni is equipped to undertake testing of tractors, combines and other agricultural machinery while other centers test agricultural machinery and irrigation equipments as well.

3) Regional Research Laboratories under CSIR

Regional research laboratories functioning under CSIR (Council of Scientific and Industrial Research) offer microprocessor-based modern testing facilities especially for metallographic and material testing. These laboratories share the research and test facilities for quality assessment of the agricultural machinery.

4) Independent testing and evaluation laboratories

Considering the vast geographical area and the extent of work, the Indian government has authorized a few NGOs, independent institutions and association for quality testing and evaluation of the products as per the BIS specifications. Some of the universities including agricultural universities and institutes functioning under the ICAR (Indian Council of Agricultural Research) conduct quality certification evaluation for consumers on request.

3.3 Functioning of the farm machinery training and testing centers

Recognizing the importance of farm mechanization which plays vital role in crop production to post harvest processing, the Government of India had undertaken the import of agricultural machinery and equipment as part of its 'First Five Year Plan'. Thus for promoting and demonstrating the use of agricultural machines to the farmers, the Government established the 'Agricultural Machinery Utilization Training Centre' in 1955 at Budni (Madhya Pradesh). In 1959 Government added the 'testing' wing to the centre and renamed it as the `Tractor Training and Testing Station'. The main motive behind the addition of a testing unit is to evaluate the imported and locally-manufactured machinery for their performance. In 1983, the Tractor Training and Testing Station was upgraded and renamed as `Central Farm Machinery Training and Testing Institute'.

Viewing the importance of testing farm machines and training on various aspects of farm machinery, and to cope with the increased demand of trained manpower in the field of agricultural mechanization, three more institutes were set up at Hissar (Haryana), Anantapur (Andhra Pradesh) and Biswanath Chariali (Assam) in the years 1963, 1983 and 1990, respectively.

3.4 Central Farm Machinery Training and Testing Institute, Budni, India

The institute plays major role in the export promotion of Indian tractors as it has accreditation of Organization for Economic Co-operation and Development (OECD), Paris. The institute has been functioning for over five decades and has developed all the necessary expertise and infrastructure to accomplish international standards in the agricultural machinery training and testing. The institute is one of the well-recognized testing and training organizations in the world.

3.5 Testing of agricultural machinery

The institute conducts testing of tractors, power tillers, combine harvesters, irrigation pumps, threshers, agricultural tyres, engines, all kinds of farm implements and components. The testing at the institute is carried out in four different testing categories as given below (CFMTTI, 2010):

1) Commercial test

The test is carried out to establish the performance characteristics of machine that are ready under commercialized production. There are three types:

a) Initial commercial tests on indigenous or imported machines ready for commercial production.
b) Batch tests on machines which have already undergone initial commercial test and/or are being manufactured commercially in the country; available only for tractor and power tiller.
c) Users' Survey gives a good feedback from farmers' about the performance of the machine, its durability and efficiency of after-sale-service provided by the manufacturer.

2) Confidential test

The institute offers confidential tests to the machine manufacturers about the performance of their machine and any other additional amendments required.

3) OECD test

The institute offers the testing facility in accordance with the OECD Official Test Codes for the agricultural machinery set for the export purpose.

4) Test under CMV rule, 1989

The institute evaluates agricultural tractors and other self propelled equipments for compliance to CMVR (Central Motor Vehicle Rules) requirements, which is the national testing authority for tractors and allied agricultural machines and offers CMVR certificates.

3.5.1 Tractor test

Tractor test is carried out in accordance with IS: 5994-1998 as amended from time to time. A tractor is subjected to the laboratory as well as field tests and evaluation.

1) Lab Test

a) Checking of specifications
b) P.T.O. performance test
c) Belt pulley test(optional)
d) Drawbar performance test
e) Power lift and hydraulic performance test
f) Brake test
g) Air cleaner oil pull over test
h) Noise measurement

i) Mechanical vibration measurement
j) Location of centre of gravity
k) Turning ability
l) Visibility

2) Field Test

For Initial commercial tests 50 hours and for batch test 40 hours of field tests with the following implements:

a) Plough/ Rotavator
b) Puddling under actual field condition followed by Water Proof Test.

Haulage test with 2/4 wheel trailers and the gross load recommended by the manufacturer. Components and assembly inspection is made to assess the wear, breakdowns, etc.

3.5.2 Power tiller test

Performance evaluation of power tiller is conducted in accordance with IS: 9935-2002 as amended from time to time. A power tiller is put into the laboratory and field tests and evaluation:

1) Lab Test

a) Specification checking
b) Engine performance test
c) Rotary shaft performance test
d) Drawbar performance test
e) Parking brake test
f) Noise measurement
g) Air cleaner oil pull over test
h) Mechanical vibration measurement
i) Turning ability test
j) Chemical composition test and wear characteristics test of rotavator blades

2) Field Test

For initial commercial tests (ICT) 75 hours and for batch test 50 hours of field tests with the following implements.

a) Mould board ploughing (10 hours for I.C.T. only)
b) Dry rotavation (40 hours for I.C.T and 25 hours for batch tests)
c) Puddling under actual field condition (25 hours for I.C.T. and batch tests both)

3.5.3 Combine harvester test

Combine harvester testing is done in accordance with IS: 8122-1994 Part-I & IS: 8122-2000 Part-II as amended from time to time. A combine harvester is put to the following different tests:

1) Lab Test

a) Specification checking
b) Engine performance test
c) Turning ability test
d) Location of centre of gravity test
e) Visibility test

f) Brake performance test
g) Air cleaner oil pull over test
h) Mechanical vibration test
i) Noise measurement test

2) Field Test

200 hours of field test on the following crops are performed.

a) Wheat harvesting
b) Paddy harvesting
c) Any other crop (if recommended)

3.5.4 Testing of miscellaneous equipments:

1) Paddy transplanter:

The Institute tests transplanters for evaluating engine performance and field performance to assess suitability and its output in the field.

2) Tractor tyres

Drive wheel tyres of tractors are tested for assessing the performance on drawbar work as well as wear of tyres on dimension and on mass basis per unit of time.

3) Irrigation pumps

Irrigation pumps are tested for power requirement, pressure discharge characteristics, efficiency etc. as per the requirement of relevant Indian Standards.

4) Power units

Power units viz. engines are tested under ISI mark certification scheme or as requested by the manufacturers for different application.

5) Tillage and sowing implements

Tillage and sowing equipment are tested for material composition of soil engaging components and assessing the field performance for the intended purpose.

3.6 Formulation of Indian standards

BIS is the nodal organization for formulating and publishing the Indian Standards (IS) on agricultural machines and their components. This Institute actively participates in formulation of the Indian Standards on agricultural tractors and other farm equipments.

3.7 Formulation of standards under C.M.V. rules

The Ministry of Road Transport and Highways is the nodal agency for formulation of standards, effecting amendments in CMVR and its implementation. The Institute has a permanent representation in the following committees in the field relating to tractors and accessories and power operated agricultural machines/equipment as:

a) Standing Committee on Implementation of Emission Norms
b) Committee of Sub-Group on Roadworthiness Certification

3.8 Testing Statistics

Figure 2.56 shows total number of machines tested from 1961 to 31st March 2009 in India. Figure 2.57 shows category-wise machines tested from 1961 to 31st March 2009.

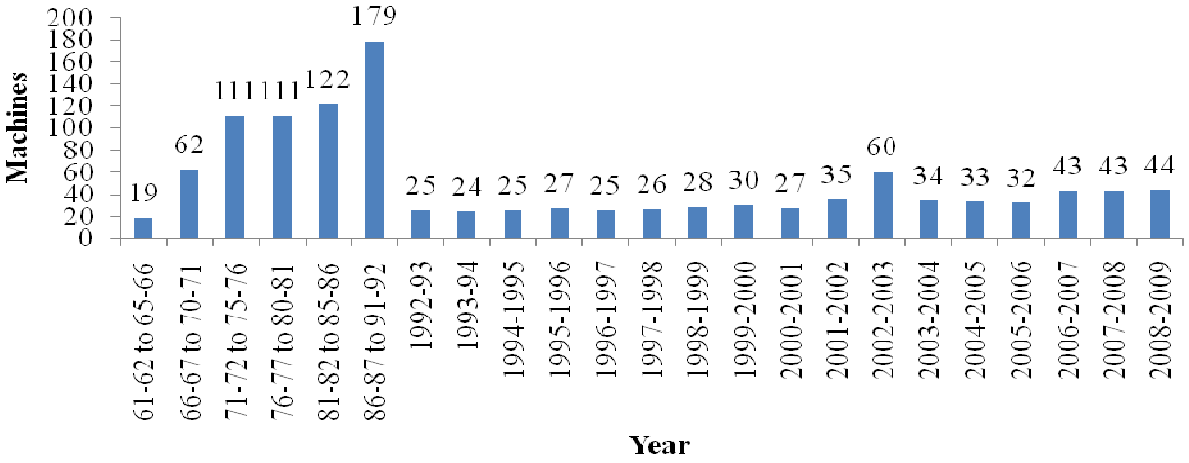


Figure 2.56: Total number of machines tested from 1961 to 31st March 2009
(Source: http://dacnet.nic.in/cfmtti/testingrates.htm)

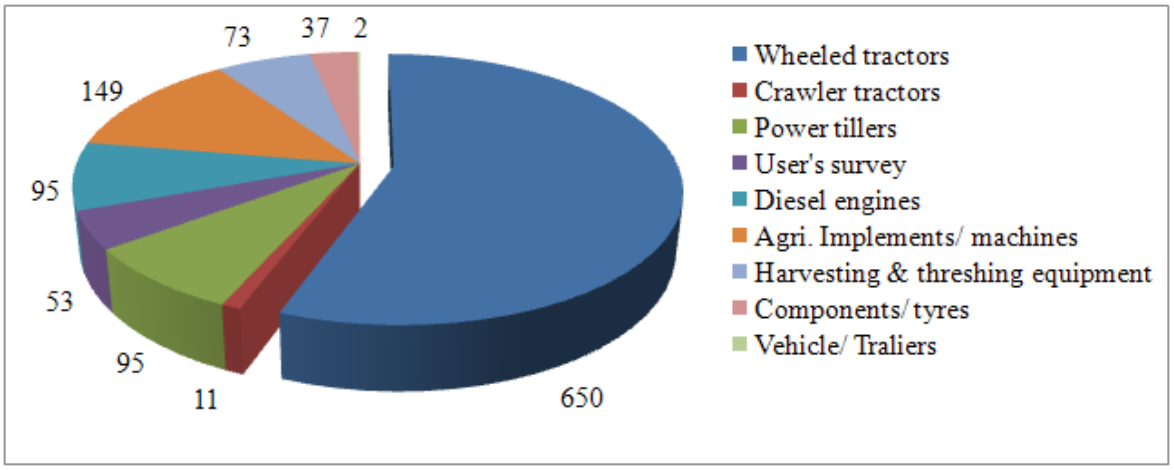


Figure 2.57: Category wise machines tested from 1961 to 31st March 2009
(Source: http://dacnet.nic.in/cfmtti/catwise.htm)

3.9 Training Statistics & Programs

Figure 2.58 shows year-wise trainees trained until 31st March 2009. Figure 2.59 shows category-wise trainees trained until 31st March 2009 in India. The training and testing institute runs following 11 types of regular training programs:

a) User's level course
b) Technician's level course
c) Earning while learning course
d) Management level course
e) Academic level course
f) Technology transfer camps
g) SJGSY (Swarn jayanti gram swarojgar yojana or Golden jubilee village entrepreneurship scheme) training course

h) Training courses for foreign nationals
i) Need based training course
j) Program for defense personnel
k) Awareness courses through multimedia

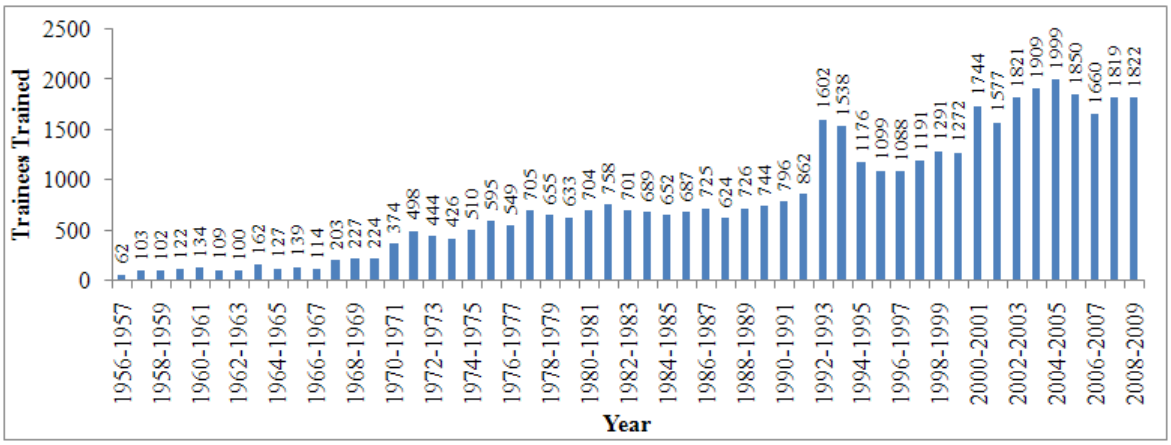


Figure 2.58: Year-wise trainees trained until 31st March 2009
(Source: http://dacnet.nic.in/cfmtti/yeartrain.htm)

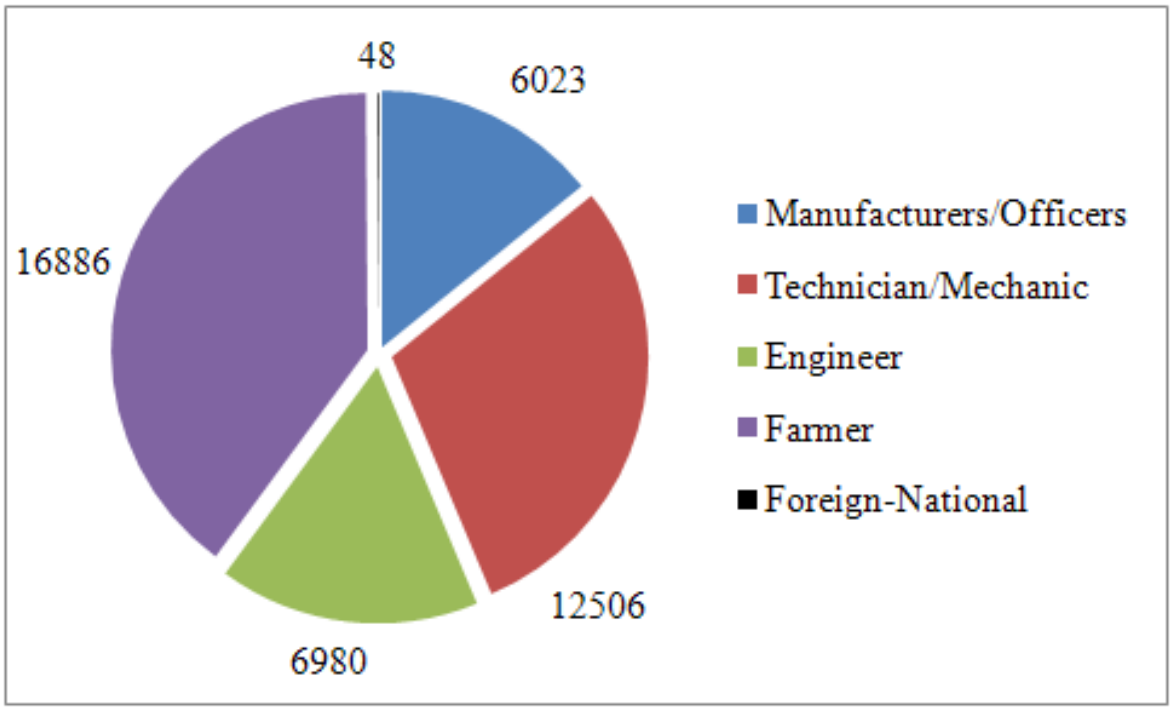


Figure 2.59: Category-wise trainees trained until 31st March 2009
(Source: http://dacnet.nic.in/cfmtti/cattrain.htm)

D) THE PHILIPPINES

1. General overview of agriculture

1.1. Social and economic conditions

The Philippines is basically an agrarian economy with 13 million hectares of cropland. The harvested area for rice is 4.27 million hectares with the average yield of 3.8 mt/ha. The general statistics shown in Table 2.34 indicate that rapid economic growth has been accompanied with significant structural changes in the Philippines' economy. In recent years, the agricultural sector contributed only about 14-16 per cent to GDP growth; the industrial sector and the service sector accounted for 32 per cent and 56.2 per cent of GDP, respectively. These data indicate that the Philippines economy has been transitioning from one based on agriculture to the one based more on services and industry (World Development Indicators Database). The agricultural sector, however, still employed 12 million people and contributed 34 per cent to the national employment in 2009 (Bureau of Agricultural Statistics (BAS), 2010). Agriculture is, therefore, still an important sector in the Philippines economy.

Table 2.34: Philippines statistics (World Development Indicators Database, September 2009)

	2000	**2005**	**2007**	**2008**
World view				
Population, total (millions)	77.69	85.50	88.72	90.35
Population growth (annual %)	2.0	1.9	1.8	1.8
Surface area (sq. km thousands)	300.0	300.0	300.0	300.0
Environment				
Agricultural land (% of land area)	40.7	40.9	..	..
Economy				
GDP (current US$ billions)	75.91	98.82	144.0	166.00
GDP growth (annual %)	6.0	5.0	7.1	3.8
Agriculture, value added (% of GDP)	16	14	14	15
Industry, value added (% of GDP)	32	32	32	32
Services, etc., value added (% of GDP)	52	54	54	53

1.2 Agriculture in the Philippines

1) Major crops

The Philippines is located in the tropics and its climate makes the country endowed with natural resources and one of the richest areas of biodiversity in the world. The Philippines agriculture includes three sub-sectors: field crops, livestock as well as poultry, and fisheries. Mechanization level in the field crops sector is still in the developing stage. The volume of production, the area planted/harvested and value of the main 21 crops in Philippines (2007-2009) are shown in Table 2.35, Table 2.36 and Table 2.37, respectively. The four main field crops in the Philippines are palay (unhusked rice), corn, coconut and sugarcane. The production data of these major crops can be found in Table 2.38. In 2009, palay production was 3.27 per cent lower than in 2008; corn output was up by 1.53 per cent; coconut grew by 2.27 per cent and sugarcane decreased by 13.8 per cent. Other major crops such as banana, peanut, tobacco and cassava as shown in Tables 2.35, Table 2.36 and Table 2.37 increased in production (Bureau of Agricultural Statistics (BAS), 2010,

World Bank Database).

Table 2.35: Crops' volume of production in 2007-2009

ITEM	2007	2008	2009
		('000 mt)	
TOTAL	**78,214.1**	**85,097.7**	**81,599.7**
Palay	16,240.2	16,815.5	16,266.4
Corn	6,736.9	6,928.2	7,034.0
Coconut	14,852.9	15,319.5	15,667.6
Sugarcane	22,235.3	26,601.4	22,932.8
Banana	7,484.1	8,687.6	9,013.2
Pineapple	2,016.5	2,209.3	2,198.5
Coffee	97.9	97.4	96.4
Mango	1,023.9	884.0	771.4
Tobacco	34.3	32.5	36.4
Abaca	66.4	68.4	65.8
Peanut	31.2	30.2	31.0
Mongo	29.1	29.6	27.7
Cassava	1,871.1	1,941.6	2,043.7
Camote	573.7	572.7	560.5
Tomato	188.8	195.8	198.9
Garlic	11.3	11.3	10.5
Onion	146.1	128.9	127.1
Cabbage	123.4	128.9	124.7
Eggplant	210.2	199.6	200.9
Calamansi	201.6	199.7	192.2
Rubber	404.1	411.0	391.0
Others	3,635.1	3,604.5	3,608.9

Table 2.36: Planted/harvested areas, Philippines, 2007-2009

ITEM	2007	2008	2009
		('000 has)	
TOTAL	**12,641.0**	**12,894.5**	**13,031.5**
Palay	4,272.9	4,460.0	4,532.3
Corn	2,648.3	2,661.0	2,683.9
Coconut	3,359.8	3,379.7	3,401.5
Sugarcane	383.0	398.0	404.0
Banana	436.8	438.6	446.4
Pineapple	54.0	58.3	58.8
Coffee	124.0	123.3	122.6
Mango	184.2	186.8	188.1
Tobacco	23.9	22.2	26.1
Abaca	136.1	137.5	135.1
Peanut	28.3	27.7	28.2
Mongo	39.0	39.9	38.7
Cassava	209.6	211.7	215.9
Camote	117.6	116.5	114.4
Tomato	17.5	17.6	17.7
Garlic	3.9	3.8	3.6
Onion	15.9	14.6	14.5
Cabbage	8.5	8.6	8.5
Eggplant	21.6	21.3	21.2
Calamansi	20.5	21.0	20.9
Rubber	111.0	123.3	128.3
Others	424.8	423.2	420.7

1/ Area planted for permanent crops and area harvested for temporary crops.

Table 2.37: Crop value of agricultural production, Philippines, 2007-2009

ITEM	2007	2008	2009
	(million pesos, at current prices)		
TOTAL	**512,275.2 R**	**631,026.1 R**	**631,454.7**
Palay	182,052.6 R	234,072.5	238,140.4
Corn	65,887.4 R	75,864.0 R	76,037.9
Coconut	59,708.8	80,121.1	65,020.4
Sugarcane	28,905.9	33,251.7 R	28,895.4
Banana	58,301.0 R	75,321.7	89,050.3
Pineapple	9,860.5	11,113.0	11,586.1
Coffee	5,496.0	6,218.0	5,586.8
Mango	17,386.0	19,881.4	18,144.5
Tobacco	1,944.6	2,583.2 R	2,446.2
Abaca	2,266.9	3,011.2	2,363.3
Peanut	766.3	766.8 R	844.5
Mongo	928.2	989.0	1,001.4
Cassava	8,850.4	10,581.6	11,894.5
Camote	4,779.3	5,342.9	5,229.7
Tomato	2,140.4	2,535.7	2,397.2
Garlic	776.9	601.3	799.9
Onion	2,223.6	5,297.7	3,572.9
Cabbage	1,439.4	1,350.5	1,990.5
Eggplant	2,353.8	3,446.7	3,142.9
Calamansi	1,758.1	1,916.8	3,394.1
Rubber	17,261.9	15,631.9	13,144.4
Others	37,187.3	41,127.3	46,771.6

Table 2.38: Major crops and their productions in Philippines, 2009

	Production ('000 mt)			
Crops	***Palay* (Rice)**	**Corn**	**Coconut**	**Sugarcane**
Philippines	16,266.4	7,034.0	15,667.6	22,932.8

Source: Bureau of Agricultural Statistics, 2010

2) Agricultural support services

Agriculture is an important sector in the Philippine economy. In 2009, government expenditures for the agriculture sector amounted to 75.27 billion Philippine Pesos (PHPs), which was 5 per cent of national government expenditures. Meanwhile, agricultural loans in 2009 increased by 3.88 per cent to 481.13 billion PHPs of which 44 per cent were production loans (Bureau of Agricultural Statistics (BAS), 2010).

3) Exports and imports of agricultural products

Exports and imports of agricultural products play an important role in the Philippine economy. The country's total exports were US$3,135.75 million in 2009, a 19.37 per cent decrease from the 2008 record (Table 2.39). Coconut oil and fresh banana remained on the top of the list of agricultural exports (Table 2.40). Agricultural import expenditures reached US$6,079.80 million in 2009, 20.88 per cent less than the previous year (Table 2.41). Rice, wheat and meslin accounted for 31 per cent of total agricultural imports. The bulk of rice imports came from Vietnam while the major sources of wheat and meslin were the United States and Ukraine. Corn (or maize) replaced rubber in 8th place on the list of major agricultural imports. The major suppliers of corn were Brazil, Thailand and Argentina. For exports, coconut oil was mostly exported to the United States and the Netherlands. The major markets of fresh banana were Japan and Iran. Major markets for tuna were the United States, Germany, Great Britain and Ireland.

These data indicate that the Philippines is not a fully food self-sufficient country. It exports cash crops and imports cereal crops including rice, wheat, soybean and corn. Improving the

productivity of field crops, particularly staple crops, is of paramount importance to ensure food security in the Philippines.

Table 2.39: Top agricultural exports: volume and value, Philippines, 2007-2009

ITEM	2007	2008	2009P
VOLUME OF TOP EXPORTS ('000 mt)			
Coconut Oil	888.85	850.08	832.94
Banana, Fresh	2,199.32	2192.55	1,664.05
Tuna	73.93	108.24	105.25
Pineapple & Pineapple Products	587.82	586.15	487.70
Desiccated Coconut	130.72	142.66	116.42
Tobacco Manufactured	17.68	20.01	17.24
Seaweeds & Carageenan	26.18	26.25	24.08
Unmanufactured Tobacco	18.90	23.64	30.09
Milk and Cream & Products	35.94	37.96	26.61
Fertilizer Manufactured	255.85	213.46	324.96
Mango, fresh	26.34	20.84	20.38
VALUE OF TOTAL AGRICULTURAL EXPORTS (FOB in million US $)	**3,168.07**	**3,889.30**	**3,135.75**
VALUE OF TOP EXPORTS (FOB in million US $)			
Coconut Oil	733.81	1,039.61	594.49
Banana, fresh	396.28	405.56	344.43
Tuna	210.87	388.78	334.82
Pineapple & Pineapple Products	247.42	255.51	263.27
Desiccated Coconut	157.43	240.36	145.76
Tobacco Manufactured	97.89	125.26	109.36
Seaweeds & Carageenan	91.64	122.03	98.68
Unmanufactured Tobacco	42.98	63.03	96.85
Milk and Cream & Products	138.76	162.50	95.62
Fertilizer Manufactured	53.64	55.81	92.50
Mango, fresh	23.28	19.58	15.98

Source: NSO

Table 2.40: Selected Philippines exports: percentage share in world market, 2006-2007

COMMODITY	2006	2007
	PHILIPPINE SHARE %	
VOLUME OF EXPORTS		
Banana fresh	13.77	12.55
Coconut Oil	51.72	43.16
Dessicated Coconut	33.95	46.07
Mango, Mangosteen and Guava	2.90	2.55
Pineapple and Pineapple products	9.22	9.80

Sources: FAO and NSO

Table 2.41: Top agricultural imports: volume and value, Philippines, 2007-2009

ITEM	2007	2008	2009P
VOLUME OF TOP IMPORTS ('000 mt)			
Rice	1,805.61	2,432.85	1,755.18
Wheat and Meslin	1,871.80	1,703.46	3,028.18
Soya bean Oil Cake/Meal	1,322.49	1,203.16	1,267.63
Milk & Cream & Products	262.27	234.26	256.64
Tobacco, *Unmanufactured*	58.81	60.73	46.77
Urea	462.60	524.59	626.64
Meat of Bovine Animals	104.52	109.25	84.02
Food Preparations for Infant Use	17.41	21.27	19.91
Corn	152.31	22.97	303.12
Coffee	30.79	36.03	51.09
VALUE OF TOTAL AGRICULTURAL IMPORTS (CIF in million US $)	**4,918.29**	**7,684.74**	**6,079.80**
VALUE OF TOP IMPORTS (CIF in million US $)			
Rice	657.14	1,956.78	1039.64
Wheat and Meslin	424.44	618.43	816.45
Soya bean Oil Cake/Meal	392.02	506.58	422.16
Milk & Cream & Products	588.72	724.37	385.68
Tobacco, *Unmanufactured*	182.49	223.46	192.53
Urea	123.35	199.87	185.93
Meat of Bovine Animals	139.27	209.17	143.83
Food Preparations for Infant Use	97.76	124.99	125.50
Corn	48.46	25.41	104.21
Coffee	69.86	91.09	88.13

Source: NSO

1.3 Issues surrounding agricultural development in the Philippines

Farming conditions in the country can be described by a mixture of small, medium and large farms. A majority of the farms are small with an average of 2ha/farm. There are two basic challenges faced by the agricultural sector in the Philippines. In the face of global climate change, labor shortage and dwindling land and water resources, agricultural production in Philippines must increase significantly in order to meet the growing demand for food. Second, profitability of agricultural production systems must be increased amidst global free trade. Farmers' agricultural products must be able to meet quality standards and cost of production must be reduced to be able to compete under global free trade conditions.

2. Agricultural mechanization

2.1 Status of agricultural mechanization in the Philippines

Farm mechanization contributes to the intensification and diversification of agricultural production systems. This, in turn, can generate rural employment, reduce post-harvest losses and increase the value of a product through processing. Thus, the application of agricultural machinery in field operation and technology transfer is an important consideration in the Philippine agriculture (Philippines' Country Report, 2009).

The level of agricultural mechanization in the Philippines is relatively low in comparison with other countries like Japan, Korea and China in the region. Most farmers in the Philippines are still

using inefficient manual tools in many farm production operations. This is particularly true for main field crops, such as rice and corn. In particular, the level of mechanization in the Philippines, in terms of available manpower, animal and mechanical power in the rice and corn farms was 1.68 hp/ha (Rodulfo, et al., 1999) (Table 2.42). Another indication of the level of mechanization is presented in Table 2.43 which gives the percentage utilization of the farms surveyed using man, animal and mechanical power.

The production of rice and corn are relatively more mechanized than other crops. The level of mechanization for land preparation, threshing, shelling operations are intermediate to high while milling is highly mechanized (Suministrado, 2003). Other operations like planting, crop caring, harvesting and drying are in the low level of mechanization. The overall mechanization level of vegetable farming, coconut, fruits and fiber crops is low except in sugarcane production where imported equipment and machines are widely used. The fisheries sector is at the intermediate level of mechanization mainly due to the use of engine-powered boats for accessing to fishing sites and transporting of harvests to coastal markets (Franco et al., 2002). The levels of mechanization of various operations of other crops are shown in Table 2.44.

Sugarcane has the highest degree of mechanization among the major agricultural crops. Large imported equipment such as four-wheel tractors, plows, semi-automatic planters, cultivators, harvesters, and mills are used making 83 percent of farm operations in sugarcane mechanized.

In rice, land preparation is mechanized through the use of power tiller. Pumps are widely used to facilitate irrigation. About 47 percent of rice produced is threshed with the power threshers while 98 percent of the rice farmers bring their *palay* to rice mills. There is also practically one knapsack sprayer per farmer. Table 2.45 presents the percent usage and the available technologies for some rice postproduction operations. For corn, a survey of 13 provinces in the Philippines indicated that mechanization is concentrated in land preparation, shelling and transportation only. (Suministrado *et al.,* 2003). For coconut, mechanization has taken place through the presence of oil mills, oil refineries, desiccated coconut plants, activated carbon plants, and oleochemical plants.

In fruits, mechanization for both production and processing is low, and there exist only a few number of processing equipment (hot water tank, sorting and grading machines, chippers/slicers, dryers, evaporators and retorts). In livestock, the feed milling operation for commercial feed mills is highly mechanized with imported and locally manufactured equipment consisting of forage chopper, hammer mill, mixer and pelletizer (Ellaine Grace L. Nagpala, Agricultural Engineering: Transformers of modern day agriculture, 2008). The use of mechanized methods in small to medium poultry and swine raising is generally low. Moreover, activities with low level of mechanization are feed preparation, feeding, drinking, manure removal, slaughtering. (Franco *et al*, 2003)

Table 2.42: Level of mechanization in rice and corn farms in hp/ha, 2005

SOURCE OF POWER	**hp/ha**
1. Human Labor	0.24
2. Draft Animal	0.08
3. Four-wheel Tractor	0.24
4. Engines	
a. Power Tiller	0.56
b. Thresher	0.34
c. Irrigation Pump	0.07
d. Harvesting, drying & shelling equipment	0.15
TOTAL	1.68

Source: Philippines' Country Report, 2009

Table 2.43: Level of mechanization in rice and corn farms, 2005

OPERATION	POWER SOURCE		
	Manual	Man-Animal	Mechanical
Land Preparation	3.2	64.7	13.2
Planting	98.7	1.2	0.2
Weeding	85.2	14.8	0
Fertilizer Application	98.7	1.7	0
Spraying	100	0	0
Harvesting	99.8	0	nil
Threshing/Shelling	31	0	69
Drying (Farm Level)	100	0	0
Milling	0	0	100
AVERAGE	56.5	19.2	21.7

Source: Philippines' Country Report, 2009

Table 2.44: Mechanization levels of various operations of selected crops

Operation	Rice & Corn	Vegetable. Legumes & Rootcrops	Coconut	Sugarcane	Fruits	Fiber crops
Land Preparation	Intermediate to high	Low		Intermediate	Low	Low
Planting transplanting	Low	Low	Low	Low to intermediate	Low	Low
Crop care or cultivation	Low	Low	Low	Low to high	Low	Low
Harvesting	Low	Low	Low	Low	Low	Low
Threshing or shelling	Intermediate to high	Low(legumes)				
Cleaning		Low				
Drying	Low	Low(legumes)	Low			
Milling/village level processing	High	Low	Low		Low	Low

Source: Delfin C. Suministrado, 2008

Table 2.45: Rice post-production operation and technologies

Operation	Technology	Capacity	Usage (%)
Harvesting	Manual Reaper Combine	240 man-h/ha 2.4-3.8 ha/d 4.5-8.0 ha/d	99.8 nil nil
Threshing	Manual Axial Flow	0.05-0.1 t/h/person 0.5-5.0 t/h	31.0 69.0
Drying	Sundrying Flatbed Recirculating Continuous	24 kg/m^2 1-6 t/batch 6-10 t/batch 2-10 t/h	86.0 14.0 Nil
Milling	Kiskisan Cono Rubber Roll	0.1-0.3 t/h 0.5-2.0 t/h 0.5-2.5 t/h	10.5 33.2 56.1
Storage	Bag Bulk	14 m2/t 1.5-1.7 m2/t	99.0 1.0

Source: Delfin C. Suministrado, 2008

The low level of mechanization in the country partly reflects various socio-economic and technological constraints. Among these are low incomes of farmers, high machinery and energy costs which reduce the profitability of local agricultural machinery manufacturers, absence of adequate resources and funding to support research and technology development, lack of local manufacturing capability for prime movers and inadequate institution and infrastructural support services and facilities, and insufficient training and demonstration of basic technological know-how and operational skills of farmers.

2.2 Farm machinery services

Custom hiring is a popular method of gaining short-term control of farm machinery, particularly for harvesting and for applying fertilizer and pesticides. Custom services may be available from a neighbor, a local dealer, or a business specializing in custom farming that performs all types of field operations.

In the province of Isabela, Philippines, local farmers had the experience of cooperatives under which farmers operated and managed custom hiring services for large machines such as tractors, planters and harvesters. Custom hiring was organized for the efficient use of farm machines for land preparation, planting and fertilizer application, and harvesting. Their experience shows that farmers owning small farms may conduct agricultural mechanization and take advantage of large machines by reducing custom hiring rates if they could increase the service area (Philippines Country Report, 2009).

Moreover, some of the documented benefits of clustering/consolidation include:

- Reduced fuel consumption in clustered/consolidated farms;
- Savings were achieved with corn seeds since the use of planter could precisely plant one seed per hill;
- Increased service area in clustered/consolidated farms because of the removal of boundariess among farms;
- Increased crop production for farms that used mechanical planter since corn plants are evenly spaced and the extra area formerly used as boundaries are also planted.

Thus, in small to medium scale farms, farmers could utilize farm machines through machinery pooling and custom hiring services. Custom hiring services could be a viable farm enterprise since it enables farmers to utilize machines without actually owning high-investment machines (Philippines' Country Report, 2009).

2.3 Agricultural machinery industry

Agricultural machinery industry in the Philippines is characterized by imports of heavy machines and prime movers, and local assembly and fabrication of small equipment. With these prime movers and important component parts, locally manufactured machines have high import content sometimes constituting more than half of the total machinery cost. Since the 1970s, the Agricultural Machinery Manufacturers and Distributors Association (AMMDA) has emerged as a highly credible spokesman of the industry. There are now about 400 registered manufacturers and dealers of agricultural machinery of various sizes, services and after-sales capabilities in the country. More than half of these agricultural machinery enterprises are found in the island of Luzon, about a third in Mindanao and the rest in the Visayas islands (Philippines' Country Report, 2009).

The adoption of agricultural machinery in the Philippines is beset with major problems as listed in Table 2.46, where possible solutions are also indicated.

Table 2.46: Problems and possible solutions to agricultural machinery sector

	PROBLEMS	SUGGESTED SOLUTIONS
1.	Technical – High acquisition cost – Inappropriate technology – Low reasearch & extension capability of appropriate farm machinery	–Collective machinery ownership / machinery pooling / custom hiring –Needs assesment of agricultural mechanization suitability –Capacity/capability enhancement/training
2.	Socio-economic Low income/lack of capital Small & fragmented land holdings Unfavourable market price for the farmerCheap & abundant labour (in some areas) and seasonal labour shortage	–Provision of credit facilities, clustering farmers into groups –Farm clustering & custom services –Floor price, train farmers into entrepreneurs (processing & business) –Absorbing unemployed into other jobs, retooling –Encourage farm business enterprises –Creating new jobs in agricultural activities (processing, waste handling, etc.)
	Environment / infrastructure – Lack of infrastructure – Diversity in agroecosystem – Weak agricultural manufacturing industry – Environmental degradation	–Put in place irrigation, processing facilities, farm roads, access to market –Adjust agricultural mechanization to the local-specific conditions –Select the most promising machines to produce locally –Support local manufacturers, through R&D, training, financial asistance –Introduce the business of service and maintenance of agricultural mechanization –Promote joint ventures with foreign manufacturers –Control utilization of chemical materials –Promote sustainable farming systems
4.	**Political / Institutional** – Inconsistant pocolies to support agricultural machinery	–Educate the policy makers on the importance of agricultural mechanization –Put agricultural mechanization into strategic long-term programmes –Promote agricultural mechanization through international networking & cooperation

Source: Philippines' Country Report, 2009

(Note: The main sources of information for this table come from the Philippines' Country Reports presented at UNAPCAEM meetings during 2005—2009 and information collected by the author during the field visit to the Philippines)

3. Research, Development and Extension of Agricultural Mechanization Technology

3.1. Agricultural Mechanization Development Program (AMDP)

There are many government agencies involved in RD and E of agricultural mechanization in the Philippines. Among which is the Agricultural Mechanization Development Program (AMDP) of the Institute of Agricultural Engineering (IAE), College of Engineering and Agro-Industrial Technology (CEAT), University of the Philippines (UPLB).

The College of Engineering and Agro-Industrial (CEAT), formerly Institute of Agricultural Engineering and Technology (INSAET) of UPLB was designated as the National Institute (NI) and Philippine government counterpart to implement the Regional Network on Agricultural Machinery (RNAM) projects as stipulated in the September 1977 a memorandum of agreement

between the Government of the Philippines (GOP), through the Department of Foreign Affairs (DFA) and the Economic and Social Commission for Asia and the Pacific (ESCAP). ESCAP in turn was designated as the executing agency for the UNDP-supported project known as RNAM the Under the agreement,

The Agricultural Mechanization Development Program (AMDP) was established by the INSAET (now CEAT) to implement the R&D and Extension activities on agricultural mechanization and as the Philippine representative to RNAM. The involvement of the Philippines in RNAM is towards the promotion of technical cooperation among developing countries for the advancement of agricultural mechanization in Asia and the Pacific. It is proud to be one of the eight countries that originally comprised RNAM. As of 1999, RNAM increased its members to 12 countries. RNAM was later renamed as Regional Network for Agricultural Engineering and Machinery (RNAEM). In 2002, RNAEM was eventually renamed to Asian and Pacific Center for Agricultural Engineering and Machinery (APCAEM) and the Philippines held the first chairmanship of the APCAEM governing board.

Since its establishment in 1979, AMDP has tackled various activities that contribute to government efforts of increasing agricultural productivity and improving the income of our farmers. The Program has assisted various levels of government, farmers and their communities through its research and development efforts, extension activities and manpower development thrusts. AMDP had developed, designed, tested and promoted affordable farm machinery for farmers; conducted technology and information dissemination through, pilot testing, demonstration of machines, exhibits, publication; and conducted training for different target beneficiaries. At present, the program continues to perform its role to improve the status of the Philippine agricultural sector.

4. Testing and certification

4.1 Agricultural Machinery Testing and Evaluation Center (AMTEC)

In response to the need for an official testing agency for agricultural machinery to guide farmers and for agricultural machinery manufacturers and financing institutions in determining suitability of agricultural machines and equipment used under Philippine condition, the Agricultural Machinery Testing and Evaluation Center (AMTEC) was established in 1977 in the University of the Philippines, Los Baños. AMTEC is part of the Government's efforts to promote mechanization through improved product quality and after-sales services of agricultural machinery and equipment marketed in the Philippines.

AMTEC is mandated to establish standards of quality and performance for agricultural machinery and equipment used under the Philippines conditions; conduct laboratory and field testing of agricultural machinery used and prototypes developed and introduced in the Philippines under established standard conditions; to set standards in evaluating spare parts and after-sales service capabilities of firms engaged in sales and/or distribution of agricultural machinery and equipment in the Philippines; to promote standardization of parts of agricultural machines for interchangeability and possible complementation of manufacturing and to identify design changes for improving machine performance, durability, safety, ease of operation and workmanship.

In partnership with the Department of Agriculture, the Philippine Society of Agricultural Engineers (PSAE) and the Professional Regulatory Commission (PRC), AMTEC leads in formulating standards of quality, performance and methods of test for various agricultural machines. It initiates standardization of parts and components of agricultural machines for interchangeability. To protect machinery users, the Centre evaluates machinery firms regarding their after-sales services.

As an accredited testing station for agricultural machines, AMTEC conducts laboratory and field tests and evaluation of locally manufactured machines, either for accreditation or design and development purposes. Imported machines are tested for suitability to Philippine conditions.

Machines are tested for their rate of work, quality of work, efficiency, ease of operation and soundness of construction.

AMTEC also publishes test results in bulletin form for dissemination to farmers, manufacturers and other end-users. Following the regional development thrusts of the government, the center conducts training courses on machinery testing and evaluation to strengthen machinery research and development in the countryside.

E) REPUBLIC OF KOREA

1. General Overview of Agriculture

1.1 Agricultural production and GDP

The total land under cultivation is less than one-fourth of the country's total area. With the country more inclined towards the industrial sector, the share of agriculture in the economy declined as compared to the 1950s. But with the impetus to the agriculture given lately by means of mechanization, specialization, and commercialization things have started looking up. Figure 2.60 and Figure 2.61 clearly indicate that there has been considerable growth in agricultural production over the decades following the 1960s with an exception of cereals, which showed signs of decline.

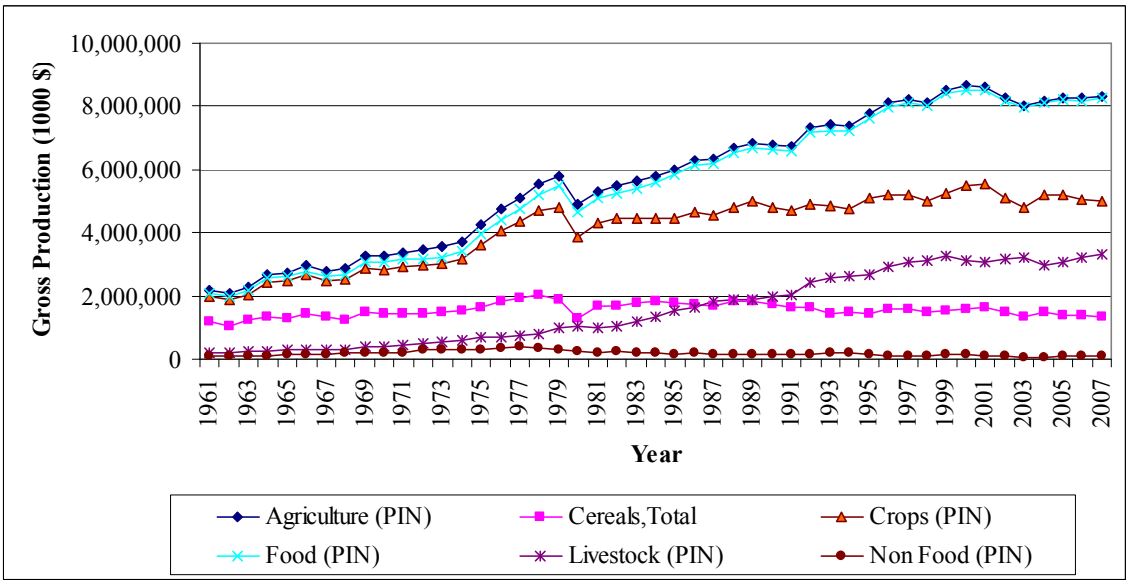


Figure 2.60: Gross production expressed as 1000 USD, Republic of Korea (FAOSTAT)

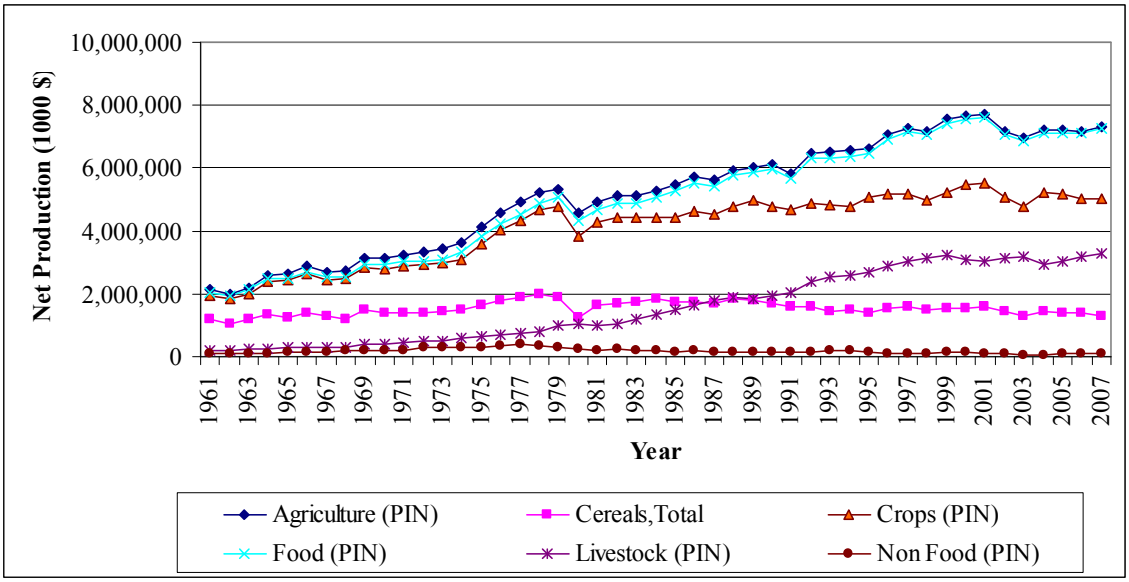


Figure 2.61: Net production expressed as 1000 USD, Republic of Korea (FAOSTAT)

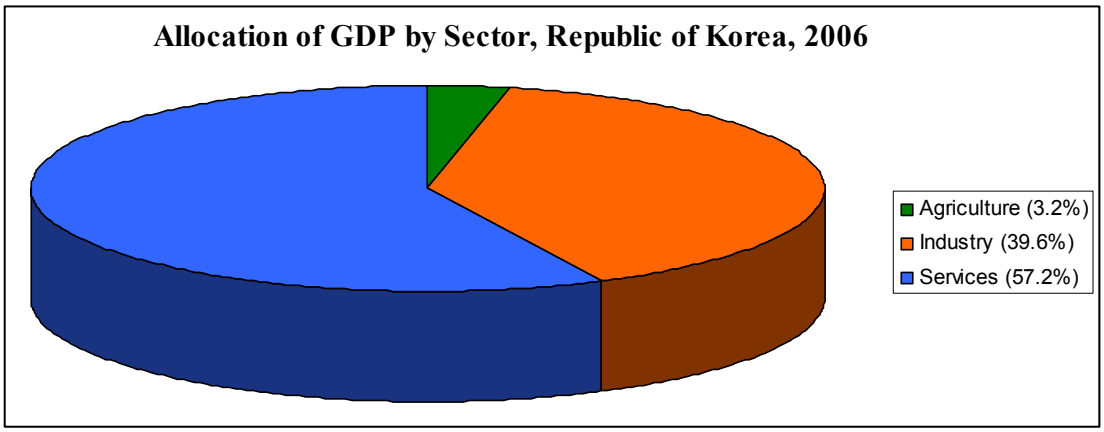


Figure 2.62: Allocation of GDP by sector for Republic of Korea in the year 2006 (Earth Trends)

There was a time when the Republic of Korea was considered as one of the world's poorest agrarian societies. But the onset of the 1960s, which brought in the economic restructuring of the country, caused an economic transformation. The positive results of this restructuring started showing in the following years which turned the poorest agrarian society into world's 13th largest economy, with 6th largest foreign reserves. The backbone of this economic turnaround was the export-oriented economy. The industry and the service sectors have had an important role in the growth of the Korean economy, which can be clearly seen in Figure 2.62. It can be seen that as of 2006 the industry and the service sectors contributed 96.8 per cent of the total GDP while agriculture contributed only 3.2 per cent to the country's GDP.

Table 2.47: Korea's production of top twenty agricultural commodities in the year 2007 (FAOSTAT)

Rank	Commodity	Production (Int $1000)	Production (MT)
1	Rice, paddy	1276292	6038000
2	Vegetables fresh nes	666157	3171000
3	Cow milk, whole, fresh	581876	2188000
4	Hen eggs, in shell	434140	543785
5	Cabbages and other brassicas	372775	2537615
6	Garlic	268243	347546
7	Onions, dry	223612	1213375
8	Strawberries	215603	203227

9	Tangerines, mandarins, clem.	176060	777547
10	Grapes	152474	328680
11	Chillies and peppers, green	142914	414136
12	Pears	133104	467426
13	Apples	125137	435686
14	Persimmons	118043	395614
15	Tomatoes	113691	479851
16	Onions (inc. shallots), green	110364	488814
17	Chestnuts	97046	77524
18	Watermelons	77355	741880
19	Potatoes	70261	574396
20	Peaches and nectarines	65863	184497

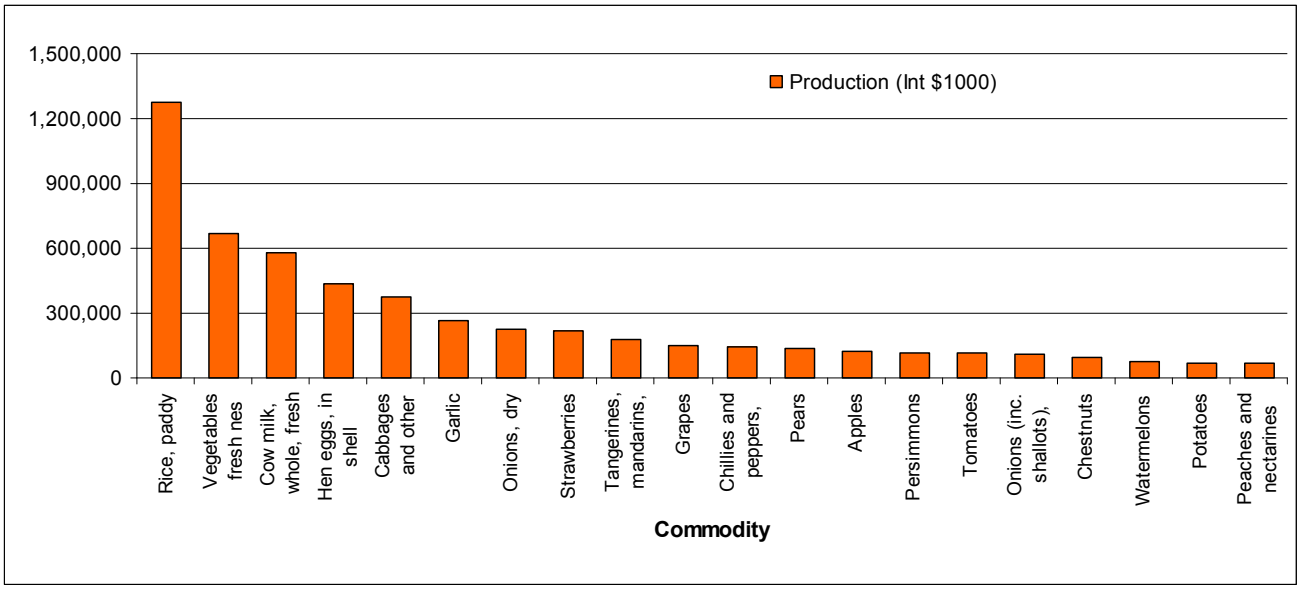


Figure 2.63: Republic of Korea's production of top twenty agricultural commodities in the year 2007 (FAOSTAT)

Table 2.47 shows the production details of the top twenty agricultural commodities for the year 2007. Rice accounted for US$1.27 billion and was having the highest production value for the concerned year, followed by vegetables at US$0.66 billion and cow milk at US$0.58 billion. The lowest production levels were seen for peaches and nectarines at US$0.065 billion. Figure 2.63 further illustrates the top twenty agricultural commodities as of 2007.

Figure 2.64 shows the relation between food production per capita and GDP per capita for the Republic of Korea. It reflects the economic growth and the increase in GDP that the Republic of Korea experienced after the economy was restructured in 1962 as well as a decline in the late 1970s and 1990s when the country experienced political instability and the Asian economic crisis, respectively. Korean GDP per capita has maintained a positive trend except for the above two instances, though lately it has not been able to achieve the same growth in GDP per capita as seen in the 1960's and the early 1970s. Though the GDP per capita has not been able to match the early rise it saw, food production per capita has seen a constant increase.

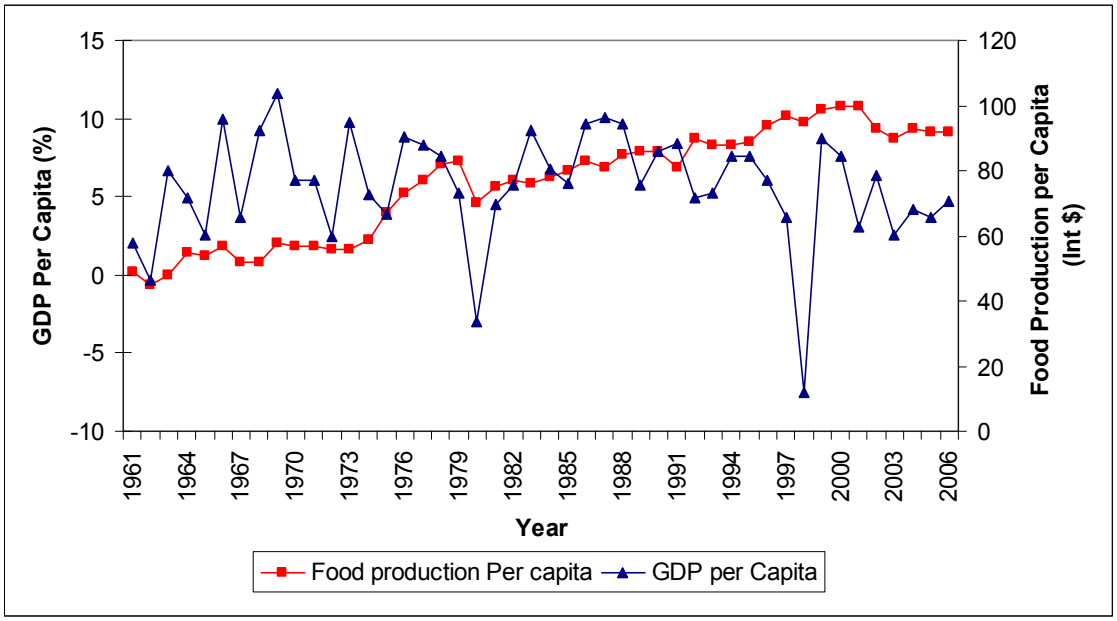


Figure 2.64: Relation between food production per capita and GDP per capita for Republic of Korea (FAOSTAT, Earth Trends)

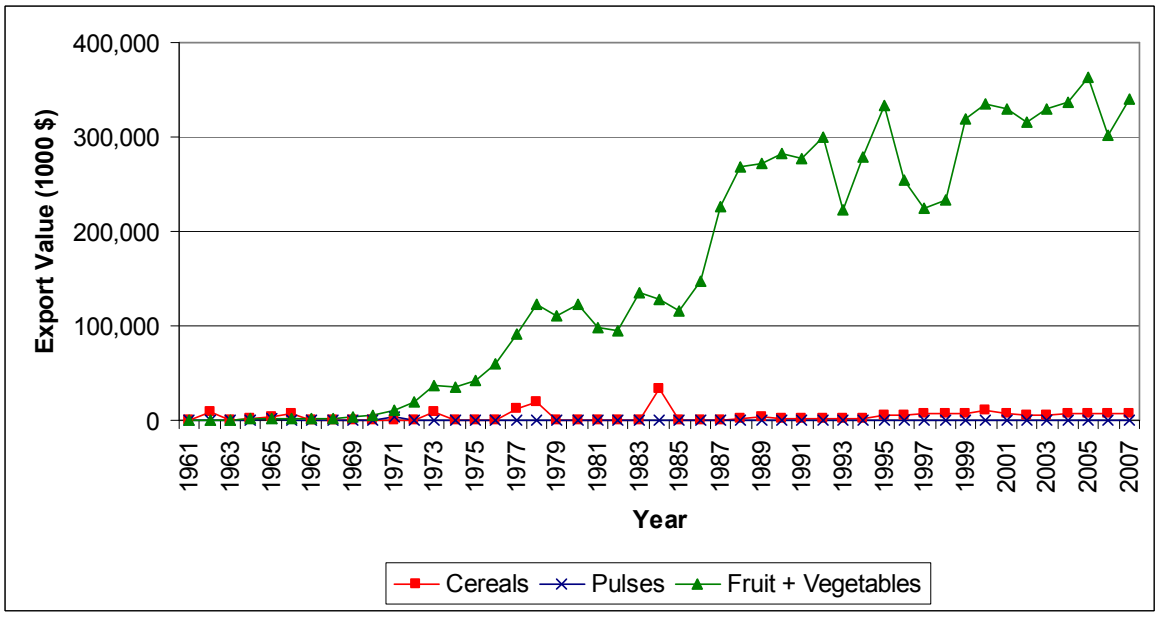


Figure 2.65: Republic of Korea's export of major agricultural commodities from 1961 to 2007 (FAOSTAT)

Fruit and vegetables are the biggest exported agricultural commodities for the Republic of Korea when considering the major agricultural commodities exported from the country, which includes cereals and pulses. It is further illustrated in Figure 2.65. Though the early 1970s saw the beginning in the increase in export of fruits and vegetables which has reached a considerable value in 2007, there has also been a marked increase in imports of fruits and vegetables in the late 1990s up to 2007. This marked increase can be seen in Figure 68 which shows the major agricultural commodities imported into the Republic of Korea. There has also been a constant growth in the import of cereals as seen in Figure 2.66.

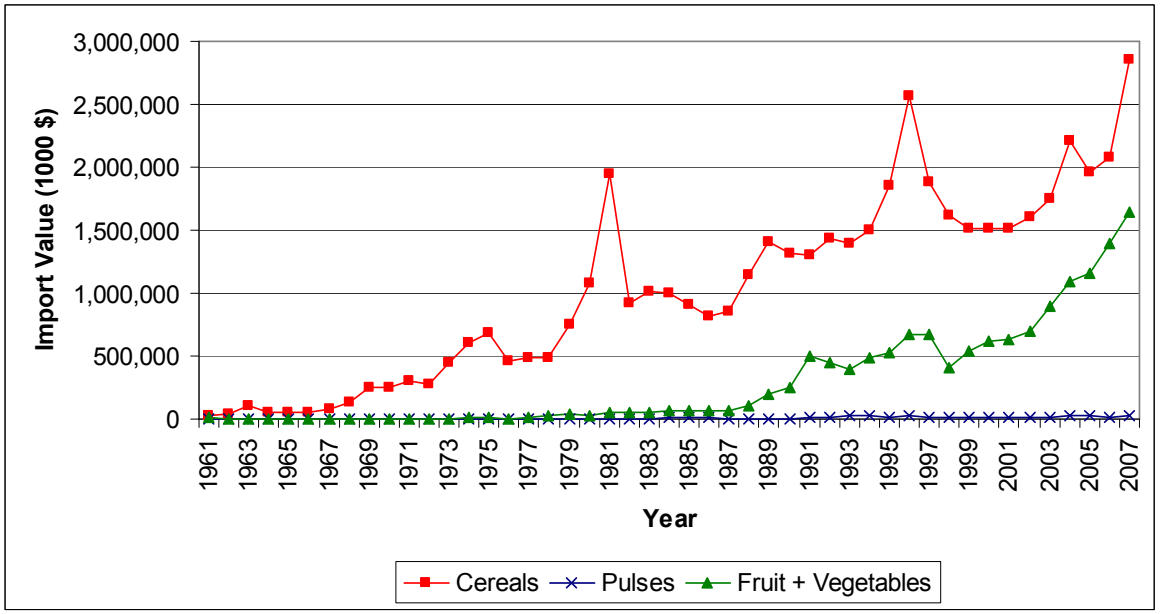


Figure 2.66: Republic of Korea import of major agricultural commodities from 1961 to 2007 (FAOSTAT)

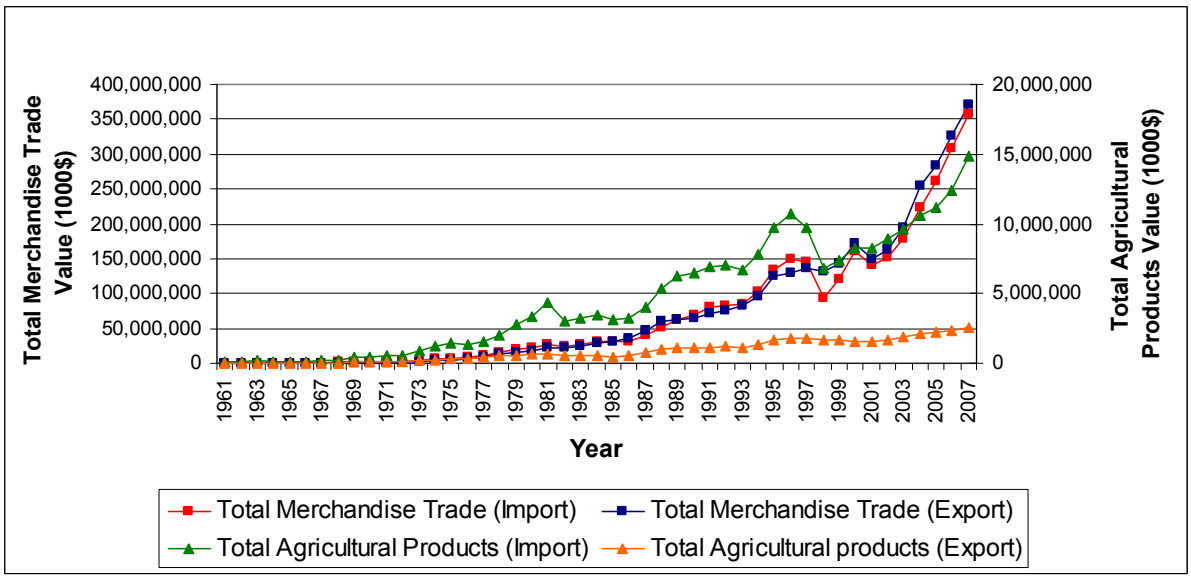


Figure 2.67: Republic of Korea's total merchandise trade and total agricultural products trade in 1000 USD (FAOSTAT)

Figure 2.67 shows the amount of total merchandise and agricultural products traded (both exports and imports) from 1961 to 2007. It demonstrates the key behind the economic restructuring of the Republic of Korea which was the export of merchandise. The export of merchandise mainly came from the non-agricultural sector, i.e., the industrial and the service sectors, which as previously stated contributed 96.8 per cent of the total GDP of the country. This fact is also seen in Figure 2.65 where agricultural exports are considerably low, though over the years there has been an increase. However, the amount of imported agricultural products has seen a considerable increase when comparing both import and export of agricultural products. There is also an important trend seen in Figure 2.67, which is almost the same level of growth in terms of import and export of total merchandise trade.

Figure 2.68 shows a declining trend from 1961 to 2007 in both export and import of per cent trade of total agricultural products to total merchandise trade. The decrease in per cent import of total agricultural to total merchandise trade signifies that the Republic of Korea is aiming to achieve a level

of sufficiency in basic food products despite the amount imported is greater than the exported amount when seen in per cent trade of total agricultural to total merchandise trade context.

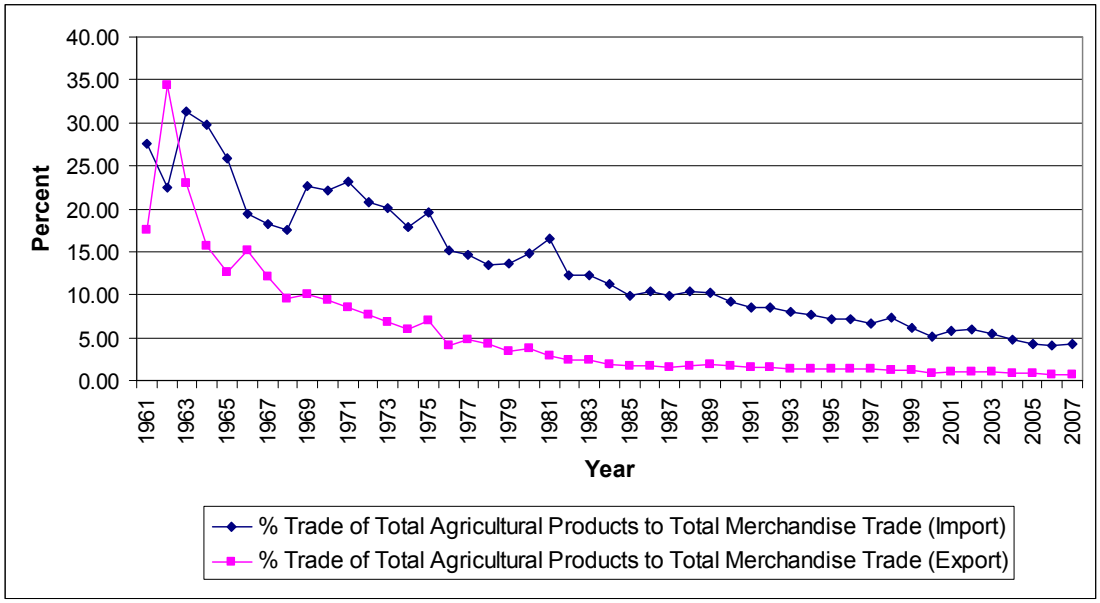


Figure 2.68: Total agricultural trade v/s total merchandise trade (Earth Trends)

1.2 Available land utilization

Figure 2.69 shows the details of different land utilization in the Republic of Korea as of 2007. Of the total country area of 9.97 million hectares, total land area is 9.69 million hectares. Out of 9.69 million hectares, 6.25 million hectares is under forest cover. The total available agricultural land is 1.8 million hectares out of which 1.78 million hectares comes under arable land and permanent crops. The total arable land and permanent crops cover 1.59 million hectares and 0.18 million hectares, respectively, while the total area equipped for irrigation is 0.85 million hectares. The inland water and permanent meadows and pastures cover 0.28 million hectares and 0.058 million hectares, respectively while 1.6 million hectares comes under the other land category.

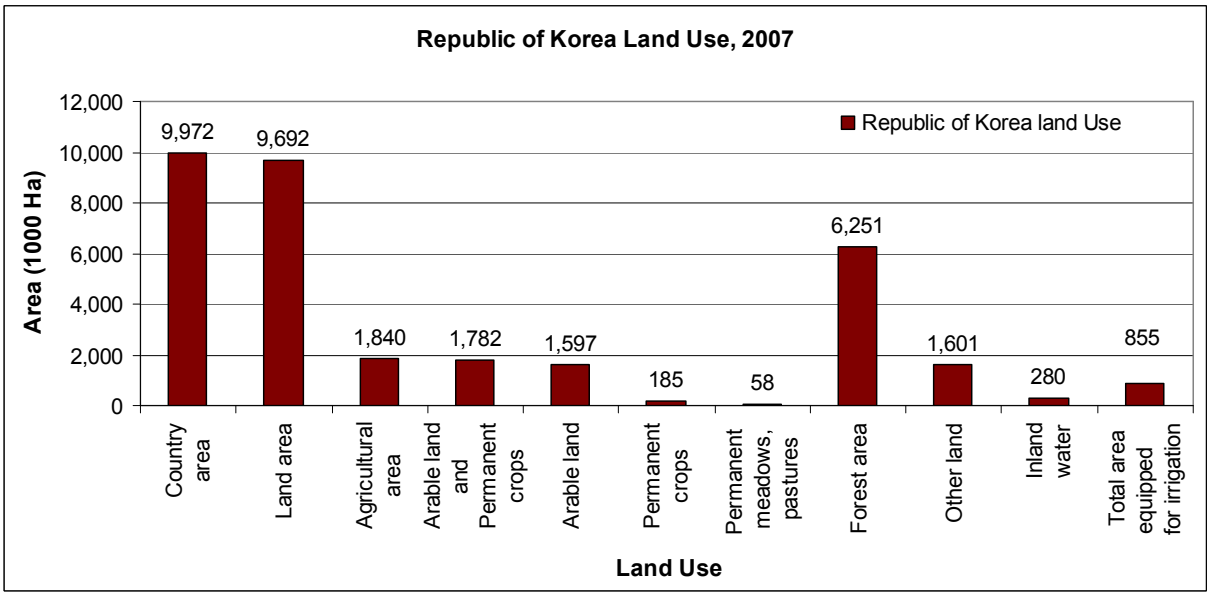


Figure 2.69: Available land use in Republic of Korea in the year 2007 (FAOSTAT, 2010)

With the increase in awareness about the benefits of organic farming and agriculturist coming to know that it is the way to a sustainable agricultural growth, there has been increase in the adoption of this technique, which is evident from Figure 2.70, which shows the total percentage of agricultural land under organic farming. Figure 2.70 also shows an increase in agricultural land under organic farming in terms of percentage value for three consecutive years. The percentage values of the total agricultural land under organic farming are 0.32, 0.45 and 0.52 for the years 2005, 2006 and 2007, respectively. Though the values might be small, they signify a changing trend in the way agriculture is done in the country.

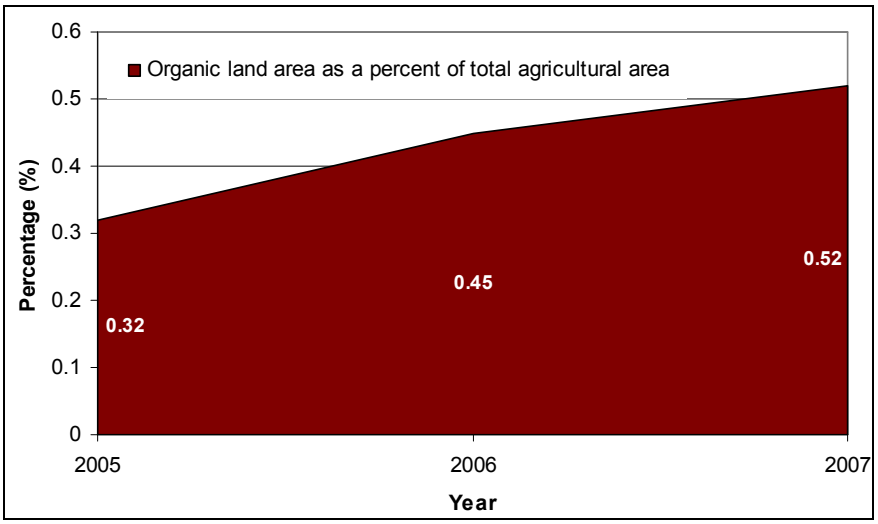


Figure 2.70: Organic land area as percentage of total agricultural area (Earth Trends)

1.3 Population: rural and urban habitation

Figure 2.71 shows the current as well as projected population up to 2050. An almost constant growth in population is seen in 2008, 2009 and 2010 with a slight increase in 2015, 2020 and 2025. However, from 2030 to 2050 negative growth is seen in terms of population growth. The population as of 2009 was 48.33 million people of which 23.93 million were males and 24.4 million were females. The projected population for 2050 is 44.07 million people of which males and females are estimated to be 21.4 million and 22.67 million, respectively. This clearly shows a negative trend in population growth of the country.

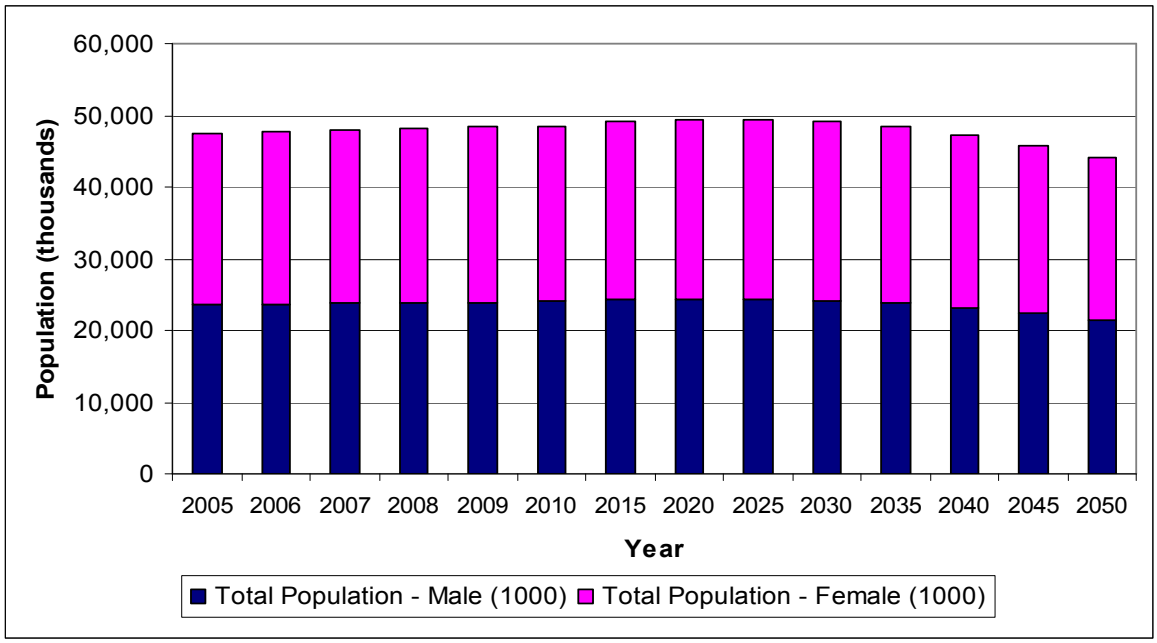


Figure 2.71: Total current and predicted population of Republic of Korea over the period of 2005 to 2050 (FAOSTAT, 2010)

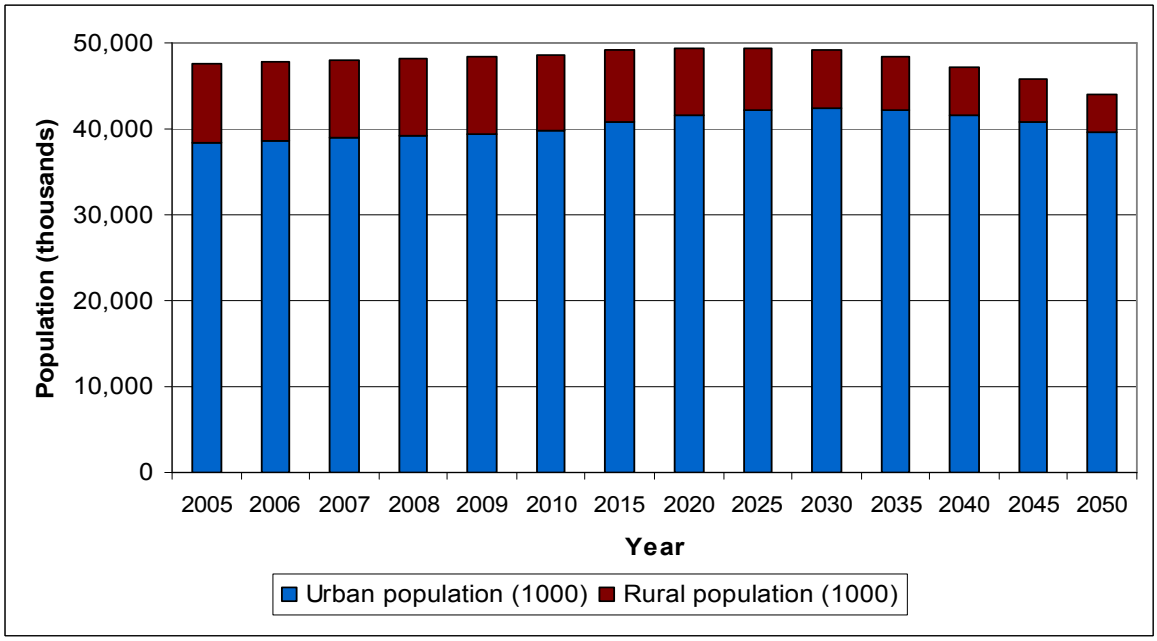


Figure 2.72: Current and predicted total rural and urban population of Republic of Korea (FAOSTAT)

Figure 2.72 illustrates the population division among the rural and urban centers of the Republic of Korea. As of 2009 out of the total population of 48.33 million people, 8.84 million people constituted the rural population and 39.49 million people constituted the urban population of the country with a steady increase in the urban population and a decrease in the rural population. The projected rural population for the year 2050 is 4.5 million people and for urban areas it is 39.56 million people. Hence, there is an overall drop projected in terms of the rural population apart from the negative trend seen in population growth.

2. Agricultural Mechanization in Republic of Korea

2.1 Agricultural mechanization in the Republic of Korea

The Republic of Korea started its mechanization of agriculture in the late 1960s with the introduction of domestically-manufactured power tillers for agricultural cultivation operations. The actual substitution of agricultural machinery to human and animal power involved in agriculture started in the 1970s. The rapid industrialization in the country attracted many of the village laborers to the cities causing a deficiency in farm labor. To accelerate the growth of industrialization and to maintain the required manpower in agriculture, the Korean Government actively promoted the agricultural mechanization program in the country.

In late 1970s rice farming was mechanized with the help of domestically-manufactured power tillers, walking type rice transplanters and few designs of combine harvesters. The Korean Government played an important role by establishing the Agricultural Mechanization Promotion Act in 1978. In the early 1980s, the Government started promoting and distributing agricultural machinery, especially for rice cultivation with subsidized cost. Along with rice farming, the promotion activities took place for horticulture, livestock and up-land farming. In 1986, along with the subsidized cost for agricultural machinery, the Korean Government offered agricultural loans with only an 8.0 per cent annual interest rate to reduce the economical burden on farmers. Also, the facilities for the repair and maintenance of agricultural machinery were established during this period.

During 1993 to 1999, the Government offered subsidies for agricultural machinery for individual farmers. Also, a special subsidy was offered to specialized rice farmers. This high amount of subsidies in agriculture caused an issue of overinvestment. Hence, from the year 2000, instead of subsidies the Korean Government supported farming communities by offering agricultural loans at an interest rate of about 3.0 per cent per year.

To facilitate lease and rental of second-hand farm machinery, the Government supported a subsidy on lease and rental of machinery. A permanent second-hand machinery exchange market was established in 2003 and supported with low interest loans offered to purchase second-hand machines.

Table 2.48 shows the yearly number of agricultural machines operated in the country. The total number of agricultural tractors in the country was only about 12,389 in 1985, reaching 258,662 in 2009. The use of cultivators and rice transplanters in agricultural production also increased. Before 2000, the use of walking-type rice transplanters was considerably higher than the riding type. However, in recent years the trend changed. The walking-type transplanters are being replaced with riding type. The number of harvesting machinery such as combines, binders and power reapers used in the country had shown an increasing trend over the 1985 to 2000 period but has shown a decreasing trend since then.

A remarkable change is observed in the agricultural mechanization of the country. The number of power tillers used is decreasing every year while use of small, medium and large farm tractors is increasing every year (Table 2.48 and Figure 2.73). These show the awareness of farming communities and government efforts to not only mechanize agricultural production but to provide ergonomically suited mechanization for the farmers.

Table 2.48: Number of agricultural machinery in the Republic of Korea

	Power Tiller	Farm Tractors				Cultivator	Rice transplanter			Harvesting Machinery
		Total	Small	Medium	Large		Sub Total	Walking	Riding	
1985	588,962	12,389	-	-	-	-	42,138	-	-	11,667
1990	751,236	41,203	-	-	-	50,699	138,405	-	-	43,594
1995	868,870	100,412	-	-	-	239,496	248,009	-	-	72,268
2000	939,219	191,631	73,366	92,123	26,142	378,814	341,978	308,286	33,692	86,982
2003	857,829	211,576	72,090	107,311	32,175	376,431	335,306	288,533	46,773	86,858
2004	832,769	219,664	73,405	112,091	34,168	382,788	333,634	282,926	13,484	87,457
2005	819,684	227,873	71,719	119,415	36,739	392,505	332,393	276,983	55,410	86,825
2006	802,662	236,707	73,557	124,391	38,759	399,226	325,351	266,743	58,608	86,492
2007	771,095	243,662	77,120	127,771	38,771	410,182	314,097	24,986	64,111	84,624
2008	739,725	253,531	78,245	134,527	40,759	421,616	309,907	73,735	236,172	85,338
2009	714,537	258,662	78,397	136,838	43,427	406,055	282,854	179,442	103,412	79,561

	Spraying and Dusting Equipments					Water Pump	Threshing Machinery	Grain Dryer	Dryer for agriculture products	Seed planter
	Total	Speed Sprayer		Power Sprayer	Mist and Duster					
		For orchards	For Paddy							
1985	517,530	1,138	2,045	291,945	222,402	286,298	301,717	3,526	1,911	3,584
1990	695,364	4,944	10,386	484,212	195,822	341,548	266,608	12,116	65,067	6,492
1995	712,882	13,472	16,735	557,349	125,326	384,900	121,970	28,408	117,875	12,995
2000	628,946	28,885	22,447	410,725	166,889	292,871	58,766	55,573	164,532	7,711
2003	65,311	35,612	29,699	-	-	-	-	63,633	171,519	-
2004	76,831	36,274	40,557	-	-	-	-	66,437	176,606	-
2005	143,426	38,790	104,636	-	-	-	-	70,363	184,097	-
2006	156,470	40,025	116,445	-	-	-	-	73,205	188,688	-
2007	166,090	41,912	124,178	-	-	-	-	73,965	197,478	-
2008	192,926	44,423	148,503	-	-	-	-	75,237	198,240	-
2009	44,312	44,064	-	-	-	-	-	75,944	198,304	-

Source: Agricultural Machinery Handbook, Republic of Korea (2010)

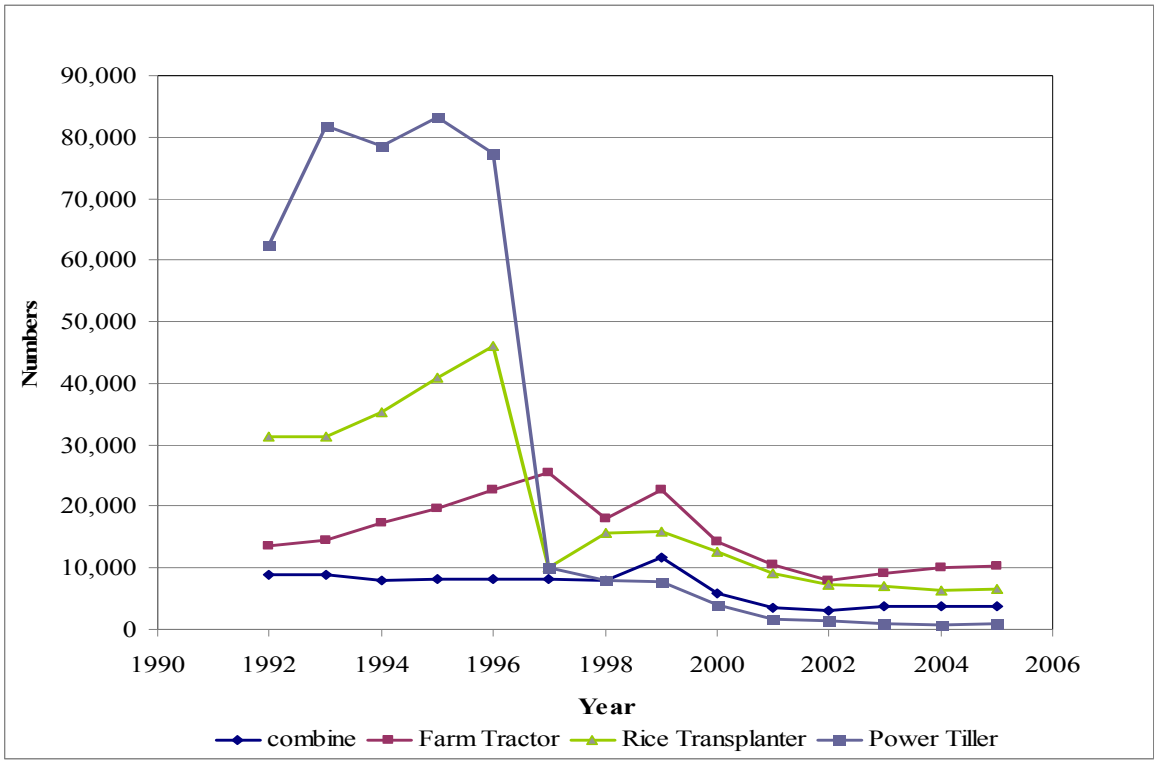


Figure 2.73: Annual supply of major agricultural machinery in Korea (NAAS, 2009)

Table 2.49: Domestic production of agricultural machinery (units)

Year	Power Tiller	Farm Tractor	Rice Transplanter	Binder	Combine	Grain Dryer	Cultivator	Speed Sprayer
1985	68773	3438	16162	5278	3813	710	-	-
1990	52707	16441	41603	10015	15392	3389	25479	1248
1995	89350	16192	29345	3768	6754	5653	51091	3627
2000	7005	23315	20854	-	11714	-	9890	-
2004	4197	26590	7367	-	4058	-	15447	-
2005	4793	31594	5640	-	4136	-	17837	-
2006	6006	28333	9132	-	5010	-	2483	-
2007	4341	31834	12478	-	4344	-	17417	-
2008	5523	29930	9159	-	5197	-	18246	-
2009	4093	27620	7034	-	3816	-	18551	-

Source: Agricultural Machinery Handbook, Rep. of Korea (2009)

Table 2.49 shows domestic production of agricultural machinery from 1985 to 2009 which includes power tillers, farm tractors, rice transplanters, binders, combines, grain dryers, cultivators and speed sprayers. Domestic production of the above agricultural machinery shows a decreasing trend for power tillers, rice transplanters, binders, cultivators and speed sprayers from 1985 to 2009. However, production of farm tractors shows an increasing trend. Production of binders, grain dryers, and speed sprayers stopped in 2000 and production of cultivators began in 1990. Figure 2.74 shows the trend of agricultural machinery holdings by year, which indicates clearly an increasing demand for bigger and higher capacity machines. The demand of tractors is replacing power tiller.

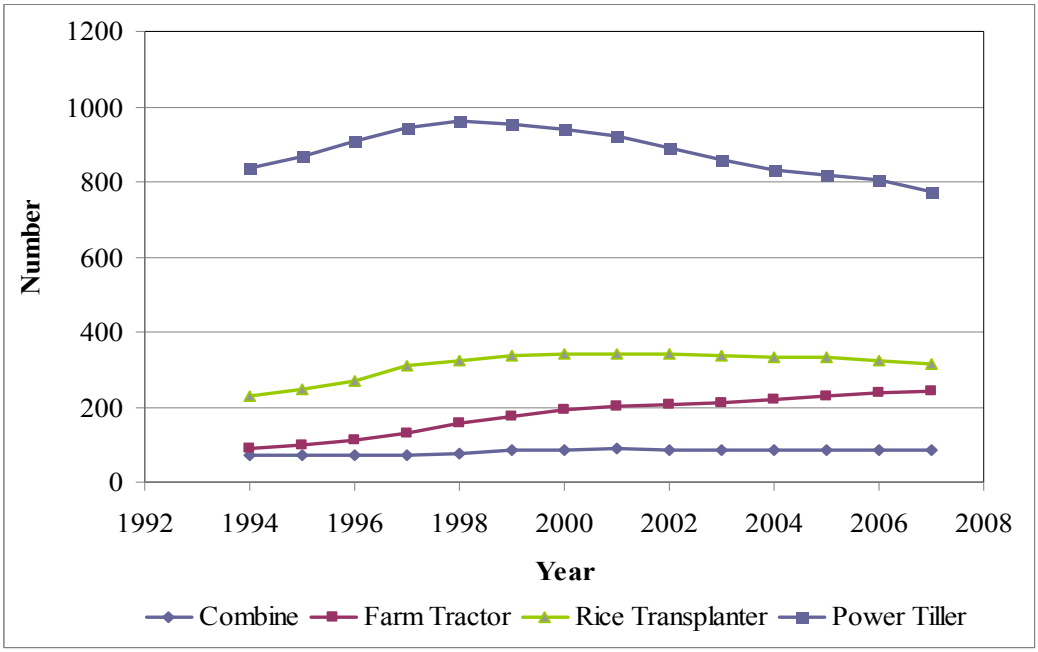


Figure 2.74: Trends of agricultural machinery holdings by year (NAAS, 2009)

Table 2.50: Annual supply of selected agricultural machinery in Korea

Item	**1990**	**1995**	**2000**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Power Tiller	40757	79750	7808	1332	903	742	883	675	547	416
Farm Tractor	14964	17282	22716	8059	9123	10121	10350	11085	12894	12381
Rice Transplanter	37609	34234	15920	7270	7069	6337	6523	7223	7359	6016
Cultivator	27286	47617	7325	3809	3569	2876	2831	2320	1950	1982
Combine	15930	8047	11767	3099	3638	3804	3669	4291	4309	3842
Grain Dryer	2970	5313	2553	2125	1832	1563	1229	1236	1077	924
Farm Heater	-	9873	2095	2133	2406	1614	1478	1073	814	752
Crop Dryer	-	10758	5295	2206	3160	2126	2259	11667	15317	15362
Binder	11109	3597	866	22	14	2	-	-	-	-
Speed Sprayer	1164	2116	2526	1277	1343	1228	1576	1762	2046	1711
Fruit Sorter	-	4547	2783	714	549	175	457	1149	1075	695
Others	1137	22678	39515	20183	22657	23853	24255	23917	26236	27368
Total	**152926**	**245902**	**121169**	**52229**	**56266**	**54737**	**55498**	**66308**	**73624**	**71449**

Source: Agricultural Machinery Handbook, Rep. of Korea (2010)

Table 2.50 shows the annual supply of agricultural machinery mentioned above. Among them, annual supply of rice transplanters was higher in 1990 and annual supply of crop dryers was higher in 2009. Total annual supply of the above mentioned agricultural machinery in 1990 was 152,926 units and increased in 1995 to 245,902 units. After 1995 annual supply of these machinery decreased until 2005; it then started increasing and reached 71,449.

Table 2.51: Korean export of agricultural machinery (unit : ea. 1000 $)

Item	2000	2002	2003	2004	2005	2006	2007	2008	2009	
									Distribution	Amount of money
Power Tiller	2225	664	-	-	-	-	-	-	-	-
Farm Tractor	45143	69839	132511	162991	203724	205828	192247	199264	18382	181618
Engine	1211	1194	2278	6029	8517	9722	9323	12063	2024	3708
Water Pump	16260	18590	-	-	-	-	-	-	-	-
Cutter	-	-	-	-	-	-	-	-	-	-
Milling Machinery and Others	29292	29068	43838	58425	73303	82533	145017	132153	687133	136722
Small Farm Machinery and Tools	16236	12512	11134	9382	8699	6406	3343	2726	-	1209
Machine Parts	24437	15615	35456	42404	46779	46380	49720	56040	1492	52200
Total	**134804**	**147542**	**225217**	**279231**	**341022**	**350869**	**399650**	**402246**	**709031**	**375457**

Source: Agricultural Machinery Handbook, Republic of Korea (2010)

Table 2.51 shows export of agricultural machinery from 2000 to 2009. Export of power tillers and water pumps was stopped beginning in 2002 and cutters were not exported at all. The export value of farm tractors was higher than any other farm machinery. Total amount of revenue generated through export of agricultural machinery was US$375.46 million.

Table 2.52: Korean import of agricultural machinery (unit : ea. 1000 $)

Item	2000	2002	2003	2004	2005	2006	2007	2008	2009		
									Total	End product	Machine parts
Farm Tractor	44456	27902	35635	65343	74461	99361	103870	119097	92448	92448	-
Rice Trans-planter	720	10737	18254	32869	43974	45089	57254	60203	49033	49033	-
Combine	10339	5489	13061	25013	30091	35496	47463	22101	31615	31615	-
Others	76291	73938	86393	98178	133788	152261	213658	268748	189109	147610	41499
Total	**131806**	**118056**	**153243**	**221403**	**282314**	**332211**	**422245**	**470149**	**362205**	**320706**	**41499**

Source: Agricultural Machinery Handbook, Republic of Korea (2010)

A similar case holds for the import values of farm tractors, rice transplanters, combines and other machinery which are provided in Table 2.52. About 422,245 agricultural machinery were imported from 2000 to 2006. Farm tractor imports continuously increased from 2002 to 2008. A similar trend was observed for rice transplanters, and other machinery. However, 320706 end products and 41499 machine parts were imported.

2.2 Farm accidents in Republic of Korea

Since the 1970s, the rapid growth of agricultural mechanization in the Korean agricultural sector caused a shortage of agricultural labor and a swift increase in wages. With increasing farm mechanization the amount of accidents with agricultural machinery operation and handling increased.

Farm machinery helps to reduce drudgery in undertaking agricultural operations. However, inappropriate use of farm machinery is harmful, which can cause farm accidents leading to death. Table 2.53 shows the frequency of accidents based on the two classifications of different farm machinery used -- farm-work accidents and traffic accidents. It can be clearly observed that frequency of accidents is more for farm work than traffic. Power tillers and farm tractors are major sources of farm machinery and traffic accidents. About 107.4 and 163.9 farm work and 22 and 20.1 traffic accidents were recorded per 10,000 power tillers and farm tractors, respectively. Some farm machinery sources can be used for transportation and off-farm use as well and causes traffic accidents which include combine harvesters, cultivators, and transplanters. However, traffic accidents were not recorded for speed sprayers and portable cutters. Average frequency of farm work accidents and traffic accidents due to farm machinery are 90.7 and 9.3 per 10,000 farm vehicles.

Table 2.53: Frequency of accidents by type of farm machinery (frequency/10,000 vehicles)

Classification	Farm-work accidents	Traffic accidents	Total
Power tiller	107.4	22.0	129.4
Farm tractor	163.9	20.1	184.0
Combine harvester	73.0	3.6	76.6
Speed sprayer	95.7	-	95.7
Cultivator	8.9	0.4	9.3
Portable cutter	10.0	-	10.0
Transplanter	-	0.7	0.7
Average	65.5 (90.7)	6.7 (9.3)	72.2 (100)

Source: (Yeoub-Shin et al, N.A.)

Table 2.54: Distribution of accidents by agricultural machinery (%)

Classification	Farm-work accidents	Traffic accidents	Average
Power tiller	56.6	77.4	72.9
Farm tractor	28.3	19.6	21.5
Combine harvester	5.7	1.5	2.4
Speed sprayer	3.7	-	0.8
Cultivator	2.0	0.5	0.8
Portable cutter	3.7	-	0.8
Transplanter	-	1.0	0.8
Total	100	100	100

Source: (Yeoub-Shin et al, N.A.)

Distribution of farm work accidents and traffic accidents in percentage is given in Table 2.54. Power tillers and farm tractors report a greater number of accidents than other farm machinery. Average

percentage of farm work and traffic accidents by power tillers and farm tractors is 72.9 and 21.5, respectively. However, only one per cent of traffic accidents are reported by transplanters.

It was observed that recorded farm work accidents were because of rollover, crash, collision, blow, jolt and seizure. The percentage distributions of farm accidents by farm machinery are given in Table 2.55. Among these, rollovers and crash accidents accounted for the largest share at 68.0 per cent. These accidents took place either on farm roads or at field entry or exit during transportation and other means. Another 32.0 per cent farm work accidents were accounted for by jolt and seizure caused by belts and chains.

Table 2.55: Types of farm-work accidents by farm machinery (%)

Classification	Power tiller	Farm tractor	Others	Average
Rollover	13.3	66.7	25.0	30.3
Crash	50.0	26.6	12.5	37.7
Collision	10.0	-	12.5	7.5
Blow	6.7	-	25.0	7.5
Jolt	6.7	-	12.5	5.7
Seizure	13.3	6.7	12.5	11.3
Total	100	100	100	100

Source: (Yeoub-Shin et al, N.A.)

Table 2.56: Causes of farm-work accidents by farm machinery (%)

Faulty driving	Immaturity	Unfamiliar places	Mechanical problems	Drunk driving	Total
49.1	26.4	17.0	5.7	1.8	100

Source: (Yeoub-Shin et al, N.A.)

Almost half (49.1 per cent) of farm accidents were caused because of faulty driving (Table 2.56). The faulty driving results because of violation of traffic rules, lack of knowledge of safe driving practices and lack of use of seat belts while driving. Another 26.4 per cent of accidents were accounted for by lack of dexterity of elderly drivers, particularly during emergency situations.

Table 2.57: Number of deaths and injuries in the farm machinery accidents (Persons/Case)

Classification		Deaths	Severe injuries	Slight injuries	Total
Farm-work accidents		0.02	0.33	0.20	0.55
Traffic accidents	Accidents caused by farm machinery	0.02	0.13	0.28	0.43
	Accidents caused by other vehicles	0.06	0.53	0.42	1.01
	Sub-total	0.05	0.41	0.38	0.84
Total		0.07	0.74	0.58	1.39

Number of deaths and injuries in the farm work accidents and traffic accidents is given in Table 2.57. A total of 1.39 persons per accident incident were recorded. Of these 0.07 persons died, 0.74 had severe injuries and 0.58 suffered slight injuries. The death toll of traffic accidents involving farm machinery was 2.5 times higher than that of farm work accidents. Overall, the number who died from farm machinery accidents caused by other vehicles was 0.06 persons per incident, which is considered very low.

3. Testing and Certification Faculties for Agricultural Machinery in Korea

3.1 Testing and evaluation of agricultural machinery

In July 1966, the Division of Agricultural Machinery was founded in the country under the National Agricultural Material Inspection Office, Ministry of Agriculture. In December 1995, the country was

designated with the OECD official test code testing authority. In July 1999, the designation for ISO service center for agricultural machinery was obtained; in July 2008 the designation service center for Agricultural Electronics was obtained. In December 2008, the country was accredited as International Official Test Station by ILAC/KOLAS in the field of tractor testing. The Korean machinery testing division was established on about 3,000 sq. m. of indoor and 27,000 sq. m. outdoor area. The main functions of the division are:

a) Developing the testing methodology
b) Testing of agricultural machinery with International standards (OECD, ISO etc.)
c) Testing, evaluation and certification on performance and safety of agricultural machinery manufactured domestically or imported from other countries
d) Research on standards, safety and ergonomics of agricultural machinery

Different kinds of testing and evaluation performed at the Korean Machinery Testing Division are:

1. International Standard Test
   It consists of testing of agricultural machinery by international codes and standards. For agricultural tractors, the performance test, noise and ROPS test are conducted by the OECD standard codes.

2. National Test
   Performance test, safety test, investigation of structure for providing information of agricultural machinery to farmers

3. Safety Test
   Conformity certification for safety, overall safety test, safety check of safety devices, safety protection of agricultural machinery for farmer's safety

4. General Test
   Integrated test on specification, performance, safety and easiness of operation

5. Partial Test
   Specific performance test for the requested terms to evaluate the function of their prototype

6. Special Test
   Specified test requested by customers (engine performance test, axle power performance test, spraying test, etc.)

7. Model Inspection
   Inspection of conformity on specification, performance, safety and easiness of operation

8. Inspection Validation
   Recall inspection to the machinery passed from model inspection

Table 2.58 shows statistics of various tests carried out at the Korean machinery testing division from 1990 to 2006. Table 2.59 shows the number of tests by machinery in 2009. While Figure 2.75 shows the total number of national, safety and OECD approved tests by the testing division, it is clearly visible in that the number of approved national tests is increasing every year. Also, the safety tests approved every year are almost the same while OECD tests performed at the testing division are showing a decreasing trend.

Table 2.58: Test by year and kinds (NAAS, 2009)

Year	1990	1995	2000	2005	2006	2007	2008	2009
International standard Test	-	-	7	15	14	8	7	20
Model Inspection	267	294	63	55	58	69	249	241
Inspection Validation	-	5	1	-	-	-	-	-
General Test	-	6	199	115	166	214	51	59
Safety Test	-	-	-	120	110	115	108	184
Partial Test	-	-	20	10	17	11	14	10
Total	**267**	**305**	**290**	**315**	**365**	**417**	**429**	**514**

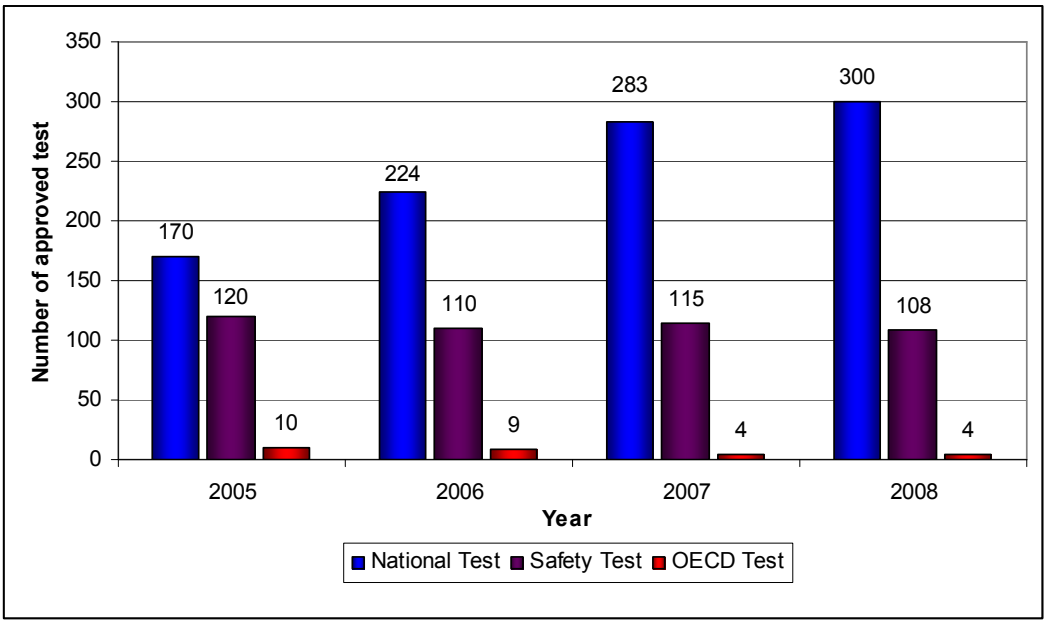


Figure 2.75: Number of tests approved by Korean machinery testing division during 2005 to 2008 (NAAS, 2009)

Table 2.59: Number of tests by machinery in the year 2009 (NAAS, 2009)

Machinery	Model Inspection	General Inspection	Safety Test
Tractor	31	3	2
Tractor-ROPS	14	-	-
Trans-planter	1	-	-
Speed sprayer	-	-	-
Combine	-	-	3
Agricultural Vehicle	-	-	41
Grain dryer	109	-	2
Batch Dryer	-	36	-
Manure Separator	1	-	14
Liquid Fertilizer	-	-	5
Bailer	-	-	3
Mover	-	-	19
Loader	-	-	4

Agricultural Heater	64	5	-
Coal Boiler	3	1	-
Self-propeller sprayer	-	-	-
Manure Spreader	-	-	14
Weeder	-	-	9
Tedder	-	-	-
Sub-soiler	-	-	-
Garlic stem cutter	-	-	11
Nondestructive sorting machine	6	2	-
Total	**241**	**59**	**184**

3.2 Performance tests for agricultural machinery

The specific tests performed for agricultural machinery in the Korean Machinery Testing Division are listed below:

a) Drawbar Performance Test – Testing drawbar performance such as drawbar power, drawbar force forward speed, slip and fuel consumption of the tractor using dynamometer car on asphalt track.

b) Brake Performance Test – Testing the brake performance such as braking, deceleration rate of the breaking devices of the tractor using DGPS and wireless communication.

c) Turning and Steering Performance Test – Measuring the turning radius, turning area and steering capability such as steering force and safety using DGPS and wireless communication

d) Position of Center of Gravity Test – Position of center of gravity, an important element for evaluation of tractor stability and overturning, is measured.

e) Hydraulic Power and Lifting Force Test – The performance of the hydraulic system and the force of the three-point linkage such as outlet flow, oil pressure, output power, oil temperature and maximum lifting force is measured.

f) Overturning Angle Test – Real overturning angle of agricultural vehicle such as tractor is measured and compared with theoretical overturning angle and safety of agricultural vehicle in inclined field is verified.

g) Protective Structure Safety Test –Safety of an operator is measured with static test (horizontal load and crush) of ROPS mounted on agricultural tractor.

h) Fan Performance Test – Fan performance such as wind speed, wind pressure and power requirement of dryer, speed sprayer and agricultural warm-air heater s measured.

i) Engine Performance Test – Engine performance such as torque, engine speed, fuel consumption and engine power is measured with dynamometer.

j) Exhaust Emission Test – Measuring the engine performance (torque, engine speed, fuel consumption and engine power) and the exhaust emission for agricultural engines.

F) THAILAND

1. General overview of agriculture

1.1 Social and economic conditions

Being a middle-income country, Thailand has made important progress in social and economic development, even though it has suffered several years of financial and economic crisis in the late 1990s. After recovering from the "Asian Crisis" of 1997-1998, the Thai economy took off again. From 2002-2006, Thailand's growth averaged at 5.6 percent. In 2008, GDP grew by 1.7%, with agriculture accounting for 11.6% of GDP, industry and services 44.2% respectively, and manufacturing 34.9 % (World Bank).

1.2 Agriculture in Thailand

Approximately 21 million hectares, or 40.9 per cent of the total area, is used for agricultural production. About 31.3 three per cent and 27.8 per cent are under forest and unclassified land, respectively. About 49.8 per cent of the agricultural land is used for growing rice, 21.5 per cent for other field crops, 21.2 per cent for fruits and horticultural crops and 7.5 per cent for others (OAE, 2008). Thailand is almost self sufficient in food production. Agriculture is an important sector and the largest source of employment of rural population of the country. About 46.6 per cent of the total population is engaged in this sector. Agricultural production not only contributes to domestic consumption but also plays a significant role in export earnings. However, the importance of agriculture declined slightly due to the expansion of other sectors (industry, tourism, construction and other service sectors). Figure 2.76 shows the top agricultural production in Thailand in 2007. Rice, cassava and sugarcane are the main agricultural crops. Table 2.60 shows the top 20 agricultural commodities, including rice, cassava, sugarcane, pineapples, mangoes, eggs, palm oil, bananas, cow milk, fresh vegetables, coconuts, fruits and maize.

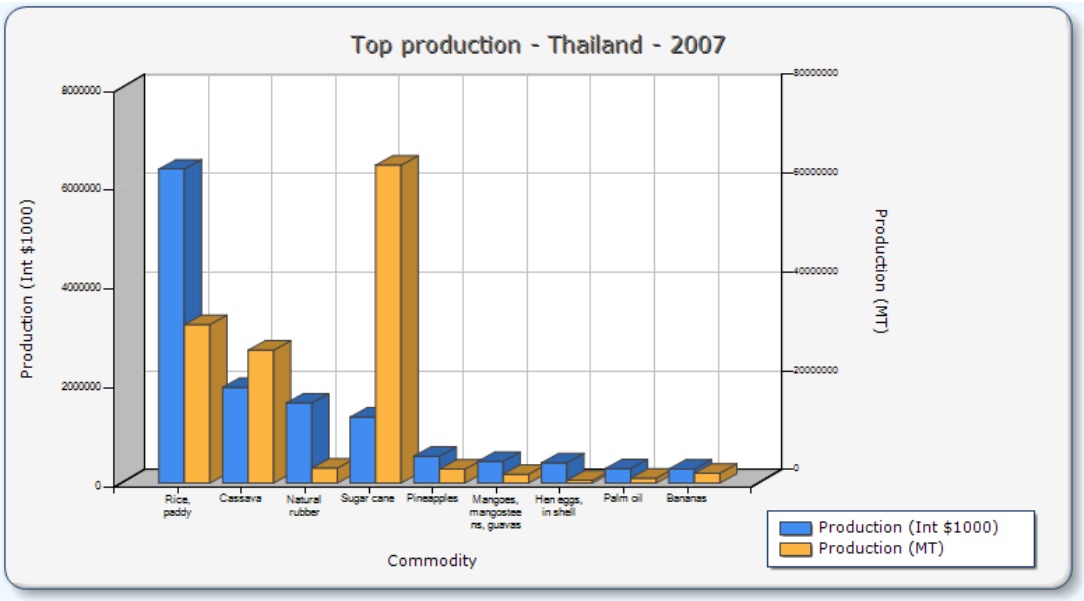


Figure 2.76: Top agricultural production in Thailand in 2007

Table 2.60: Production of top 20 agricultural commodities in Thailand in 2007 (FAOSTAT)

Rank	Commodity	Production (Int $1000)	Production (MT)
1	Rice, paddy	6357229	32099401
2	Cassava	1939534	26915541
3	Natural rubber	1622124	3024207
4	Sugar cane	1336871	64365482
5	Pineapples	544446	2815275
6	Mangoes, mangosteens, guavas	438282	1800000
7	Hen eggs, in shell	409307	539400
8	Palm oil	292163	965000
9	Bananas	285020	2000000
10	Cow milk, whole, fresh	218658	822211
11	Vegetables fresh nes	190464	1015000
12	Coconuts	155705	1721640
13	Tangerines, mandarins, clem.	151708	670000
14	Tobacco, unmanufactured	127625	70000
15	Chillies and peppers, dry	115836	39000
16	Maize	103292	3661323
17	Fruit, tropical fresh nes	88134	770000
18	Tomatoes	63971	270000
19	Oranges	61509	350000
20	Maize, green	60020	305000

Figure 2.77 and Figure 2.78 show the steady growth of gross and net values of agricultural production in Thailand since 1960. During this period, field crops experienced significant growth, which contributed significantly to the overall agricultural growth of this country.

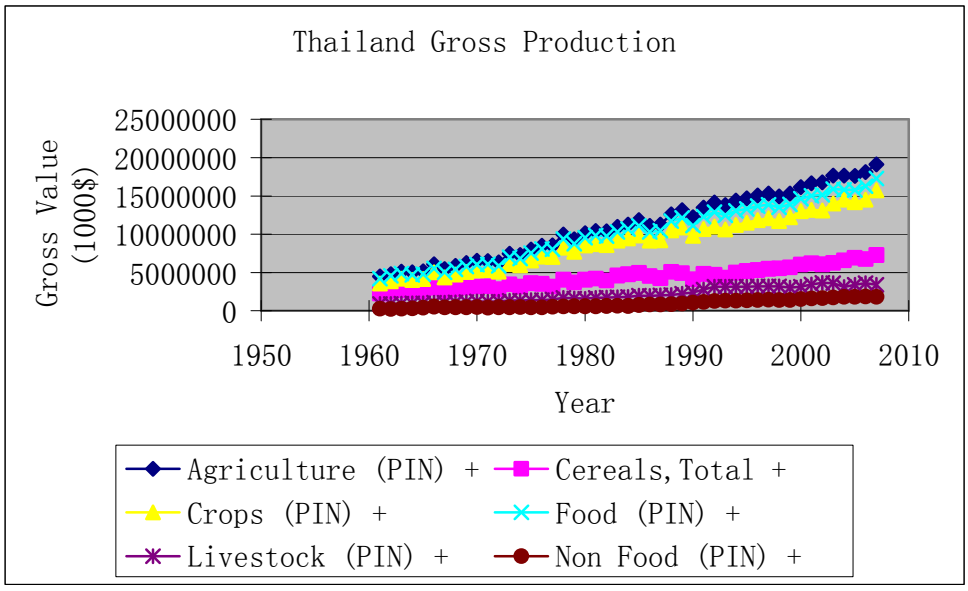


Figure 2.77: Gross value of production in US$ 1,000, Thailand

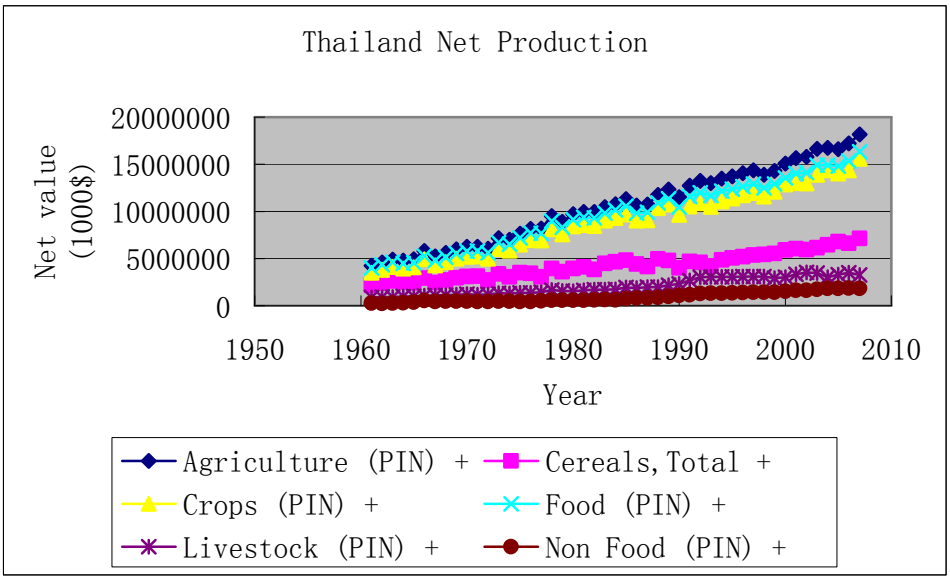


Figure 2.78: Net value of production in US$ 1,000, Thailand

1.3 Agricultural trade

Thailand is an emerging economy which is heavily export-dependent with exports accounting for more than two thirds of GDP. Thailand's import status can be seen in Figure 2.79 and Table 2.61 (FAOSTAT). Thailand exports an increasing volume of goods and services with a total annual export value of over US$105.0 billion. Major exported commodities include agricultural products such as Thai rice and fishery products. Rice is the most important crop in the country. Thailand is the world's number one exporter of rice, exporting more than 6.5 million tons of milled rice annually (see Figure 2.80 and Table 2.62).

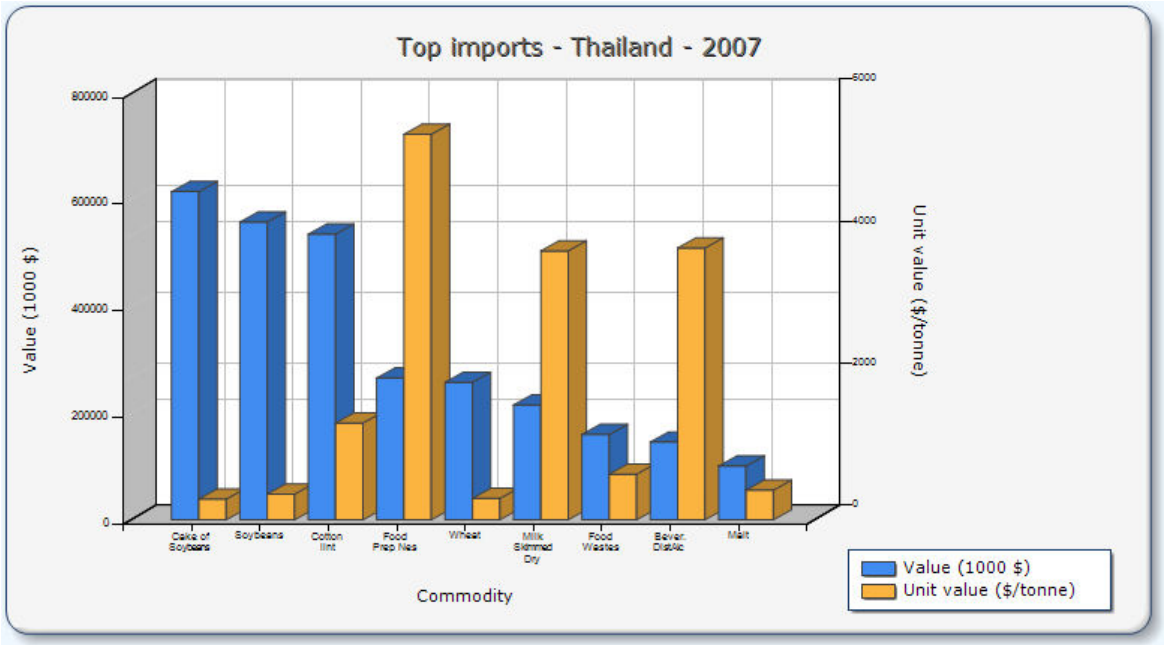


Figure 2.79: Thailand's Imports of Major Agricultural Commodities, 2007 (FAOSTAT)

Table 2.61: Top 20 imported agricultural products in Thailand, 2007

Rank	Commodity	Quantity (tonnes)	Value (1000 $)	Unit value ($/tonne)
1	Cake of Soybeans	2104512	616030	293
2	Soybeans	1540835	559096	363
3	Cotton lint	393125	536240	1364
4	Food Prep Nes	49020	266179	5430
5	Wheat	856765	258246	301
6	Milk Skimmed Dry	56940	215638	3787
7	Food Wastes	249048	160268	644
8	Bever. Dist.Alc	38129	145973	3828
9	Malt	241879	101014	418
10	Hides Wet Salted Cattle	44164	95211	2156
11	Cigarettes	12381	93420	7545
12	Fruit Prp Nes	97775	93333	955
13	Hidesdry S. Cattle	43109	82602	1916
14	Milk Whole Dried	28767	81346	2828
15	Infant Food	12361	71790	5808
16	Apples	93629	70186	750
17	Food Prep, Flour, Malt Extract	37183	69285	1863
18	Flour of Wheat	179032	58924	329
19	Cake of Rapeseed	295945	55588	188
20	Oil Hydrogenated	46773	46018	984

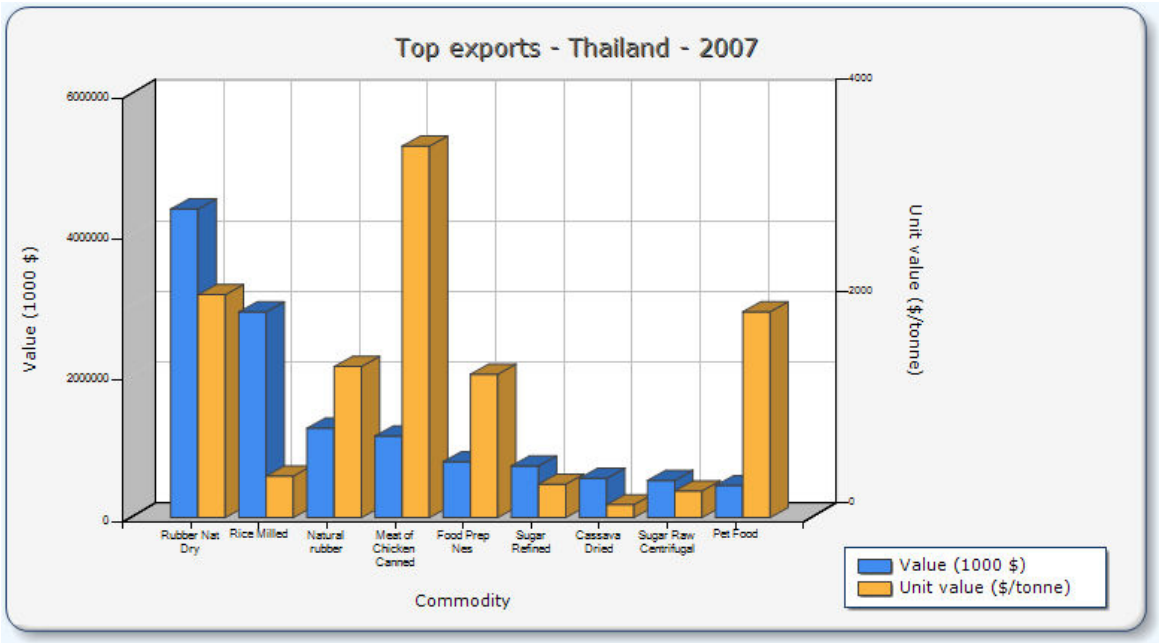


Figure 2.80: Thailand's exports of major agricultural commodities, 2007 (FAOSTAT)

Table 2.62: Top 20 exported agricultural commodities in Thailand, 2007 (FAOSTAT)

Rank	Commodity	Quantity (tonnes)	Value (1000 $)	Unit value ($/tonne)
1	Rubber Nat Dry	2077771	4372726	2105
2	Rice Milled	7408299	2913289	393
3	Natural rubber	887544	1266405	1427
4	Meat of Chicken Canned	329475	1156034	3509
5	Food Prep Nes	584964	792125	1354
6	Sugar Refined	2316754	732087	316
7	Cassava Dried	4558811	556784	122
8	Sugar Raw Centrifugal	2091589	526821	252
9	Pet Food	233422	453707	1944
10	Rice Broken	1479477	439404	297
11	Pineapples Cand	568416	420656	740
12	Cassava Starch	1422102	390876	275
13	Fruit Prp Nes	300537	367190	1222
14	Palm oil	283065	198606	702
15	Beverage Non-Alc	226288	159580	705
16	Food Wastes	199247	135462	680
17	Sweet Corn Prep or Preserved	151719	133786	882
18	Fruit,Nut,Peel, Sugar Prs	70352	131560	1870
19	Food Prep,Flour,Malt Extract	79165	130780	1652
20	Pineapple Juice Conc	132632	121688	917

2. Agricultural mechanization

2.1 Overview of agricultural mechanization

Agriculture mechanization in Thailand started 50 years ago with land consolidating and leveling being the main operations and continuing for many years. At present, ratios of mechanization for land preparation and harvesting have reached 90 per cent and 40 per cent, respectively. Mechanization has played a significant role in increasing agricultural production by completing farm operations in time, reducing cost of production and increasing crop intensity.

Since the fourth National Economic and Social Development Plan (NESDP), other economic sectors of the country (industry, construction, tourism and services) have been greatly expanded. These expansions resulted in a major shift of labor force from the agricultural sector and led to an on-farm labor shortage crisis. Mechanization, therefore, became a way out for the development of modern agricultural production system in Thailand. It initially started in the central plain and then expanded to other regions. It started with power-intensive machines, such as irrigation pumps, power tillers and threshers. Most farm machinery used is locally manufactured, except some sophisticated machines which are imported. Now mechanization in Thailand is rapidly expanding both in terms of number and size of the machines in use; patterns of mechanization are also changing. In the central plain, mechanization has been changed from power-intensive to control-intensive. The number of power tillers, irrigation pumps and power threshers in the central plain has become almost stable, but the number of rice combine harvesters has been increasing rapidly. In other regions, the number of power tillers is also fast growing.

In rice harvesting, threshing machines are used everywhere. Thai-made rice combine harvesters are adopted in the irrigated areas, the low land of the north and the northeast accounting for 17 per cent of the total cultivated land. Mechanical dryers have been playing an important role in maintaining and improving rice quality. In rice planting, transplanters are popular because they save time. For one crop, it normally takes 120 days to plant without machines, but takes 100 days

if machines are employed. In sugar cane production, during the past 10 years, 500 sets of sugarcane chopper harvesters have been imported and used on big farms. For sugarcane production, nearly 100 per cent mechanization has been achieved on big farms. In the border areas, use of Myanmar and Lao labor is common.

2.2 Development of mechanization in the country

Mechanization with power technology began in 1891 when the government imported steam power tractors and rotary hoes that were found to be unsuitable for paddy conditions and also quite expensive (Sukharomana, 1982). In the early 1920s, agricultural machines were imported for trial operations, the research and development in agricultural mechanization were started but did not progress much due to lack of well trained local personnel and the onset of World War II (Mongkoltanatus, 1993).

Import of the first 2 and 4-wheeled tractors in the country began in the late 1940s and early 1950s with little success particularly promoted for use in the form of contracting services by the government (Rijk, 1989).

Significant improvements were made when local workshops began to modify designs for less costly productions and modifications up to local conditions. A major role was played by the Agricultural Engineering Division (AED) or Agricultural Engineering Research Institute (AERI) of the Ministry of Agriculture and Co-operative (MOAC) in the 1950s with the release of designs for local manufacturing mainly in the area of irrigation (water pump).

In the late 1960s private firms from abroad moved in, namely Ford and Massey Ferguson which established assembly lines for tractors. Imports in the period continued to increase; nevertheless the biggest spread of machinery was made through the production of locally made mechanization. With lower prices, adapted and modified by local workshops on the basis of imported designs, these machines, mainly tractors achieved great success.

Throughout the years AED along with the International Rice Research Institute (IRRI), released various blueprints and designs for thrashers and combine harvesters with varying success. Other machinery such as Chinese rice reapers and transplanters as well as Japanese, were also imported into the country reaching varying degrees of popularity over time.

In the late 1980s the production of Thai made combine harvesters began whose use reached a widespread audience, in 1997 there were about 2,000 units used mainly in the Central rice area of Thailand Although, still much design and development was needed to improve performance, the farming industry is commonly satisfied with the combine performance

Development of farm mechanization in the country continues till this day. Mainly farm machinery used is locally manufactured, excluding certain sophisticated machines which are imported. Machinery such as combine harvesters, power tillers and irrigation pumps is implemented significantly in the central plains of Thailand and use in other regions is rapidly growing (Thepent & Chamsing 2009).

2.3 Agricultural machinery industry

Agricultural machinery industry is one of the strongest industries in Thailand. For example, a total of 25 million rotary tiller blades were made in Thailand in 2008. In 2009, 40 million were manufactured. Other main products are:

- Farm implements -- some parts imported, most produced in Thailand.
- Tractors -- Kubota (Japanese company) set up a factory in Thailand.
- Combines -- imported most engines and hydraulic parts; machines are assembled in Thailand. (Blade: 5 thousand set × 50 / set made in Thailand in 2008) with increased production expected in subsequent years.
- Sugarcane harvesters -- imported and provision of loans for group farmers (one group usually has 50 families as this number is seen to be more responsible in using the loan). Small direct subsidy, for example for rice.

Farm machinery manufacturers have increased their productions, for example, engines and parts. Exports have increased in recent years. Most of the mechanical factories produce farm implements, plough and harrow. Some of them have shifted to other production areas, such as oil pipe. Many workers who used to work in farm machinery factories have gone to other factories. Some of them have become machinery dealers working in the business area. Production of agricultural machinery in Thailand is not only for domestic consumption but also for exports to the world market. So competitiveness of the products in the market is highly emphasized.

2.3 Issues surrounding agricultural mechanization

In Thailand, plot size for crop production is rather small, especially for rice production in the north and the northeast. This decreases field capacity of agricultural machinery and increases energy consumption per unit area, especially for big machinery. Additionally the number of able members in farm households has decreased causing issues with labor shortage. In some areas, inadequate rural infrastructure, such as lack of irrigation and drainage system, and the local socio-economic conditions have exerted negative impact on farmers' income. For landless farmers and smallholders, high land rental and lack of access to low interest loans from financial institutions have further restricted farmers from purchasing machinery. For sugarcane production in the northeast and in rain-fed rice production, under-utilization of machinery results in high fixed cost of agricultural machinery. A nation-wide extension service network needs to be established to provide training to farmers on the operation of machines so as to improve utilization efficiency and reduce maintenance cost of machines. Meanwhile, high import taxes on agricultural machinery spare parts have driven up the cost of agricultural machinery. Inadequate support of the Government for technology development has constrained the production capacity of farm machinery. Efforts need to be made to promote R & D of appropriate agricultural machinery and standardization for the benefit of farmers and manufacturers. To promote agricultural mechanization, financing schemes need to be provided to farmers to help them acquire agricultural machinery especially large size and high performance machines.

2.3.1 Local conditions and capacity

Throughout the years of increased agricultural mechanization a notable problem have been the local conditions. Apart from plot sizes, labor shortage and financial implications for farmers through its mechanization process the suitability of equipment for local conditions has been inadequate. One example is the importing and sale of approximately 1,000 units of Chinese reapers 1981 and 1982. Local rice varieties were not suitable for reaping and farmers were unable to use the equipment. Moreover, heavy weight machines were also a major problem during field operations. The same issue occurring with the early imported tractors in 1891 also unsuitable to fit local production conditions.

Coupled with the shortage of labor, a lack of capable operators for some machinery types appears in Thailand, inviting capacity building in this area.

3.1 Testing and certification

Thai Industrial Standard Institute (TISI), Ministry of Industry is responsible for standardization of agricultural machinery. TISI was established in 1968 and is the official agency responsible for the development of Thai Industrial Standards (TIS), including agricultural machinery standards.

The preparation of agricultural machinery standards is undertaken by the Technical Committee (TC). The TC, appointed by the TISI, includes representatives from Agricultural Engineering Research Institute (AERI), manufacturers, the Bank of Agriculture and Agricultural Cooperatives (BAAC) and universities. Approved standards are published in the government gazette.

Agricultural machinery standards from various countries have been studied and then adapted to be suitable with Thai agricultural machines and their corresponding working conditions. Safety standard is part of each agricultural machinery standard.

The institute is a focal point for standardization for internationally recognized in response to meet the needs of government, businesses and society and to strengthen capabilities for sustainable competitiveness. Its policy is to undertake standardization with commitment to the promotion and development of the industry, maximizing the benefits for the entrepreneurs, consumers and the nation as a whole. The Objectives of TISI are: (1) Consumers protection; (2) Environmental protection and natural resources preservation; (3) Industrial development to be competitive in the world market; (4) To ensure fair trade and eliminate trade barriers caused by standardization measures.

Most of the agricultural machinery standards are voluntary standards. Only the standard for small diesel engines is mandatory. Only a few number of agricultural machinery manufacturers apply for the TISI standard certification.

3.2 Applied Testing

Executive part of Thailand's testing and standardization of agricultural machinery and implements is done in one centre. The National Agricultural Machinery Center (NAMC) which was established in 1979 under the Research and Development Institute at Kamphaengsaen, Kasetsart University. The main functions of the center are 1) standardization 2) testing agricultural machines either locally fabricated or imported and collaborating with the Thai Industrial Standards Institute in standardizing agricultural machinery testing.

Other than the executing of testing on machinery submitted for certification, NAMC's role extends further. It provides consultation and suggestions for measuring machines used in the country. It tests and controls the measuring machines both for agricultural and commercial use, as well as the restoration and control of a variety of vehicles.

CHAPTER III

FEASIBILITY STUDY ON ASIAN AND PACIFIC NETWORK FOR TESTING AGRICULTURAL MACHINERY

Agricultural Mechanization at a Glance
Selected Country Studies in Asia
on Agricultural Machinery Development

Chapter III

FEASIBILITY STUDY ON ESTABLISHING AN ASIA-PACIFIC NETWORK FOR TESTING AGRICULTURAL MACHINERY (ANTAM)

3.1 General characteristics of agriculture mechanization in the region

The level of agriculture mechanization is decided by the level of economic development, agricultural infrastructure, purchasing capacity of farmers, level of agricultural machinery industry and demand. Although there was rapid economic development in Asia-Pacific countries in recent years, the purchasing power of farmers in this region remains low. Therefore, farmers in the developing and the least developed countries in the region cannot afford expensive agricultural machinery.

At the same time, there are varying levels of agricultural machinery industries and their use across the region. China and India have emerged as centers for gigantic agricultural machinery manufacturers 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. Among them, 1,578 are large enterprises, including main machines' manufactures as well as the spare parts producers. In India, the number of agricultural machinery manufacturers has reached over 16,000. However, in some Asian countries, there is almost no agricultural machinery industry, such as Bangladesh, Cambodia Laos and Nepal.

3.2 Level of agricultural mechanization in the Asia-Pacific region

3.2.1 Criteria for determining agricultural mechanization level

According to recent data, there are two factors that determine the level of application of agricultural machinery: total percentage of mechanized field operations and the power of machines employed in unit of field operation (Kw/ha). In addition, there are two aspects that determine manufacturing capacity: number of manufactorers (including joint ventures) and the share of domestic and regional markets of agricultural machinery.

3.2.2 Countries at different development stages and with different mechanization levels

Based on the afore-mentioned criteria, the level of mechanization in the region is categorized as high, medium and low. Application of agricultural machinery over 20% is viewed as category I (high level); application of agricultural machinery between 10 per cent and 20 per cent is referred as category II (medium level); and application of agricultural machinery below 10 per cent falls under category III (low level). Table 3.1 presents a summary of these categories by selected countries.

3.3 Constraints and challenges in development of agricultural machinery in the Asia-Pacific region

3.3.1 Population, poverty and food security

While many successes have been achieved, poverty and food security have remained serious problems in the Asia-Pacific region. The United Nations predicts a global population of more than

eight billion by the year 2030. Population growth means a greater demand for food supplies. At the same time, farmland being lost to development, drought and floods is further stressed by climate change. Therefore, developing countries especially in the Asia-Pacific region, are facing the pressure of food security and poverty (Table 3.2), and should devote more attention to sustainable agriculture.

Table 3.1: Farm mechanization in selected Asian 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
Cambodian	low	low	low	low	<10%	near nil	III	Low
China	60%	35%		30%	42%	extensively	I	High
India	30%	10%	60%	20%	25-30%	extensively	I	High
Indonesia	low	low	low	low		near nil	III	Low
Republic of Korea	high	high	high	high	>70%	extensively	I	High
Nepal		low	low	9 units of combine harvesters	low	near nil	III	Low
Philippines	13.2%	0.2%	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

In the United Nations Millennium Declaration, eradicating extremely poverty and ensuring environmental sustainability are two important goals. Solving agricultural and farmers' problems in developing countries are crucial challenges to realize these goals.

In fact, Asia's food security is facing serious challenges. There are many hungry and undernourished people in this region, hence more food needs to be produced to feed the growing population (Figure 3.1 and Figure 3.2). In 2005-2006, on average some 16 per cent of the region's population, or 542 million people, were going hungry. In 2007, as a result of sudden price rises, the number is thought to have increased to 582 million. The greatest problem revealed in South and Southwest Asia where 21 per cent of the population is undernourished.

The Bangladesh country report pointed out a need of additional 5.0 million tons of food grain from the continuously decreasing agricultural lands to meet the food requirements of the ever growing population of the country in 2015. To achieve this target, there are no other better options than to increase production per unit of land and cropping intensity. In Bangladesh, every year almost 0.2 million people are being added to the total population, whereas the estimated annual loss of agricultural land is about 0.08 million hectares (Bangladesh Country Report 2009-2010).

Table 3.2: Growth in population, average income, and food demand in selected Asian countries in 2007 (World Bank 2008)

Country (ranked by average income)	Population growth (%)	Growth in per capita income (%)	Income elasticity of food demand	Demand growth (%) *
Malaysia	1.66	3.97	-	-
Thailand	0.61	4.12	0.65	3.29
Philippines	1.87	5.34	0.66	5.39
China	0.62	11.20	-	-
Sri Lanka	0.30	6.47	0.70	4.83
Indonesia	1.15	5.10	0.69	4.67
India	1.21	7.72	-	-
Viet Nam	1.22	7.17	0.73	6.45
Pakistan	2.11	4.16	0.72	5.11
Mongolia	1.06	8.70	0.77	7.76
Bangladesh	1.64	4.78	0.73	5.13
Lao People's Democratic Republic	1.73	5.25	-	-
Cambodia	1.74	8.43	-	-
Nepal	1.67	0.80	0.75	2.27

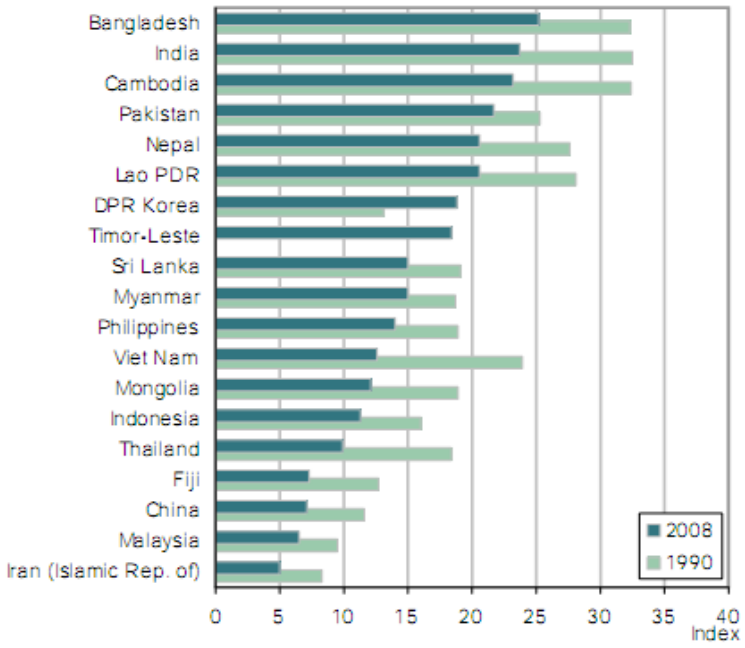


Figure 3.1 Hunger index, Asia and the Pacific Region, 1990 and 2008 (ESCAP, 2009)

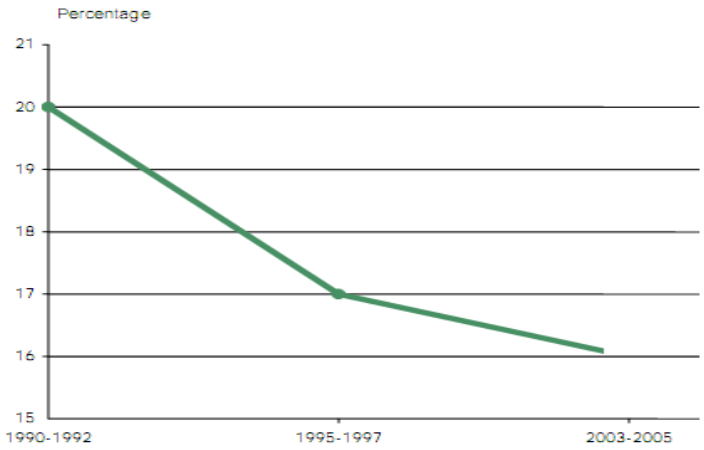


Figure 3.2: Proportion of undernourished people in Asia and the Pacific region, 1990-1992 to 2003-2005 (ESCAP 2009)

3.3.2 Agricultural population and employment

The population in the Asia-Pacific region is increasing while those engaged in agriculture is decreasing. And employment in agriculture is also decreasing. These facts imply that the traditional approach to agricultural development is no longer suitable for increasing agricultural production (Table 3.3 and Table 3.4).

Table 3.3: Agriculture population as percentage of total (%) (World Bank, 2009)

	2000	2005	2007	2008
Nepal	93.2	93.6	93.7	93.8
Lao PDR	76.7	75.8	75.5	75.3
Myanmar	71.4	69.3	68.6	68.3
Cambodia	69.8	67.5	66.5	66.1
Vietnam	68.3	66.1	65.2	64.7
China	67.2	64.5	63.5	62.9
India	54.5	52.4	51.5	51.1
Bangladesh	54.9	50.1	48.2	47.3
Pakistan	50.8	47.9	47	46.5
Sri Lanka	46.4	44.5	43.9	43.7
Thailand	49	45	43.4	42.7
Indonesia	43.8	40.4	39.1	38.5
Fiji	39.7	37.8	37.2	36.8
Philippines	39.5	36.4	35.3	34.7
Mongolia	24.1	20.8	19.7	19.1
Malaysia	17.9	14.7	13.6	13
Republic of Korea	8.7	6.3	5.5	5.2

Table 3.4 Employment in agriculture as percentage of total (%) (World Bank, 2009)

Country	1980	1990	2000	2005	2007	2008
Bangladesh	-	-	62.1	48.1	-	-
Bhutan	-	-	-	43.6	-	-
Brunei Darussalam	-	-	-	-	-	-
Cambodia	-	-	73.7	-	-	-
China	-	53.4	46.3	-	-	-
Indonesia	56.4	55.9	45.3	44	41.2	-
Republic of Korea	34	17.9	10.6	7.9	7.4	-
Lao P.D.R.	-	-	-	-	-	-
Malaysia	37.2	26	18.4	14.6	14.8	-
Mongolia	-	-	48.6	39.9	37.7	40.6
Nepal	-	-	-	-	-	-
Pakistan	52.7	51.1	48.4	43	43.6	-
Philippines	51.8	45.2	37.4	37	36.1	-
Sri Lanka	-	47.8	-	30.3	31.3	-
Thailand	70.8	63.3	48.5	42.6	41.7	-
Vietnam	-	-	65.3	-	-	-

Industrialization is a cause of labor shortage in agriculture, especially during planting and harvesting seasons, even in Asia and the Pacific region where there is an abundant labor force. Upgrading production efficiency through agricultural mechanization offers a solution.

3.3.3 Fragmented lands

Land fragmentation is a state of division of holdings into discrete parcels that are dispersed over a wide area and usually farmed as single units (Niroula and Thapa, 2005). The size of landholdings gradually decreases when they are fragmented into parcels. This is a typical phenomenon in South Asia, which is one of the main hurdles for the adaptation of mechanization in agriculture. Adopting mechanized agricultural practices in the small fragmented and uneven shaped land area is difficult. It reduces efficiency of the machinery used. Significant problem of excessive turning time for a machine operating in the field causes low fuel efficiency. Incurring higher cost of production reduces the overall productive efficiency. Ultimately, it results in gradual weakening of agricultural sector.

3.3.4 Poor buying capacity of farmers

In general, small farmers from developing countries are poor and cannot afford costly machines if purchased individually. Some wealthy farmers having a large quantity of agricultural land possess some expensive machines like tractors, power tillers, power tiller-operated seeders, combines, etc. They use these machines on their own lands and also rent them out to other farmers thereby earning a substantial return. However, the number of wealthy farmers is very limited.

3.3.5 Diverse machinery types and facilities

In the Asia-Pacific region, there exists a notable gap in the application of agricultural machinery. While making an important contribution to the development of the rural economy, agricultural mechanization is still in its infancy in most countries in Asia and the Pacific region. The infrastructure of many Asian and Pacific countries is inadequate.

Agricultural machinery and related facilities in Asia and the Pacific is characterized by diverse types, as a result of huge difference in topography, scale of farming and different levels of economic development across the region. Low or substandard machines continue to be sold in the market while some machines are found unsuitable to the farming conditions of the users. At the same time, acquiring farm machines is beyond the reach of most farmers owing to high acquisition and maintenance costs.

3.3.6 Lack of knowledge, skilled users, artisans and traders

The machine users, artisans and traders in the region have little or no education and do not posses sufficient knowledge and skill about machine operation, repair and maintenance. Machine manufacturers rarely provide after sale services to end users. Most of the times though the services are provided, those found to be inadequate. From field experience it has been found that even when machines break down for minor reasons, the machine remains idle and unused. Even when farmers seek help from artisans or local, the cost is high. In other cases, where mechanics are not readily available, the farmer stops using the machine. In addition village artisans are poorly trained and lack adequate knowledge and skill about machines.

3.3.7 Poor utilization rate and high fuel consumption

In many places in the Asia-Pacific region, land holdings are quite small and are irregular in shape. Farm operations in these kinds of conditions require high farm power per hectare, but mechanization levels are still low. High power eventually corresponds to high fuel consumption.

3.3.8 International competitiveness of agricultural products

The economic situation of farmers, particularly the smallholders, from many Asian and Pacific countries is poor, which as a result has retarded farm mechanization. While globalization since the 1990s has exerted a considerable impact on agriculture in the region, the competitiveness of agricultural products from outside of the region also challenges agricultural development in the region. This requires the Asia-Pacific region to produce more quality agricultural products with market competitive price.

3.3.9 Tariff difference on machines and spare parts

Low tariffs on imported machines and high tariffs on spare parts and materials have discouraged the local manufacturers. Since there is no quality control system on imported machinery, a large number of low or substandard machines are being traded and distributed throughout the region directly by local importers to the end users. Nonetheless, many of the imported, low quality machines have already made the farmers reluctant to use them. Once farmers decide not to use the substandard machines, it becomes increasingly difficult to convince them to acquire new machines. Furthermore, the high tariff restricts the importation of spare parts making them unavailable in the local market.

3.3.10 Agriculture machinery standards and testing

Testing stations across the region are equipped with various kinds of facilities to assess and evaluate the performance of agricultural machines. Duplication of testing facilities in some countries of the region is noted, 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. Moreover, the lack of regional testing standards in

compliance with prescribed safety and environmental standards has also created safety and environmental problems. This is an important issue for this region.

3.4 Challenges

Achieving success in agricultural mechanization according to national circumstances, including good economic returns, high utilization of land resources, effective utilization of water and environmentally sustainable agricultural practices is the greatest challenge being faced.

To improve the agricultural machinery utilization while enhancing the level of agricultural mechanization, and to confine agricultural power consumption within reasonable values, are amongst the serious challenges that developing countries are faced with. Many other Asian and Pacific countries are also likely to face the problem that farm energy consumption would not be able to keep pace with increasing levels of mechanization.

Agricultural mechanization needs to be developed under industrialization, urbanization and modernization. However, it should not be expected that the Asia-Pacific region can realize the same effective path of development of agricultural mechanization as developed countries through high input and consumption. The greater challenge will be to overcome the problems of low utilization rate of agricultural machinery with high energy consumption. It is necessary to solve the problem of scale and benefit. Small-scale land operations reduce mechanical efficiency and are not effective. Lack of multi-functional agricultural tractor power is incompatible with utilization and holdings of agricultural machinery making it difficult to take advantage of improved agricultural mechanization. It is still necessary to develop a mechanism for cooperative utilization of agricultural machinery.

3.5 Necessity for the Asia-Pacific wide testing and certification of agricultural machinery

According to the International Labor Organization, about half of the world's labor force is engaged in the agricultural sector with 60 per cent of those agricultural workers in developing countries. ILO data also indicated that injury rates are increasing in developing countries. Machinery has the highest farm injury frequency and fatality rates worldwide (ILO, 2000).

Agricultural workers in all parts of the world also share exposure to a common set of hazards, although the extent of the exposure and the degree to which it is managed vary greatly (Day, 2009). Most of the countries in the world struggle with various degrees of inadequate data systems and measurement standards to avoid fatal and serious farm injuries. The unclear definitions, misclassification and under-reporting are common problems that hinder appropriate action to be taken against agricultural farm injuries and fatalities. The exclusion of agriculture from national occupational health and safety legislation and compensation programs is also a common threat in some industrialized and developing countries (ILO, 2000).

This shows there is a need for coordinated activities to match 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. Collaborative research across different cultures has the potential to provide rich insights and extend the current theoretical and conceptual basis for research and prevention (Hosman, 2000).

3.6 Overview of ENTAM

ENTAM (European Network for Testing Agricultural Machines) is the network constituted by the official testing stations in European countries that have signed an agreement on shared activities. The ultimate aim of these shared activities is implementation of standardized tests of performance, safety and environmental aspects of agricultural machinery and tools. ENTAM was founded in 1999 by three European national testing stations carrying out voluntary testing of performance, safety and environment protection and animal welfare requirements of animal husbandry,

horticultural, agricultural and forestry machines and equipment based on national and international standards.

ENTAM tests are based on national, European or international standards, or shared agreements (or methodologies) and can provide the manufacturer with useful information on ways in which to improve its machinery.

The results are issued as test reports published by the testing stations, which work in partnership with ENTAM in a consolidated effort to overcome existing barriers. As such, applying for and obtaining the ENTAM mark on the reports are ways of confirming not only that the manufacturer works to international standards but also that all applicable regulatory requirements have been met, thus allowing the farmer to make an informed choice when purchasing new machinery.

3.7 ENTAM partners

The testing stations in ENTAM partner countries have signed an agreement to recognize test reports and technical papers containing the results of the activities carried out by each signer. ENTAM is currently made up of thirteen members, an honorary witness (FAO) and four observer members (INTA, AFMSPTC, CEA and VIM).

Members	
Austria	Hblfa Francisco Josephinum Wieselburg Blt - Biomass / Logistics / Technology (FJ-BLT) www.bmlfuw.gv.at
Denmark	AARHUS UNIVERSITET Department of Agricultural Engineering Research Centre Bygholm www.agrsci.dk/jbt
France	Cemagref - Institut de recherche pour l'ingénierie de l'agriculture et de l'environnement www.cemagref.fr
Germany	DLG - Deutsche Landwirtschafts-Gesellschaft e.V. www.dlg.org
Germany	Julius Kühn-Institut (JKI) Bundesforschungsinstitut für Kulturpflanzen Institut für Anwendungstechnik im Pflanzenschutz (Formerly: BBA - Biologische Bundesanstalt für Land- und Forstwirtschaft) www.jki.bund.de
Germany	KWF - Kuratorium für Waldarbeit und Forsttechnik www.kwf-online.de
Greece	N.AG.RE.F - National Agricultural Research Foundation (N.AG.RE.F.)
Hungary	HIAE - FVM MEZOGAZDASÁGI GÉPESÍTÉSI INTÉZET (MGI) www.fvmmi.hu
Italy	ENAMA – Ente Nazionale per la Meccanizzazione Agricola www.enama.it
Spain	EMA - Estación de Mecánica Agrícola CENTER - Centro Nacional de Tecnología de Regadíos http://www.center.es/
Spain	CMA - Centre de Mecanització Agrària email cma.darp@gencat.net
Switzerland	Forschungsanstalt Agroscope Reckenholz-Tänikon ART www.fat.admin.ch
Poland	PIMR - Przemyslowy Instytut Maszyn Rolniczych www.pimr.pl
Observer Members:	
Argentina	INTA Instituto Nacional de Tecnología Agropecuaria http://www.inta.gov.ar/
Bulgaria	AFMSPTC (Agricultural Forest Machinery and Spare Parts Test Centre) testlab@dir.bg
Brazil	CEA (Automation and Engineering Centre)
Russia	VIM (All Russian Research Institute for Mechanization in Agriculture)
Honorary Member:	
United Nations	FAO - Food and Agriculture Organization of the United Nations Agricultural and Food Engineering Technologies Service - Agricultural Support Systems Division www.fao.org

3.8 Why an "Asia-Pacific Network for Testing Agricultural Machinery" (ANTAM) is needed?

Manpower is the most valuable resource for any country. In most of the Asian countries a large amount of manpower is still involved in agriculture and allied fields. The increasing mechanization and modernization of agriculture and allied fields increased efficiency and production, but at the same time improper machines affect workers' health. The available data indicate that agricultural injury rates are increasing in developing countries, and that the disparity in fatality and injury rates between agriculture and other occupations observed in industrialized countries is also apparent in developing countries (Day, 2009).

The lack of safety and quality equipment hinders the growth of agricultural mechanization in the Asian countries. This indicates the necessity of common standards for agricultural machinery within the member countries to maintain health and safety of the people and to facilitate easy trading of agricultural machinery.

Some of the Asian countries are still in the developing phase where sophisticated testing centers for agricultural machinery are not available. In other countries the inadequacy and inaccessibility of well-equipped testing centers hampers the proper testing and certification of agricultural machinery. Lack of common testing standards and certification increases the cost due to the repeated testing of the same machinery by importers and exporters. On the other hand, countries where well equipped testing units are not available accept the machinery without any standard and compatibility checking which increases the vulnerability of agricultural accidents.

All these indicate that there is a need to design common agricultural machinery standards for the Asian region to facilitate the growth of agricultural development and trading of agricultural machinery.

3.9 Pathway to establish ANTAM

Based on discussions with experts, academicians, administrators and policy makers from selected Asian countries, the following steps are suggested leading to the establishment of ANTAM:

1. Receiving formal expression of interest from the member countries.
2. Preparation of a comprehensive document of various national standards and agricultural machinery test codes – currently existing and practiced.
3. Recognizing comparative levels of rigorousness (or weakness) among national standards/tests and thereby establishing equivalence factors – leading to bring them to a common regional platform.
4. Bring governments to an agreement for recognizing each other's national standards/ test codes.
5. Preparation of a matrix of test centers versus test facilities and their capabilities through a detailed survey of existing test centers.
6. Evaluate/conform each center for its consistency and credibility.
7. Authorize evaluated test centers to use "ANTAM Certified" logo – with region-wide acceptability.
8. Strive to formulate and popularize region-wide standards and test codes to enhance uniformity in testing of agricultural machinery and its performance.
9. Implement regional capacity building and expert exchange to help building / updating / upgrading test facilities of popular agricultural machinery in other countries in the region.
10. Implement voluntary / enforced standards into agricultural machinery trade and cooperate with other regional/international testing networks.

3.10 Proposed model for ANTAM

Structure

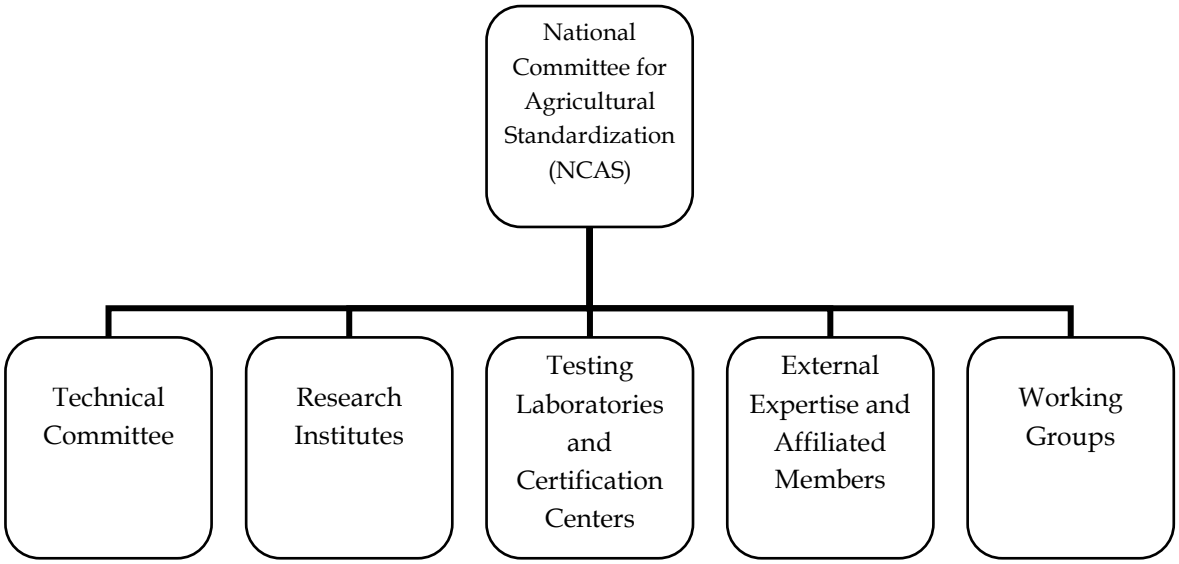


Figure 3.3: NCAS (National Committee for Agricultural Standardization)

Formation of NCAS at the national level within the member countries is essential to compile the available existing standards, local and regional requirements, applications of the results of the research findings and establishing the testing and certification centers as per the ANTAM standards. The main structural cluster of NCAS includes a committee of technical expertise, research institutes, external expertise and stakeholders, certified testing certification centers and extensional working groups.

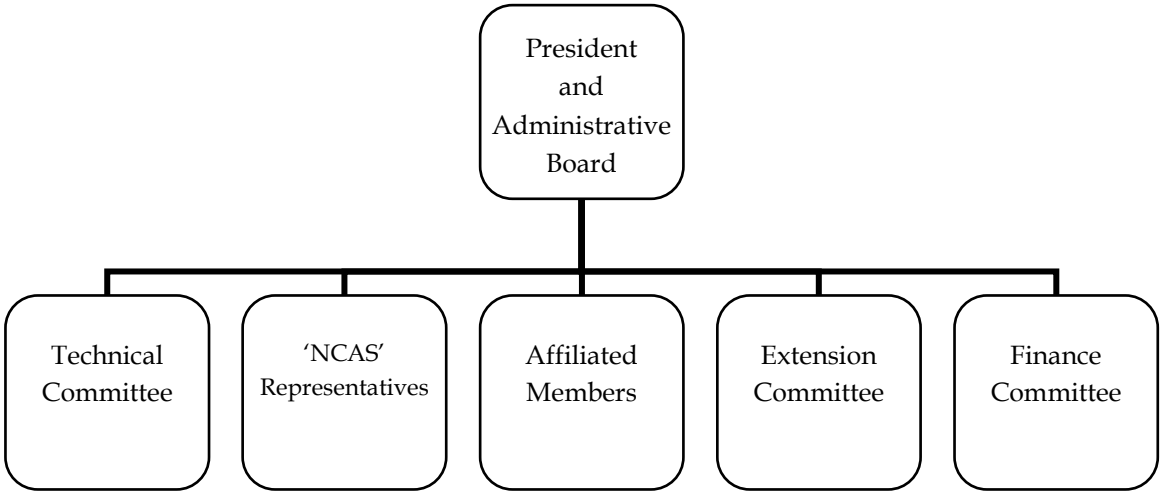


Figure 3.4: Schematic of administrative board and its functional committees for the ANTAM (Asia Pacific Network of Testing Agricultural Machinery)

The president and administrative board will govern the ANTAM. The administrative board will act as a final certifying committee, which will be assisted by a technical committee, NCAS representatives and affiliated members, extension and finance committee. The detailed functionality of the proposed ANTAM is discussed in the following figure.

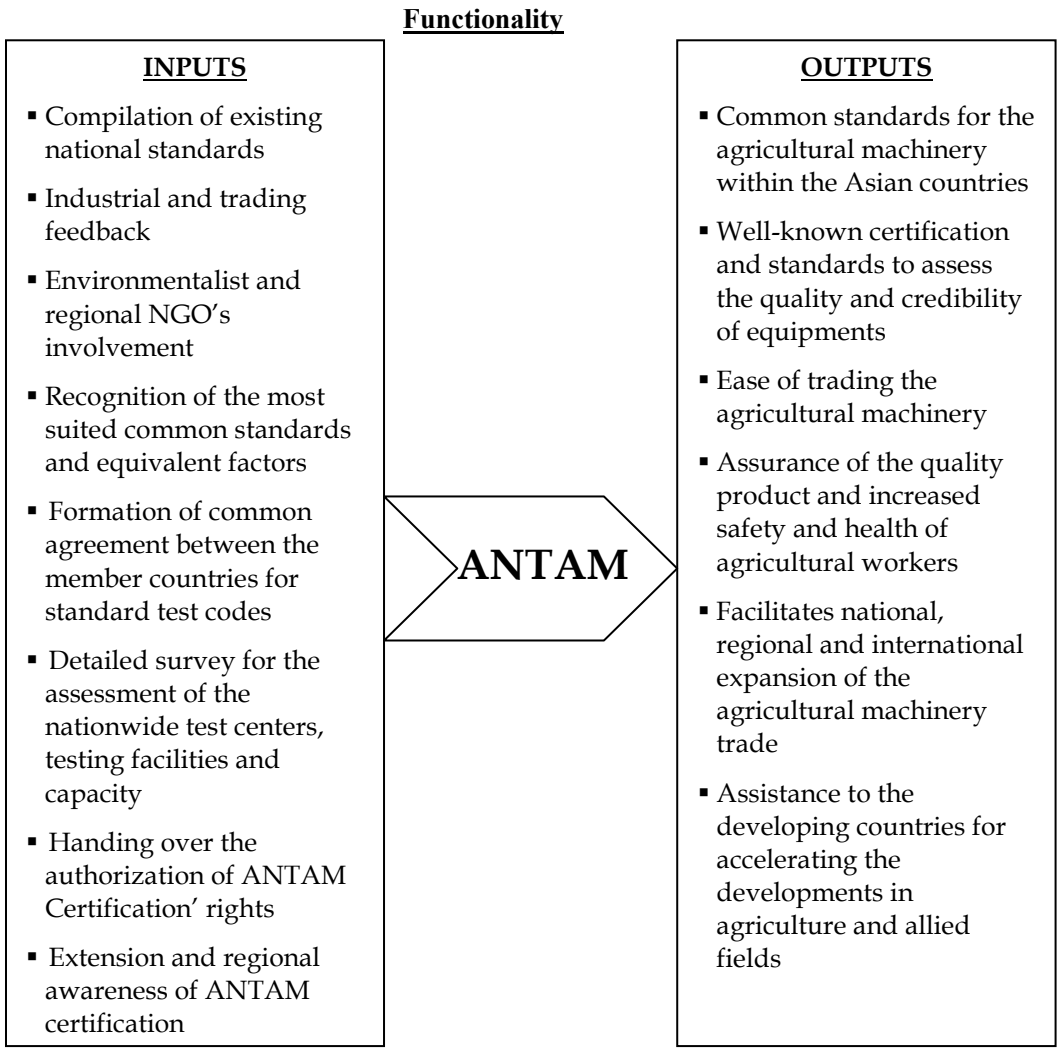


Figure 3.5: Schematics of input and output factors of the proposed ANTAM standardization

3.11 Challenges to establish ANTAM

The following are the challenges and constraints to establishing ANTAM:

- **Financial constraints**: Sources of funding
- **Administrative constraints**: Issues pertaining to governance and coordination
- **Stakeholders' constraints**: Acceptability by end users, manufacturers, traders, etc.
- **Miscellaneous constraints**: Significant variations in standards and test codes/procedures among member countries; heterogeneous needs of farmers, manufacturers and traders of agricultural machinery; and bureaucratic delays in taking timely decisions.

These are depicted in Figure 3.6.

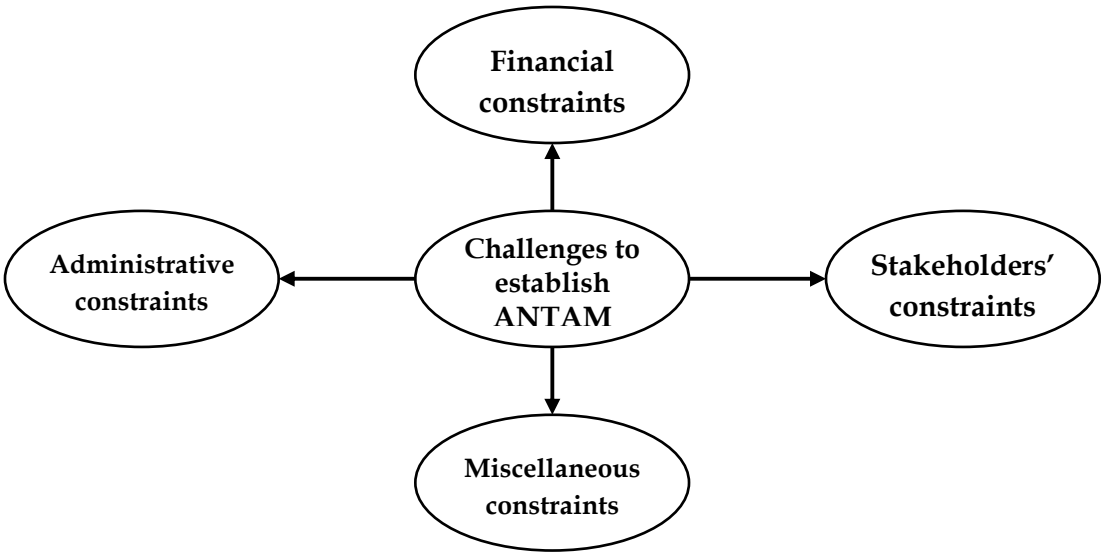


Figure 3.6: Challenges to establish ANTAM

3.12 Policy recommendations on ANTAM development

1) There might be different views and opinions for the building and formulation of ANTAM. The most feasible and suitable way is to have several meetings of UNAPCAEM with member countries. The major points to be resolved in the meetings are listed below:

- To study the necessity, feasibility and required conditions for building ANTAM;
- To delineate comprehensive planning of ANTAM network and corresponding plans with detailed steps;
- To organize the ANTAM preparatory group and identification of focal points involved in the ANTAM activities;
- To guide the testing organizations of member countries and promote the cooperative functioning in testing and standardization procedure;
- To bring forward suggestions and recommendations for UNAPCAEM and each country's Governing Council members / institutions.

2) UNAPCAEM will cooperate with the ANTAM preparatory group to promote business communications among testing organizations of member countries. This will be undertaken

through regular exchange of business information to identify similarities and differences among country standards and to find a suitable conversion factor to bring together different standards on a common ground to facilitate the formation of ANTAM.

3) Emphasis should be given to strengthen the study and discussion on testing technology and to encourage member countries to organize test training courses for the regional testing staff. UNAPCAEM will provide the necessary support to supply the foundation for conjunct test standards.

4) Preliminary focus should be given on cooperation in priority development areas such as medium and small power tractors, diesel engines, irrigation pumps, rice transplanters, combine harvesters, direct seeders and plant protection facilities.

5) For the establishment of unified measures and test standards, it is advisable that the ANTAM preparatory group reinforces exchange and cooperation with agricultural machinery testing organizations of member countries to promote the confidence recommendation on those agricultural machines which the test organizations have the confidence to extend them in their country.

6) Find the source of finance for sustainable development ensuring that ANTAM can be established and be a self-sustaining, sustainable organization.

3.13 Conclusion

Agricultural mechanization is needed if the objective is to lift regional traditional agriculture to an agricultural business. The use of mechanized equipment has proven to be effective for farm operations by maximizing production efficiency. Adaptation of agricultural mechanization is inevitable if the agricultural sector is to fulfill the food demand of the increasing population of the region.

To promote the development of a proper mechanized agricultural sector, development of a common standard test code for the region is important to facilitate the accelerated use of agricultural machinery. The various problems associated with machinery such as availability, repair and maintenance facilities, universal adaptability, faulty and incorrect local manufacturing can be overcome with the promotion and use of regional standardized machinery for agricultural operations.

This report can be considered as the initial effort toward the development of the proposed model for the establishment of an Asia-Pacific Network for Testing Agricultural Machinery (ANTAM).

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