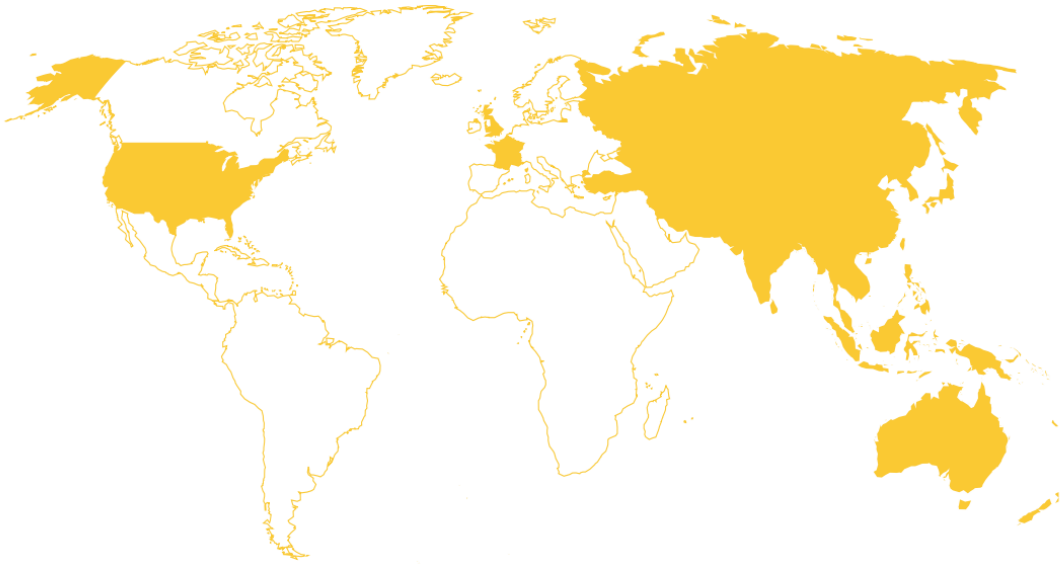
Mechanization of Agriculture: Market Dynamics in China, India, Sri Lanka and Thailand

Centre for Sustainable Agricultural Mechanization
United Nations Economic and Social Commission for Asia and Pacific

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

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

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



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

Mechanization of Agriculture: Market Dynamics in China, India, Sri Lanka and Thailand

Centre for Sustainable Agricultural Mechanization
United Nations Economic and Social Commission
for Asia and Pacific

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

Mechanization of Agriculture: Market Dynamics in China, India, Sri Lanka and Thailand

Centre for Sustainable Agricultural Mechanization
United Nations Economic and Social Commission for Asia and the Pacific

November 2020

CSAM-ESCAP
Room 2060/Floor 20
Beijing Sunflower Tower
No.37 Maizidian Street
Chaoyang District
Beijing, China 100125

Printed in Beijing, China

Photo by Lasantha Wickremesooriya

Acknowledgements

The Centre for Sustainable Agricultural Mechanization (CSAM) is a regional institution of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP). The need for a market study was voiced during the 4th Member Meeting of the CSAM-led initiative titled Regional Council of Agricultural Machinery Associations in Asia and the Pacific (ReCAMA), wherein the network members expressed a need to better understand the dynamics of individual country markets, levels of penetration of mechanization; gaps in mechanization for specific applications; opportunities for growth, and sustainability and gender related issues. In response, this study was carried out to analyze the market status in respect of agricultural machinery in China, India, Sri Lanka, and Thailand. Nominees of the respective agricultural machinery associations in these countries carried out the study as part of the research team under the guidance of the lead consultant.

The study was conducted under the overall guidance of Dr. Li Yutong, Head of CSAM and Mr. Anshuman Varma, Deputy Head/Programme Officer of CSAM. The efforts of Mr. Lasantha Wickremesooriya, the lead consultant of the research team and President of Sri Lanka Agriculture Machinery Manufacturers and Suppliers Association, are duly acknowledged for providing overall guidance for this study and leading the research team comprising of Mr. Ru Yi of China Agricultural Machinery Distribution Association (CAMDA), Dr. Surendra Singh of the Agricultural Machinery Manufactures' Association of India (AMMA-India), and Ms. Dares Kittiyopas of the Ministry of Agriculture and Cooperatives of Thailand (MOAC) who contributed their wealth of knowledge, experience, and competencies to produce a comprehensive study.

Mr. Ma Zheng from CAMDA, Mr. Amjad Rajap, Ms. Milinda Fernando, Mr. Nishantha Ekanayake, Mr. Vajira Priyankara, numerous field officers from the Department of Agriculture from Sri Lanka. Mr. Jiraphat Dean Kittiyopas from Thai Society of Agricultural Engineering all contributed substantially to this study. Special thanks also go to Mr. Anshuman Varma, Ms. Yuee Feng, Ms. Carter Cheng and Ms. Yanni Dong of CSAM for providing tremendous support towards the development and editing of this study. We are also grateful to Ms. Ruiquan Chang for lay-out and design of the report.

Content

List of Tables

China

India

Sri Lanka

Thailand

List of Figures

India

Sri Lanka

Thailand

Photo by Honlin Tan

List of Abbreviations

ASEAN	Association of Southeast Asian Nations
Bn	Billion
CAMDA	China Agricultural Machinery Distribution Association
CSAM	Centre for Sustainable Agricultural Mechanization
CAGR	Cumulative annual growth rate
CNY	Chinese Yuan
DAC	Department of Agriculture & Cooperation
DoA	Department of Agriculture
FAO	Food and Agriculture Organisation of the United Nations
GDP	Gross Domestic Production
GNI	Gross National Income
Ha	Hectare
ICAR	The Indian Council of Agricultural Research
INR	Indian Rupee
JLB	Joint Liability Groups
KCC	Kisan Credit Card
PTMA	Power Tiller Manufacturers Association
ReCAMA	The Regional Council of Agricultural Machinery Associations in Asia and the Pacific
RBI	Reserve Bank of India
SDGs	Sustainable Development Goals
SLR	Sri Lankan Rupee
SMEs	Small and medium scale enterprises
THB	Thai Bhat
Tn	Trillion
TMA	Tractor and Manufacturers Association of India
USD	United States Dollar

012

Executive Summary

Given multiple challenges, such as a growing population, poverty, and the adverse impacts of climate change that the farming community faces, agriculture mechanization plays a significant role in ensuring food security. The food production value chain comprises of a wide range of stakeholders who play different roles and contribute in numerous ways. This study was conducted to understand the market dynamics of agriculture machinery trade in China, India, Sri Lanka and Thailand. Such an understanding aims to assist various stakeholders, particularly manufacturers, exporters, importers, distributors, retailers, service providers and end-users, in their trade interactions with each other in different markets as well as exploring new opportunities.

Amongst the four country markets investigated, the study finds several similarities as well as new initiatives in the individual markets which can facilitate stakeholders in more effective trade interactions with each other. Similarities are seen in the areas of product applications, distribution systems, after-sales- services and financing of machinery purchases. The need for mechanisation and Government involvement in terms of policy support is evident across all four countries. In all four, the mechanisation of paddy has advanced significantly over other crops. Except for transplanting, all other stages of paddy cultivation through to harvesting are mechanised to near saturated levels. Distribution networks too are well established in all of the markets, and there is a smooth transition of products from manufacturer to the end-user via retailers. Hence, based on this study, accessibility of farm machinery to the end-user is not seen as a major constraint. New initiatives are being taken in areas such as establishing custom hiring centres, gender-based mechanisation and cluster-based cooperatives systems to facilitate the sharing of resources.

The scale of machinery in use differs across the country markets, and is related to the landscape of the country and its geographical size. In China and India, where commercial scale crops such as cotton, corn and wheat are grown, large farm machineries are seen in operation. In Sri Lanka and Thailand, these types of crops are not in production at any major scale and the primary crop is paddy. Hence, the size of machinery operated in these operations are relatively smaller. This affects the demand patterns for different types of machinery. In spite of the existence of commercial crop production in China and India, the study reveals that, in all of the country markets, the majority of the farmers are small-scale landowners holding an average of 0.5 to 1 hectare farming plots. Further, the lands are marginalised and are scattered over large areas, making it difficult for large machinery to operate. Hence, there exists a sizeable demand for small to medium sized machinery which are not necessarily as efficient as larger ones, yet provide a pragmatic solution given the specific context. To overcome the disadvantages arising from marginalized lands, Thailand has begun operating a cluster system, whereby such small farms are brought together as one cohort, so that resources can be shared, and operations are economised. The project is new, and more time is needed to assess its effectiveness, but the direction of the initiative is positive. China also made modification to its pertinent laws and regulations in recent years to encourage renting farmland from other farmers for larger scale operation.

Both China and India are encouraging the transition to mechanization by providing subsidies to farmers at the national level. The subsidy scheme attracts both the farmers and the manufacturers since the demand created by the incentive is matched by the supply. This is not the case in Sri Lanka and Thailand where farmers depend on their own capital for purchasing required machinery for agriculture. However, in all four country markets, the intervention of the government through line ministries are evident by way of conducive policies to promote mechanization of agriculture. The Governments in China and India have intervened to introduce custom hiring centres, which can facilitate farmers who cannot purchase their own machinery to hire them instead. In India, the centres are managed and operated by private enterprises, but the Government has stepped in by providing partial seed capital.

Apart from the above, financing for procurement of machinery by farmers remains one of the biggest problems. The problem lies not with the availability of funding, but rather with the cost at which a farmer has to fund his/her purchase when the interest rates are prohibitively high. This is a huge burden on the farmers and erodes their profits substantially. The frequent labour shortages seen today and shorter windows for land preparation and harvesting make it almost essential for farmers to deploy machinery. The farmers are hence depending more and more on the non-banking financial sector which has stepped into a void created by commercial banks to offer financial solutions speedily (as short as 48 hours) but which come at a price. Coordinated national endeavours are necessary to overcome this constraint.

The study also provides insights into areas of emerging opportunities across all the four markets. Several opportunities exist in the non-paddy segment for mechanization and these should be pursued jointly by distributors and manufacturers, using their business experience and learnings. Some of the major crops that offer significant opportunities for mechanization include corn, sugarcane, a variety of pulses and seeds, and vegetables. These crops are particularly cultivated by small scale farmers who possess landholdings of less than 2 hectares on average. Another important social group that engages in the cultivation of these crops are women farmers. The introduction of appropriate machinery that are easy to operate and convenient will empower this segment significantly and strengthen the total crop production process. Overall, the non-paddy segment of the market is virtually untapped and can be readily explored on an enhanced scale.

With foundations in mechanisation laid in these respective markets (especially the economic aspects), policy makers and members of the supply chain in mechanisation are now beginning to focus more of their efforts on the social and environmental dimensions of sustainable agricultural mechanisation. Towards this end, the principles of conservation agriculture are being promoted for adoption, which include minimum mechanical soil disturbance, permanent organic soil cover and varied crop sequences. From a mechanisation perspective, this includes direct seeding and fertilizer placement with minimal impact to the soil. It also involves rolling or slashing the weeds, to maintain the mulch instead of rotary tilling as traditionally done. The other contemporary issue is related to the environmental damage caused by greenhouse gas emissions and the need for environmentally friendly farming practices. In this context, conservation agricultural practices which protect the soil, consume less energy, conserve water, improve input efficiency and reduce post-harvest losses can help mitigate the effects of climate change by reducing greenhouse gas emissions through more efficient use of resources.

Overall, as outlined by the Food and Agriculture Organisation of the United Nations, mechanisation in agriculture can ease and reduce hard labour, relieve labour shortages, improve productivity and timeliness of agricultural operations, improve the efficient use of resources, enhance market access and contribute to mitigating climate related hazards. Dynamic markets, that facilitate information sharing and transparency in agricultural practices can certainly contribute to adopting sustainable agriculture. Such practices will enable present and future generations to provide food for the growing population of this planet. Sustainable agriculture has great potential to drive inclusive growth in societies, enhance soil health and regenerate lands, conserve water and empower the rural population to become critical agents of change. Moreover, mechanization has the potential to attract to agriculture the youth who are often more technology savvy. The adoption of modern technology can open an important channel for youth towards market-driven and profitable farming.

The following specific observations and recommendations emerge from this study.

- The prospect for agricultural mechanization is very positive and demand is expected to continue to grow. A closer two-way communication between distributors and manufacturers is important for the development of agricultural mechanization. On the one hand, feedback from end-users must be communicated to manufacturers' R&D centres directly or through intermediaries. On the other hand, manufacturers must communicate information on new technologies, on-going R&D efforts and their benefits to intermediaries and end-users. Looking forward, innovative technologies and appropriate machinery design will continue to be an important feature for market development and for further adoption of sustainable mechanization in agriculture. Accelerating the speed at which such technologies are introduced and making more effective the manner in which they are introduced can lead to faster adoption by traditional or more conservative farmers. Bi-directional information sharing becomes a must under these circumstances.

- Another important area for future R&D is the design and manufacture of women friendly farm machinery, especially in the non-paddy segment. Women play a vitally important but often less recognized role in agriculture along-side their male counterparts. Both manufacturers and distributors must work together to design and introduce user friendly, convenient, smaller-sized machinery with woman workers in mind. This is an immediate need which should be supported as a matter of priority.

- Financing remains a key bottleneck in the agriculture machinery supply chain. The prohibitive costs resulting from high interest rates erode the profits of farmers. A national endeavour supported by international development banks can be among the ways forward. A regional initiative through a development bank to offer re-financed loan schemes, especially targeting small scale farmers with a specific cap on the maximum amount to be disbursed to an individual, is recommended. However, a sound payback system is required to be ensured for this purpose.

- Machinery parts and components have an important linkage with the objective of reducing the burden on the end-user i.e. the farmer. In view of the diversity of machinery brands that are sold in the market, diversity in parts is also adding to the cost. It is recommended that manufacturers look at the possibility of harmonising some of the common parts so as to bring a degree of standardisation, without compromising quality. Such standardisation can help bring down the cost of maintenance.

- Apart from parts and components, another driver of the cost of machinery is logistics. The nature of agricultural machinery often makes it voluminous and therefore costly to move or transport. Manufacturers should be encouraged to look into the possibility of re-locating sections of their value chain activities to be in proximity to markets, where machinery can be shipped in knock-down form and then reassembled using local resources, which can bring about savings in logistic costs. Such savings can potentially be transferred to the farmers.

- Finally, this study draws attention to a part of the market that requires greater attention, namely the non-paddy segment, i.e. vegetables, seeds and pulses. While commercial growers are also there, these crops are very often grown by smallholder farmers on plots of less than 1 hectare. They require a range of machinery for operations, from land preparation to seeding, and weeding to harvesting, which are mostly carried out through manual labour. This is also often where most of the women work force is deployed. Hence, a concerted effort is required to manufacture and introduce such machinery suitable for smallholders as well as hilly and mountainous areas.

In conclusion, as the demands on the agricultural sector continue to grow and as the sector plays an increasingly critical role towards eradicating poverty and hunger, the relevance and importance of sustainable mechanization is also increasing manifold. While there are a wide range of efforts by different stakeholders underway for promoting sustainable mechanization in agriculture and many deserve to be applauded, there is still a lot more work to be done to strengthen this sub-sector in the collective endeavour towards meeting the Sustainable Development Goals.

Photo by Kaiqiang Zhou

Chapter 1: Introduction

1.1 Background

Mechanization is an important aspect in agricultural crop production. Recent years have seen a rising trend in the use of farm machinery, particularly in developing countries. Agricultural mechanization has been defined in a number of ways by different scholars and experts. One of the most often cited definitions is that it is the process of improving farm labour productivity through the use of agricultural machinery, implements and tools (FAO).[1] We use the term 'mechanization' generally to represent a variety of mechanical inputs, such as powered machinery, implements and tools (Clarke, 2000).

Enhancing avenues to make available sustainable mechanization means that, more tasks can be performed at the most opportune time, faster and on an expanded scale, resulting in producing larger quantities of crops while conserving natural resources as much as possible. The advent of innovative technology that are environmentally friendly will enable farmers to produce agricultural crops in an environmentally friendly manner with higher productivity gains. Apart from the pre-harvesting activities, sustainable agricultural mechanization can also contribute significantly to the development of value chains and food systems, as it has the potential to render post harvest operations, value added processing and marketing functions more efficient, effective and environmentally friendly.

With increasing urbanisation around the globe, the land available for expansion of agriculture is diminishing. Hence, there is an urgent need for an increase in quantity yields to meet the growing demand of the increasing global population. Whilst such yield increases can be realised with inputs such as superior planting material, pesticides, fertilizer, better water (irrigation) management techniques, the full benefit can only be met with the use of appropriate mechanization inputs.

The key benefits from agricultural mechanization can be summarised as follows[2]:

- Supplementing of labour usage by removing bottle necks and making best use of available time
- Timeliness of farming operations through targeting agronomic windows, reducing harvest losses
- Efficient use of inputs, such as seeds, nutrients, fertilizers, pesticides, and water
- Reduce losses in crop handling
- Effective and efficient usage of land
- Productivity improvement and thus increased earnings

Countries in Asia and the Pacific region are currently at different stages in relation to the adoption of agricultural mechanization. While a few have already attained a high level of adoption, others are experiencing rapid progress, while many others lag behind and/or have suffered from inappropriate and fragmented approaches to mechanization. In many cases, there have been negative impacts on environmental sustainability, social equity, and labour productivity. The overall level of agricultural mechanization development in the region is still comparatively low with vast disparity not just among countries but different areas and districts within countries. Major gaps also exist among different crops and different stages of production as well as across social groups.

The Centre for Sustainable Agricultural Mechanization (CSAM) is a Regional Institution of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP). CSAM supports the efforts of 62 ESCAP Member States and Associate Members towards sustainable agricultural mechanization to contribute to agricultural and rural development and the attainment of the Sustainable Development Goals in the Asia-Pacific region. In order to facilitate sustainable agricultural mechanization, CSAM's work promotes setting of agricultural machinery testing standards and protocols, policy dialogue, policy advice, information exchange, facilitation of regional agro-business and trade, farm machinery management data and related capacity building in the region.

[1] http://www.fao.org/tc/exact/sustainable-agriculture-platform-pilot-website/energy-management/mechanization/en/

[2] Trade and Investment Policies on Mechanization of Agriculture: Case Studies of Selected Member Countries of the Regional Council of Agricultural Machinery Associations in Asia and the Pacific (ReCAMA), 2018

1.2 Linkages with ReCAMA

The Regional Council of Agricultural Machinery Associations in Asia and the Pacific (ReCAMA) established in October 2014, is one of the flagship programmes of CSAM to engage the private sector. ReCAMA is built on the mission to promote sustainable agricultural mechanization in Asia and the Pacific, by strengthening the capacity of national agricultural machinery associations, facilitating exchange of knowledge and information, and enhancing collaboration and closer business connections among national associations and their members. ReCAMA seeks to play an instrumental role in facilitating research, trade and investment in relation to sustainable agricultural mechanization. It facilitates the linkages and networking amongst associations representing the manufacturers, distributors and users of farm machinery and implements in the region.

Since its inception, the ReCAMA initiative led by CSAM in 2014, has been working towards forging stronger ties inter-alia with associations in the region and promoting trade and investment amongst their members. With CSAM's facilitation, ReCAMA has been able to expand and deepen the exchange of knowledge and information and enhance closer collaboration and networking among national associations and their members. At the 4th ReCAMA Member Meeting held in August 2018, the members endorsed a proposal to conduct a study on market status of agricultural mechanization in China, India, Thailand and Sri Lanka. The research aims to focus on strategies for ensuring sustainability of this sector through the contribution to the whole value chain and to the Sustainable Development Goals[3].

The member countries of ReCAMA are diverse in several ways, including level of economic development, extent of agriculture vis-à-vis its contribution to GDP, manufacturing capacity, level of technology, research and development capabilities, government policy and the level of infrastructure development, particularly relevant to agriculture. The intra-connectivity brought about by CSAM's initiative via ReCAMA is intended to help member associations to exchange information and make available requisite mechanization and technology to meet each country's requirement.

At the current juncture, the focus is on understanding the market dynamics of each of the aforementioned countries. The market dynamics will look at primarily how markets are structured within each country; the dynamics of both demand and supply; insights into specific consumer (farmers) behaviours; the market segments as seen within each country; the extent to which current status of mechanization (quantified) meets the demand; potential demand in the near future; the emerging trends towards mechanization in each country market and how such process can be driven on a sustainable basis. A cross-country study can therefore provide a good opportunity for ReCAMA members to understand the diverse market dynamics and perhaps even similarities in certain areas, which it is believed will be useful for manufacturers as well as marketing & distributing companies.

For the respective members of the agriculture mechanization associations, knowledge and information are critical to make meaningful contributions in promoting sustainable agriculture mechanization in their respective countries, through informed decisions. A sound understanding of market dynamics of the selected countries, will benefit members in producing/sourcing appropriate machinery to the different segments that will be identified in this study. Thus, a study of this nature, whilst providing rich insights into market dynamics, will also lead to a minimization of risk for marketing/sourcing by selecting appropriate machinery for respective segments. This could lead to further growth in agriculture mechanization in a sustainable manner, across the region.

1.3 Scope of the study

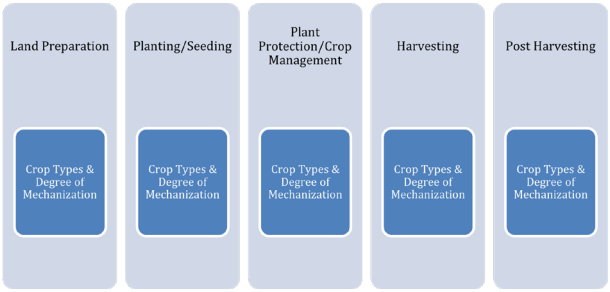
This study focuses on studying the national market status on mechanization of agriculture in China, India, Sri Lanka and Thailand. Its aim is to ensure sustainable development of agriculture mechanization through the whole value chain and thereby contribute towards achieving the Sustainable Development Goals (SDGs) of the United Nations.

'Market' is a broad notion. Taking an economic view, we can understand 'market' as where buyers and sellers come into contact with each other directly or indirectly to buy and sell goods. It refers to the whole area of operation of demand and supply. Further, it refers to the conditions and commercial relationships facilitating transactions between buyers and sellers. Therefore, a market signifies any arrangement in which the sale and purchase of goods take place. For the purpose of this study, we will consider each country as a market by itself.

[3] https://iddcconsortium.net/sites/default/files/resources-tools/files/ida-iddc_agenda_2030_easy_read_1.0.pdf

A market analysis is generally useful for supply side players. By carrying out an analysis of the structure and dynamics of the respective market, this study can provide them with useful insights into the performance of different products vis-à-vis competition; understand buyer behaviour ; evaluate current performance as well as future prospects; and construct marketing strategies which are responsive to the challenges presented by specific segments of the overall market. In addition, the outcome of this study, will be useful for those on the demand side, such as entities who are looking to buy/ source farm machinery, as well as those who wish to have access to information on how the markets are operating in countries, particularly where domestic agriculture production is dominant.

The framework for conducting this study was based on the stages of application and by crop, that would give us insights into the degree of mechanization as well as gaps that exist.



1.4 Research Objectives and Research Questions

1.4.1 Research Objectives

A market study of this nature is useful for buyers, suppliers, and other key stakeholders, such as policymakers. The intelligence arising from such a study will help both suppliers and buyers to work in tandem in finding appropriate solutions to mechanization of a broad range of agriculture production sectors. Knowledge and information of available technologies, best practices, market conditions, channels of distribution, production capacities etc will assist member countries increasing their capacities to introduce mechanization across a wider range of crop production facilities.

The key objectives of this study are to:

- Analyse the structure and dynamics of the market for agricultural machinery in the respective application stages in the selected countries; namely China, India, Sri Lanka and Thailand, and thereby gain insights into the performance of mechanization of agriculture in the present context.
- Assess the current demand for farm machinery in the respective application stages, evaluate the unmet demand and future trends, where applicable in each of the application stages.
- Evaluate the extent to which the market is addressing the need for economic, social and environmental sustainability and identify gaps.
- Compare and contrast the market dynamics for farm machinery in the aforementioned countries, so as to understand the similarities and dis-similarities in the said markets.
- Propose recommendations for different stakeholders as applicable (including in relation to future research, training and market awareness etc) on how the market can be leveraged to better promote sustainable agricultural mechanization for the benefit of the countries under study as well as for the region more broadly.

1.4.2 Research Questions

Based on the above research objectives, the key research questions and corresponding analyses of this study are stated as follow:

- To what extent is the country's agricultural production mechanised by crop type in each of the application stages?
  - A review of major crops cultivated and the extent of mechanization in each stage of applications
- How large is the market for each application stage? What are the market trends? What are the factors driving these trends?
  - A list of machinery in use (volumes per year by application and by crop)
  - Machinery applications by crop type
  - Trend analysis
- What are the major forces influencing demand (drivers) for mechanization of different crops for different applications?
  - Determinants: i.e.; government subsidy, financing schemes, levels of disposable income, economic expectations, technology, legislation etc.
- How consistent is demand? Does it fluctuate sharply in response to temporal or cyclical factors?
  - Demand patterns and their sensitivity to external factors

- How are markets segmented? Along what dimensions are markets segmented?
  - By crop and by customer type (age, gender, scale, geography, income level)
  - Demographics (broad) of customers and potential customers? Age, geographic, Income level or scale
  - Customer perceptions in regard to adoption of mechanization in agriculture
- Who are the typical consumers (end users) we are looking at?
  - Segment profiles of end users
  - Their outlook towards mechanization
  - Any major customer needs/wants which are not currently being satisfied
- How does the supply chain operate in each of our country markets?
  - Description of product and service flow from Producer to end user
  - Identifying the key stakeholders in the supply chain and their roles
  - How are end users accessed and made aware of products and new technology
  - Accessibility routes to products/service by end users
  - Type of services support provided
  - Financing options for acquiring mechanization
- To what extent is the market addressing the need for economic sustainability
  - The extent to which the market is addressing the need for economic sustainability (including needs of resource poor and smallholder farmers etc.), social sustainability (women, elderly workers, disadvantaged groups etc.) and environmental sustainability.
  - Any foreseen gaps and how can they be addressed

1.5 Country Selection

The countries selected for this study are China, India, Sri Lanka and Thailand. Geographically the chosen countries represent diverse sub-regions, namely, East Asia, South Asia and Southeast Asia, and consequently provide perspectives from different agro-ecological contexts. Furthermore, China, India and Thailand are major production centres for agricultural machinery in the region, whilst Sri Lanka is a net importer of agriculture machinery. An analysis of the situations in these countries can provide rich insights into varied market dynamics and will be beneficial to both buyers and producers of agriculture machinery.

1.6 Study Approach

This study employs primary and secondary research in its assessment of the market statuses of agricultural machinery in the Asia-Pacific region. Secondary research constitutes the major portion of the study as the research involves extensive data mining and verification of data sources, such as independent studies, government and regulatory published material, technical journals, and trade magazines. Supplementary to the data analyses is primary research, which include interviews with key stakeholders with regard to the qualitative aspects, such as the role of intermediaries, government agencies, end users and supporting industries, of the agricultural machinery industry in the region.

1.7 Report Structure

Chapter 1 begins with an introduction of the study. It presents the research objectives and the justification for the research.

Chapter 2 elaborates the role of agriculture mechanization and emerging technology in this field, in the context of overcoming the challenges in the drive for global food production in the 21st century.

Chapter 3 is dedicated for the country studies. A sub-section is dedicated for the market status for each country. It primarily covers an overview of the country's agriculture profile, extent of mechanization at present, profile of end users, demand for mechanization, supply chain, sustainability issues with a country-wise conclusion.

Chapter 4 draws conclusions on the study's findings and provides recommendations for various stakeholders.

Chapter 2:
The Role of Mechanization in Sustainable Agricultural Development

The Sustainable Development Goals are "a plan of action for people, planet, and prosperity" to all countries – no matter whether they are developing or developed countries. There are 17 goals and they serve as a blueprint to achieve a better and more sustainable future for all mankind. They recognize that ending poverty must go hand-in-hand with strategies that build economic growth and address a range of social needs including education, health, social protection, and job opportunities, while tackling climate change and environmental protection (United Nations, Sustainable Development Goals [UN], n.d.). In the context of this study, the focus will be on SDG 1 (No Poverty) and SDG 2 (Zero Hunger), particularly targets 1.1 (eradicating extreme poverty), 2.3 (doubling the agricultural productivity and incomes of small-scale food producers) and 2.4 (ensure sustainable food production systems), (United Nations, 2015). Moreover, this study also links to SDG 5 for achieving gender quality, SDG 12 for ensuring sustainable consumption and production patters, SDG 13 for combating climate change and its impact and SDG 15 to promote sustainable use of terrestrial ecosystems. At the same time, it must be underscored that all the Sustainable Development Goals are inter-connected and together reflect the economic, social and environmental dimensions of sustainable development.

It is projected that by 2050 the world will need to feed a growing population reaching almost 9 billion people, which is said to be nearly 70% more food than what is consumed in the present day (Denis, Flocco & Openheim, 2015). Increasing food production is not straightforward. The challenges are plentiful. Increasing urbanisation is putting pressure on the extent of available land for agriculture production. At the same time, the growing middle class and their increasing per capita spend are driving the demand for more durables, homes as well as higher quality food. The demands are at crossroads. Growing population and urbanisation in need of modern housing is driving land prices to an extent, where such lands may not be economical for agriculture production. At the same time, climate variability and change are affecting the consistency of production and availability of food crops. The availability of fresh water sources is another related challenge. Increasing water usage and rising temperatures have already begun to increase water stress around the globe. Then, we also have a situation where the new generation of youth are shying away from agriculture. Given this scenario, which we can describe as being highly turbulent, requires a collective approach involving diverse stakeholders including, governments, development agencies, researchers, private sector and producers working in coordination to build a food sector that will meet the SDG 1 and SDG 2.

Interestingly, Denis et al (2015) posits that, irrespective of the level of economic development of countries or scale, a resilient food economy stands on four building blocks. These requirements include efficient agriculture production, tailored trade and investment strategies, well-functioning domestic market and strategic reserves of food and water. Thus, the importance of efficient agricultural production cannot be over emphasised.

The comparative study on Trade & Investment Policies on Mechanization of Agriculture (2018) by CSAM found that all the countries in the study (China, India, Nepal, Sri Lanka and Thailand) from this region had conducive environments to accelerate mechanization of agriculture. As countries in the region continue to work hard on overcoming the macro challenges to accelerate growth in food production, the extent of mechanization of agriculture too is gathering momentum. However, the growth of mechanization does not necessarily mean making substantial investments in machinery nor deploying extremely high-end technology. Considering the different levels of economic development, land holding/scale, cost of finance, gender and other relevant market forces, producers of machinery and consumers of such machinery must consider 'appropriate mechanization' to suit localized conditions.

It is therefore important to have a thorough understanding of the market dynamics, including consumer types and their behavioural patterns, crops and cropping patterns, extent of mechanization and the gaps, so as to ensure that farmers have access to appropriate technology at competitive prices, and that the researchers and producers are able to supply such requirements. In other words, the suppliers of mechanization inputs must take into consideration the design, economics and the socio-cultural dimensions and adapt their products/services that meet such differences, which will lead to sustainability. Hence, a thorough understanding of the markets is a critical pre-requisite.

Emerging Trends

Technology is pervading across all industries and disrupting business models. Agriculture is no exception to the pervasion of technology. As we all know, with the projected world population expected to rise to 9bn by 2050, feeding the global population is a major challenge. Digitisation of agriculture is one such trend that is emerging to facilitate smart, efficient and sustainable use of natural resources to increase agriculture productivity. Digital solutions could provide more economical means of usage of fuel, fertilizers, pesticides and other inputs in a more targeted manner maximising efficiency and effectiveness. The use of technology to collect data is another dimension that is showing growing usage in the agriculture industry. Deployment of GPS, aerial imagery and electromagnetic soil mapping are examples of such data collecting mechanisms, when used can be deployed to grow more climate changing responsive and resilient crops. The use of real time information from GPS satellites on when to fertilize, when to irrigate, what crops to plant at what times of the year are a few such examples. Precision agriculture will be the way forward but the degree to which such technologies will be diffused into the industry and in particular for the small and medium scale farmers, will depend on costs.

The other trend, particularly in small farmer land holdings, where the cost of possessing agriculture machinery could be prohibitively costly or not viable due to low scale, is the establishment of custom hiring centres. Such centres could provide machinery for cultivation, planting and seeding, crop management, harvesting and postharvest operations, thereby facilitating those farmers who cannot either afford to find it unviable to own such a range of machineries, to deploy same in their operations. This is an operation that should be carried out by the private sector and hereto, partnerships between manufacturers and distributors can strengthen the business model.

Chapter 3:
Country Market Dynamics

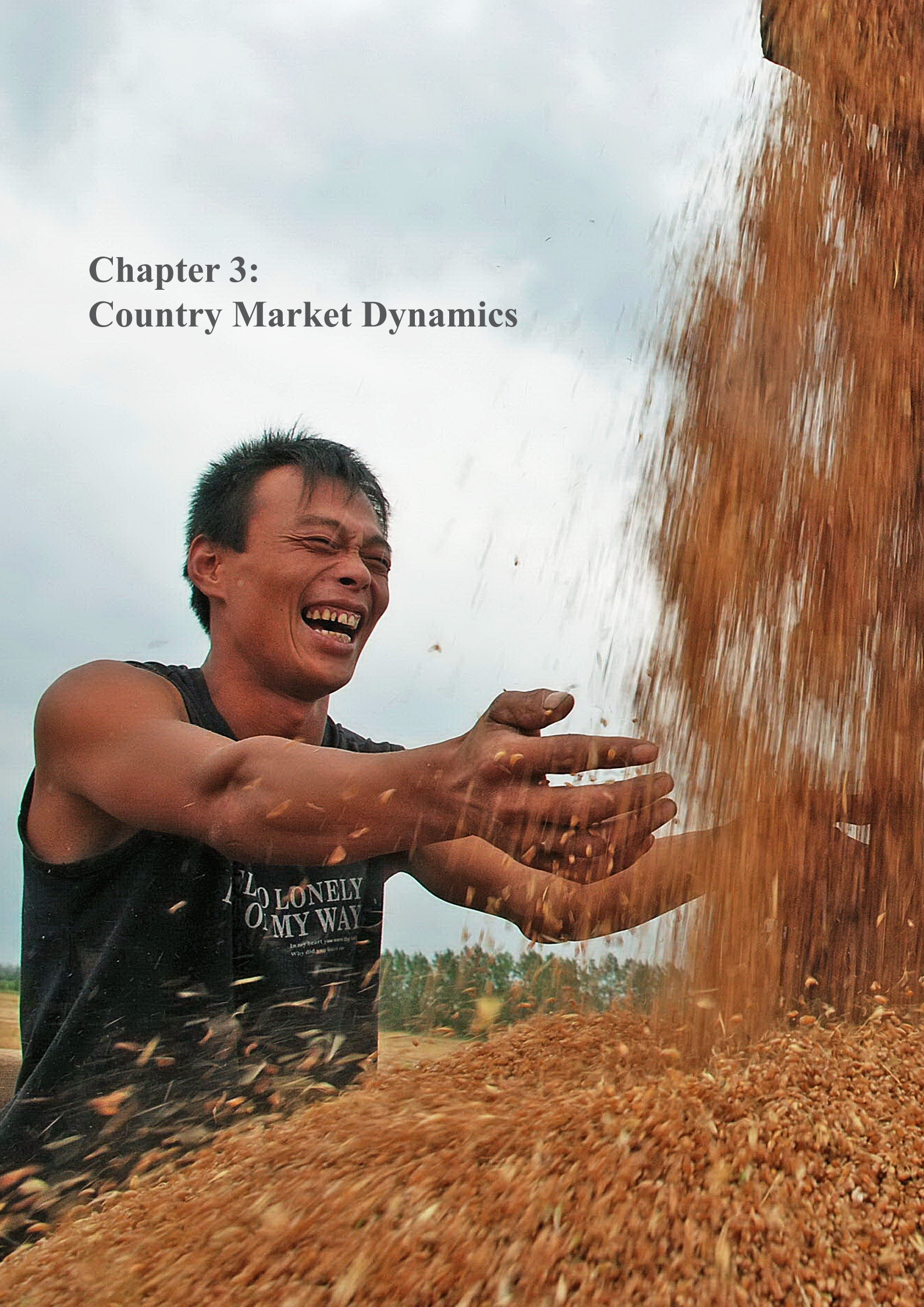


Photo by Jianhua Yi

3.1 China Country Market

Overview of China's Agriculture and Agricultural Machinery sub-sector

In China, agriculture consists of the industries of crop-planting, forestry, animal husbandry and fishery. In 2018, China's agricultural production was stable, and the industrial prospect is sanguine. This research report will focus mostly on China's crop-planting and related agricultural machinery and implements.

According to the Statistical Communiqué of the People's Republic of China on the 2018 National Economic and Social Development, the sown area of grain in 2018 was 117.04 million hectares, a drop of 0.95 million hectares compared with that in 2017. Among them, the sown area of wheat was 24.27 million hectares, a decrease of 0.24 million hectares; the sown area of rice was 30.19 million hectares, a decrease of 0.56 million hectares; the sown area of corn was 42.13 million hectares, a decrease of 0.27 million hectares. The sown area of cotton was 3.35 million hectares, an increase of 0.16 million hectares. The sown area of oil-bearing crops was 12.89 million hectares, a decrease of 0.33 million hectares; the sown area of sugar crops was 1.63 million hectares, an increase of 90 thousand hectares.

Table 3.1.1: Sown Areas of Major Farm Crops from 2013 to 2017

Indicators (1000 hectares)	2017	2016	2015	2014	2013
Total Sown Areas of Farm Crops	166,331.91	166,939.04	166,829.28	164,965.83	163,453.12
Sown Area of Grain Crops	117,989.06	119,230.07	118,962.81	117,455.18	115,907.55
Sown Area of Cereal	100,764.56	102,701.73	103,225.31	101,086.79	99,287.58
Sown Area of Rice	30,747.19	30,745.89	30,784.09	30,765.12	30,709.74
Sown Area of Wheat	24,507.99	24,693.97	24,596.45	24,472.31	24,470.12
Sown Area of Corn	42,399.00	44,177.61	44,968.39	42,996.81	41,299.21
Sown Area of Millet	861	857.2	842.38	791.53	720.72
Sown Area of Jowar	506.46	472.8	424.94	491	486.57
Sown Area of Barley	329.99	360.9	374.51	381.37	440.79
Sown Area of Beans	10,051.29	9,287.20	8,432.73	8,823.92	8,892.86
Sown Area of Soybean	8,244.81	7,598.53	6,827.39	7,097.57	7,049.92
Sown Area of Tubers	7,173.21	7,241.14	7,304.77	7,544.47	7,727.10
Sown Area of Potato	4,859.92	4,802.40	4,785.58	4,910.41	5,025.76
Sown Area of Oil-bearing Crops	13,223.16	13,191.12	13,314.39	13,394.68	13,437.92
Sown Area of Peanuts	4,607.66	4,448.40	4,385.52	4,369.70	4,396.09
Sown Area of Rapeseeds	6,653.01	6,622.80	7,027.66	7,158.09	7,193.49
Sown Area of Sesame	227.66	230.21	301.23	302.59	299.93
Sown Area of Helianthus	1,170.75	1,278.93	1,086.46	956.45	926.09
Sown Area of Benne	234.55	243.11	244.12	270.97	269.24
Sown Area of Cotton	3,194.73	3,198.32	3,774.98	4,176.47	4,162.15
Sown Area of Fibre Crops	58.45	54.17	53.54	58.01	63.46
Sown Area of Sugar Crops	1,545.65	1,555.25	1,572.63	1,737.10	1,844.42
Sown Area of Sugarcane	1,371.36	1,401.65	1,476.18	1,638.16	1,704.10
Sown Area of Beetroots	174.29	153.6	96.45	98.95	140.32
Sown Area of Tobacco	1,130.60	1,208.42	1,254.40	1,397.65	1,551.65
Sown Area of Flue-cured Tobacco	1,080.93	1,152.89	1,197.17	1,330.15	1,472.44
Sown Area of Vegetables	19,981.07	19,553.14	19,613.06	19,224.12	18,836.25
Sown Area of Medicinal Materials	2,161.07	1,932.44	1,860.96	1,758.89	1,648.41
Sown Area of Succulence	1,874.14	1,813.48	1,633.49	1,583.72	1,617.41

Source: National Bureau of Statistics

China's total output of grain in 2018 was 657.89 million tons, a decrease of 3.71 million tons or down by 0.6 percent over the previous year. Among the figures, the output of rice was 212.13 million tons, down by 0.3 percent; that of wheat was 131.43 million tons, down by 2.2 percent; and that of corn was 257.33 million tons, down by 0.7 percent.

In 2018, China's output of cotton was 6.10 million tons, an increase of 7.8 percent over the previous year, that of oil-bearing crops was 34.39 million tons, down by 1.0 percent, that of sugar crops was 119.76 million tons, up by 5.3 percent, and that of tea was 2.61 million tons, up by 5.9 percent.

The total output of pork, beef, mutton and poultry in 2018 reached 85.17 million tons, down by 0.3 percent over the previous year. Of this total, the output of pork was 54.04 million tons, down by 0.9 percent; that of beef was 6.44 million tons, up by 1.5 percent; that of mutton was 4.75 million tons, up by 0.8 percent; and that of poultry was 19.94 million tons, up by 0.6 percent.

The total output of aquatic products in 2018 was 64.69 million tons, up by 0.4 percent over the previous year. Of this total, the output of cultured aquatic products was 50.18 million tons, up by 2.3 percent; and that of fished aquatic products was 14.51 million tons, down by 5.7 percent over the previous year.

The total production of timber for 2018 reached 84.32 million cubic meters, up by 0.4 percent over the previous year.

Furthermore, according to the 3rd National Agricultural Census, by the end of 2016, China's cultivated land area was 134,921 thousand hectares. There were 207.43 million households who work on agriculture in the country. The sum of agricultural business units was 2.04 million all over the country, among which the total number of farmer cooperatives was 1.79 million. There were 314.22 million people who engage in agricultural production, operation or management, of which 92.9% were crop-planting related personnel.

Agricultural Mechanization

In 2018, the agricultural mechanization level in China developed smoothly. The comprehensive mechanization rate of tillage, planting and harvesting of main crops in China has reached 68%, up by 1 percentage point over the previous year. Wheat has basically achieved full mechanization, and the comprehensive mechanization rate of rice and corn has exceeded 80%. The mechanization level of major economic crops has increased, for example, the mechanization rate of rapeseeds harvesting, peanut planting and harvesting have all exceeded 40%, all of which increased by more than 3 percentage point over the previous year.

Table 3.1.2: Ownership of Major Agricultural Machinery Products from 2013 to 2017 (unit)

Indicators	2017	2016	2015	2014	2013
Large and Medium-sized Tractors	6,700,800	6,453,546	6,072,900	5,679,500	5,270,200
Small Tractors	16,342,400	16,716,149	17,030,400	17,297,700	17,522,800
Towing Farm Machinery of Large and Medium-sized Tractors	10,700,281	10,281,100	9,620,000	8,896,400	8,266,200
Towing Farm Machinery of Small Tractors	29,314,300	29,940,300	30,415,200	30,536,300	30,492,100
Combine Harvesters	1,985,400	1,902,000	1,739,000	1,584,600	1,421,000
Tillage Machinery	10,627,600	9,983,500	8,975,700	8,654,300	7,654,100
Power Plough	12,892,500	13,054,200	13,032,600	13,166,600	13,124,900
Rotary Cultivator	6,421,800	6,329,100	6,086,800	5,846,300	5,324,500
Subsoiler	280,700	267,700	240,200	224,800	233,600
Power Rake	7,046,500	7,198,200	7,257,900	7,285,100	7,285,600
Planter	6,466,700	6,501,800	6,367,300	6,233,600	600,500
Rice Transplanters	822,300	771,000	725,700	670,000	604,500
Power Sprayer	6,183,200	6,296,900	6,188,500	6,140,400	5,591,900
Cereal Dryer	118,700	93,200	68,700	54,400	42,800

Source: China Agricultural Machinery Industry Yearbook (2018)

Domestic Production

According to the National Bureau of Statistics, the prime operating revenue of agricultural machinery enterprises above designated size (companies with business income more than CNY 20 million per year) was $260 billion RMB in 2018. Its growth rate was 1.67% while the profits fell by 15.76%. Due to the continuous increase in ownership, the output of tractors, grain harvesters and transplanters continued to decline, while that of corn harvesters, silage harvesters, cotton harvesters and animal husbandry machinery increased slightly.

Table 3.1.2: Ownership of Major Agricultural Machinery Products from 2013 to 2017 (unit)

Indicators	2017	2016	2015
Large Tractors	51,052	62,979	77,675
Medium Tractors	367,210	566,914	606,900
Small Tractors	996,176	1,355,300	1,395,100
Cereal Harvesters	234,991	332,635	342,025
Corn Harvesters	77,429	95,033	125,323
Post-Harvest Processing Machineries	976,136	900,853	771,974
Agro-Product Primary Processing Machineries	2,752,838	2,691,700	2,946,000
Special Equipment for Feed Production	488,035	477,227	454,421
Cotton Processing Machineries	10,889	8,889	9,060

Source: China Agricultural Machinery Industry Yearbook (2018)

The Chinese government launched the agricultural machinery subsidy policy in 2004. Since then, all information pertaining to the scheme are open and transparent to all stakeholders. However, it should be noted that not all the agricultural machineries are covered by the subsidy policy. CAMDA has analysed and processed on the subsidy information of 2018. The brand rankings of sales volumes of wheeled-tractors, rice transplanters, cereal combine harvesters and corn harvester which are given below. These types are the main agricultural machinery bought by Chinese farmers and they all benefit from the subsidy policy.

Table 3.1.4: Sales of Major Agricultural Machinery Categories and Brands in 2018 Covered under Subsidy (units)

Machinery Type	Brand	Volume
Tractor	YTO	37,059
	LOVOL	26,430
	DONGFENG	18,860
	John Deere	12,580
	Taishan Guotai	9,675
	World	9,049
	Changfa	7,760
	Huaxia	6,989
	Shifeng	6,461
	BAILI	5,529
Paddy	Kubota	20,156
	jiufu	9,752
	World	8,556
	YANMAR	6,961
	iseki	2,865
Cereal Combine	World	33,115
	LOVOL	13,651
	Kubota	10,189
	zoomlion	5,377
	Thinker	3,745
Corn Harvesters	LOVOL	4,469
	GIMIG	3,670
	yinghu	2,780
	GOLD	2,343
	yongmeng	2,212

Source: China Agricultural Machinery Distribution Association (2018)

Import and Export of Agricultural Machinery

In 2017, China's agricultural machinery exports totalled 29.751 billion US dollars, which accounted for an 8.72% increase over the previous year. Its imports totalled 13.375 billion US dollars, up 10.55% over the previous year. Global procurement, global manufacturing and global sales will promote the development of agricultural machinery enterprises and products from China. Regarding export products, the export volume of pump products is 4.314 billion US dollars. Tractor export volume is 546 million US dollars. Agricultural vehicle export volume is 1.15 billion US dollars. Forage machinery export volume is 1.109 billion US dollars. Harvester machinery export volume is 353 million US dollars. Plow harrow and sprayer products export amount are 559 million US dollars. Agricultural machinery spare parts export volume is 14.46 billion US dollars.

Table 3.1.5: Import and Export of Main Products of Agricultural Machinery from 2013 to 2017

Indicator (US$10,000)	2017	2016	2015	2014	2013
Agricultural machinery and parts (export)	2,975,198.80	2,735,905.80	2,840,140.40	2,966,954.50	2,700,748.20
Agricultural machinery and parts (import)	1,337,784.20	1,210,166.40	1,305,288.80	1,581,625.90	1,464,175.10
among them					
irrigation and drainage machinery (export)	390,222.40	369,635.10	376,320.20	409,952.50	361,074.80
irrigation and drainage machinery (import)	245,568.20	237,936.20	252,384.50	300,410.70	285,356.30
irrigation and drainage machinery parts (export)	163,652.00	137,500.50	147,284.90	164,173.90	149,272.00
irrigation and drainage machinery parts (import)	79,383.70	68,006.30	57,015.10	66,099.00	70,877.90
Tractor (export)	54,565.90	39,650.10	45,264.40	47,250.90	49,722.50
Tractor (import)	11,914.10	12,992.60	11,487.60	9,555.90	11,810.50
Tractor parts (export)	353,432.60	324,367.20	354,010.60	352,476.90	327,789.10
Tractor parts (import)	88,742.10	81,828.70	83,985.10	100,488.40	89,821.10
Harvesting machinery (export)	145,944.70	117,984.30	115,900.80	109,971.90	93,794.40
Harvesting machinery (import)	20,989.10	25,223.20	48,491.20	37,878.90	38,738.60
Harvesting machinery parts (export)	46,504.80	35,852.40	37,161.30	37,745.20	34,399.70
Harvesting machinery parts (import)	9,252.70	8,498.00	7,920.90	6,933.00	10,631.10
Planting machinery (export)	4,120.90	4,901.70	4,453.80	3,534.30	2,914.70
Planting machinery (import)	3,993.70	4,258.20	4,567.50	6,127.40	8,379.00

Source: General Administration of Customs

Production and Mechanization of Major Crops, Problem and Trend Analysis

This component mainly focuses on the production and mechanization of rice, wheat, corn, Soybean, potato, peanut, rapeseeds and cotton. According to the adjustment plan of national planting structure, by 2020, the sown area of rice, wheat, peanut, rapeseeds and cotton will remain stable, that of corn will reduce appropriately, and that of Soybean and potato will increase accordingly. The adjustment of crop sown areas will affect the product and regional layout of agricultural machinery.

Tractor

Because of centralized land management, the ownership of large tractors (including their supporting implements) increases annually, while that of small tractors (including their supporting implements) decreases annually. Because agricultural machinery with multi functions can improve the efficiency of agricultural operation and users are willing to buy them, the ownership of such agricultural machinery also increases annually, the ownership of agricultural machinery with single function decreases annually (e.g. plough and harrow).

Rice Production and Mechanization

In recent years, the rice sown area has remained stable at the level of over 30,700 thousand hectares. Thanks to the agricultural machinery, the output of rice continues to see sustainable growth. The rice tillage has realized full mechanization (more than 99%): over 90% of rice harvesting has used machines. These machines are developing towards large feeding volume, while the mechanization level of some hilly and small fields is still relatively low.

Table 3.1.6: Rice Production and Mechanization from 2013 to 2017

Indicators	2017	2016	2015	2014	2013
Sown Area of Rice (1000 hectares)	30,747.19	30,745.89	30,784.09	30,765.12	30,709.74
Output of Rice (10000 tons)	21,267.59	21,109.42	21,214.19	20,960.91	20,628.56
Output of Rice Per Hectare (kg/hectare)	6,916.92	6,865.77	6,891.28	6,813.21	6,717.27
Ownership of Rice Transplanters (unit)	822,300	771,000	725,700	670,000	604,500
Ownership of Rice and Wheat Combine Harvester (unit)	1,484,900	1,428,300	1,318,400	1,223,800	1,134,300
Among above: Half-Feeding Combine Harvester (unit)	123,200	119,700	117,500	112,500	107,200

Source: National Bureau of Statistic

The mechanization rate of rice planting is not high (i.e. 45%). The main reason behind this phenomenon is due to the complexity of rice seedling machineries. Farmers often encounter difficulties in operating them. Also, if the farmers buy the high-speed transplanters, they would need to invest considerable amount of money while the return time is too long, so the enthusiasm of farmers is not high. Although the price of hand transplanters is relatively cheap, the labour intensity is very high. In addition, the mechanized transplanting requires a lot of auxiliary labour, which is not economical for small plots. For Hunan Province, mechanical seedling throwing is a preferred method. The recent years saw a wider adoption of high-speed seedling throwing machines. Technology as such substantially reduced the labour hours that the process previously entailed. The mechanical direct seeding of rice can lower the production cost, but many agronomic problems have not been solved, which leads to slow speed of promotion. If the agronomic problems are addressed, the rice direct seeding machinery will have a greater development space.

Solutions to improve the level of mechanical rice transplanting include increasing subsidies for efficient and suitable transplanting machines, improving the standardization of farmland, carrying out centralized seedling raising, and promoting advanced rice planting technology. When harvesting rice, we can choose full-feeding or half-feeding combine harvesting machinery or mechanical cutting or threshing machinery according to different conditions. It is advocated to select large full feeding combine harvester to improve the efficiency. In order to meet the standard moisture content, rice should be dried by grain dryer after harvest.

Wheat Production and Mechanization

The wheat production has basically realized mechanization, with more than 99% mechanical tillage, 90% mechanical sowing and 95% mechanical harvesting. It is developing towards the direction of large-scale, complex and efficient machinery. In order to improve the quality of seeding, mechanical precision seeding technology is used to complete the multiple operations like straw treatment, seeding, fertilization and suppression at one time. At the same sown area,

the output of wheat increases annually while the seeds required decreases and the cost is reduced.

Table 3.1.7: Wheat Production and Mechanization from 2013 to 2017

Indicators	2017	2016	2015	2014	2013
Sown Area of Wheat (1000 hectares)	24,507.99	24,693.97	24,596.45	24,472.31	24,470.12
Output of Wheat (10000 tons)	13,433.39	13,327.05	13,263.93	12,832.09	12,371.03
Output of Wheat Per Hectare (kg/hectare)	5,481.23	5,396.88	5,392.62	5,243.51	5,055.57
Ownership of Rice and Wheat Combine Harvest	1,484,900	1,428,300	1,318,400	1,223,800	1,134,300

Source: General Administration of Customs

Because of the emergence of agricultural machinery with multi purposes, the number of agricultural supporting implements entering farmland is reduced and the efficiency of wheat production is greatly improved, which reduces the damage to farmland and saves the production cost. The number of wheat combine harvesters with large feeding volume is increasing rapidly. Because of their high harvesting efficiency, it is very helpful to cope with the bad weather. In order to improve the seedling quality of the next crop, wheat combine harvester is required to have straw crushing and spraying devices to ensure that straws are evenly distributed on the surface of the soil.

Corn Production and Mechanization

Corn tillage has almost realized mechanization (more than 95%). The steps before sowing varies in different region. Multi-functional combine equipment is usually used before sowing. The government advocates conservation tillage; therefore, the subsoiler is often used to break the plough pan. Small rotary machines are used in hilly and mountainous areas, for cultivated land with gentle slope. And small and medium-sized rotary machines are used, or direct sowing without land preparation.

Table 3.1.8: Corn Production and Mechanization from 2013 to 2017

Indicators	2017	2016	2015	2014	2013
Sown Area of Corn (1000 hectares)	42,399.00	44,177.61	44,968.39	42,996.81	41,299.21
Output of Corn (10000 tons)	25,907.07	26,361.31	26,499.22	24,976.44	24,845.32
Output of Corn Per Hectare (kg/hectare)	6,110.30	5,967.12	5,892.85	5,808.91	6,015.93
Ownership of Corn Combine Harvester (unit)	500,300	473,900	420,700	360,400	286,800

Source: National Bureau of Statistics

The mechanization rate of corn sowing has reached 85%. Now the mechanical precision seeding technology is popularized. According to the situation of the plot, farmers choose suitable precision seeding machines for sowing. When harvesting, the appropriate combine harvesters or silage harvesters will be selected according to the plot size, planting row space and operation requirements.

Corn harvesting mechanization is an area to be improved. The rate of mechanized harvesting is 70%, which is much lower than that of rice and wheat. The main reasons for such are as follows: 1) the development of corn harvesting machinery only started around 10 years ago, which was mainly driven by the national agricultural machinery subsidy policy. The technical level of corn harvesting machinery develops slowly and the quality of corn harvester is not high. 2) The technology and machinery are lacking for harvesting corn for different purposes, for example for seeds, fresh-eating or silage. In addition, the suitable corn varieties are also not available. 3) It is the agronomic problems, such as row space and interplanting. Because of the above reasons, the popularization and spread of corn harvesters are limited, which is also the next research direction. In addition, the national policy of reducing corn sown area also led to the shrinkage of the corn harvester market.

Soybean Production and Mechanization

According to the National Agricultural Modernization Plan (2016-2020), the sown area of Soybean will reach 9.333 million hectares by 2020, increase of 2.667 million hectares over 2016 and increase by 40%, which is good news for Soybean production machinery.

Table 3.1.9: Soybean Production and Mechanization from 2013 to 2017

Indicators	2017	2016	2015	2014	2013
Sown Area of Soybean (1000 hectares)	8,244.81	7,598.53	6,827.39	7,097.57	7,049.92
Output of Soybean (10000 tons)	1,528.25	1,359.55	1,236.74	1,268.57	1,240.71
Output of Soybean Per Hectare (kg/hectare)	1,853.59	1,789.23	1,811.44	1,787.33	1,759.89
Ownership of Soybean Harvester (unit)	19,900	20,000	19,600	20,300	20,400

Source: National Bureau of Statistics

In the tillage step, the current machinery can basically meet the market demand, mechanization rate is 80%. According to the different soil type, different agricultural machinery, such as combine tiller, subsoiler, plough, and harrow, can be used. Multi-functional precision sowing machines can complete the operation of sowing, fertilization, suppression at one time, which can improve the efficiency and save cost greatly. Nowadays, the quantity and quality of multi-functional and single-function agricultural machinery can meet the market. At present, the mechanization rate of sowing has reached 75%.

At present, the mechanization level of Soybean harvesting is at a lower level (only 70%). Various soybean harvesting machines are mainly modified from wheat combine harvester. Because the growing conditions of Soybean is different from wheat, the harvesting quality is not high. The specialized Soybean combine harvester can basically meet the requirements of testing, but the harvesting loss is substantial. The impurity content is high, and reliability is low. Because most Soybean combine harvesters are produced by small and medium-sized manufacturers, the technology is mature, and the variety are limited. In addition, the Soybean combine harvester has single function and can only harvest Soybean. Therefore, the utilization rate of the harvester is low, and farmers are unwilling to buy it.

In addition, Soybean harvesting can also be completed by stages. For example, the specialized soybean swather or

windrower cuts hay or small grain crops and forms them into a windrow. It allows drying in the wind and sunlight before being baled, combined, or rolled. The soybean swather is suitable for small plots with lower cost. It can easily be power-matched, but its efficiency is low compared to combine harvester.

Potato Production and Mechanization

Table 3.1.10: Potato Production and Mechanization from 2013 to 2017

Indicators	2017	2016	2015	2014	2013
Sown Area of Potato (1000 hectares)	4,859.92	4,802.40	4,785.58	4,910.41	5,025.76
Output of Potato (10000 tons)	1,769.63	1,698.57	1,645.33	1,683.11	1,717.59
Output of Potato Per Hectare (kg/hectare)	3,641.28	3,536.91	3,438.10	3,427.63	3,417.57
Ownership of Potato Harvester (unit)	72,200	64,600	59,600	55,300	48,700

Source: National Bureau of Statistic

Potato tillage and preparation machines have been serialized and universalized, including subsoiling, stubble elimination, rotary tillage, harrowing, ridging, fertilization, suppression and other operations. Conditional areas have adopted multi-functional machines according to their needs. Now the tillage mechanization rate of potato is 65%, there is still much space for development.

Potato planting machinery is relatively mature, which can complete ditching, fertilization, sowing, film laying, soil covering and pressing at one time. It has high efficiency and is suitable for large blocks. However, its mechanization rate is only 30%, which is mainly because the agronomic problems restrict the development of seeding machinery. The mechanical structure and performance need to be improved, compared with the foreign advanced and large potato seeders. There is still a big gap.

Before harvesting, potato stalk needs to be cut (by stalk cutter) in order to reduce the damage during harvesting, which is conducive to the realization of mechanization. The main harvesting machines include digging separation potato harvester, which completes digging, separating, transporting and laying at one time, and then picking up afterwards. Potato combine harvester, which completes many processes such as stalk removal, digging, separation, cleaning, transportation and collection at one time, it is suitable for harvesting potatoes in large area. At present, the mechanization rate of potato harvesting is only 30%, which needs to be developed vigorously.

The major problem at present is that the potato harvesters are mainly in small and medium size, some of which have single function, low efficiency, poor separation effect, high damage rate of the potato, lack of advanced stalk treatment equipment and suitable plastic film recycling machinery. Potato seeder with buds is also scarce. According to the plan, the sown area of potatoes will continue to expand. It is expected to reach 100 million mu[4], or around 6.7 million hectares by 2020. The market demand for potato machinery is also expected to increase gradually.

Peanuts Production and Mechanization

Table 3.1.11: Peanuts Production and Mechanization from 2013 to 2017

Indicators	2017	2016	2015	2014	2013
Sown Area of Peanuts (1000 hectares)	4,607.66	4,448.40	4,385.52	4,369.70	4,396.09
Output of Peanuts (10000 tons)	1,709.23	1,636.13	1,596.13	1,590.08	1,608.24
Output of Peanuts Per Hectare (kg/hectare)	3,709.54	3,678.02	3,639.55	3,638.88	3,658.34
Ownership of Peanuts Harvester (unit)	170,100	150,700	142,500	137,600	130,400

Source: National Bureau of Statistic

The tillage of peanut is basically mechanized (75%). The degree of mechanization for peanut sowing is not high (only 45%), which is mainly affected by planting mode, plot size and peanut seeds.

The mechanization level of peanut harvesting is low (40% more or less), and the technology and adaptability of the sectional harvester are poor. The combine harvester needs to be matched the drying equipment with larger investment. The number and variety of manufactures are few, and farmers have little choice. High-efficiency and high-quality peanut harvesters and relative matched drying equipment need to be researched and developed further.

Rapeseeds Production and Mechanization

Table 3.1.12: Rapeseeds Production and Mechanization from 2013 to 2017

Indicators	2017	2016	2015	2014	2013
Sown Area of Rapeseeds (1000 hectares)	6,653.01	6,622.80	7,027.66	7,158.09	7,193.49
Output of Rapeseeds (10000 tons)	1,327.41	1,312.80	1,385.92	1,391.43	1,352.34
Output of Rapeseeds Per Hectare (kg/hectare)	1,995.20	1,982.24	1,972.09	1,943.86	1,879.95
Ownership of Rapeseeds Harvester (unit)	21,500	20,900	20,900	20,600	19,400

Source: National Bureau of Statistic

The mechanization level of rapeseeds is also low, mainly in the sowing and harvesting steps, whose mechanization rate is 30% and 40%, respectively. The small plot of rapeseeds and agronomic problem are the reasons for the low mechanization level. The mechanization rate of rapeseeds tillage reached 80%. The tillage machinery has strong adaptability and good development situation. Rapeseeds transplanting machine requires high cost for seedling raising, more auxiliary labour and is in low efficiency. And the rapeseeds direct seeding machine has single function, requires more sowing procedures, high investment and is in low efficiency as well. At present, the rapeseeds combine harvester is modified from rice-wheat combine harvester, which has poor adaptability and high loss rate. The segmented rapeseeds harvester lacks practical swathing, picking and threshing equipment, and it needs more manual labour.

[4] Chinese unit of land measurement where 1 hectare equals 15 mu

Cotton Production and Mechanization

Table 3.1.13: Cotton Production and Mechanization from 2013 to 2017

Indicators	2017	2016	2015	2014	2013
Sown Area of Cotton (1000 hectares)	3,194.73	3,198.32	3,774.98	4,176.47	4,162.15
Output of Cotton (10000 tons)	565.3	534.28	590.74	629.94	628.16
Output of Cotton Per Hectare (kg/hectare)	1,769.48	1,670.50	1,564.88	1,508.31	1,509.22
Ownership of Cotton Harvester (unit)	4,100	3,800	3,700	3,200	2,700

Source: National Bureau of Statistic

The cotton tillage and sowing have basically realized mechanization, the mechanization rate of which reached 95% and 85% respectively; but for harvesting, the national average rate is only a bit over 25%.

The mechanization harvesting rate of cotton in Xinjiang Production and Construction Corps and Northern Xinjiang is over 80%. The cotton sown area and output in Xinjiang are over 70% of the national cotton sown area and production. This is due to the large-scale cotton sown area and standardization of farmland in Xinjiang, and the use of large machines with high efficiency and good benefits. In the past few years, large cotton harvesters were mainly imported. In recent years, domestic cotton harvesters have developed rapidly, and their quality has been continuously improved. And the price is much lower than that of imported cotton harvesters. The major problem for developing cotton mechanization is that there are many planting modes, which are not suitable for mechanical harvesting, for example, different sizes of row space, interplanting, density and nonuniform height. Small plots are not suitable for mechanized operation.

Factors Affecting the Development of Agricultural Mechanization

Planting Structure Adjustment

Planning of crop sown area will affect the market demand and development direction of agricultural machinery products.

By 2020, the sown area of rice will be stable at 450 million mu (15 mu equals 1 hectare), the proportion of high-quality rice will reach 80%; the sown area of wheat will be kept at 360 million mu; that of corn will be at 500 million mu, the sown area of corn in some areas will be reduced by more than 50 million mu, the sown area of silage corn will reach 25 million mu, the sown area of fresh-eating corn will reach 15 million mu; Soybean sown area will reach 140 million mu, an increase of about 40 million mu; potato and miscellaneous grain sown area will reach 230 million mu; cotton at about 50 million mu, of which Xinjiang cotton sown area will be stabilized at about 25 million mu; rapeseeds sown area at about 100 million mu; peanut sown area at 70 million mu; sugar crops sown area at 24 million mu, of which the sugarcane sown area will be 21 million mu; vegetable sown area at 320 million mu, of which 63 million mu are facility vegetables, and 35 million mu for alfalfa.

The Land Factors

Because of the small scale of farmland, scattered and fragmented crop sowing, it is difficult to use large and advanced agricultural machinery for unified tillage, planting and harvesting. Some hilly and mountainous areas do not have the conditions to use agricultural machinery, which also limits the development of agricultural mechanization.

China made modification of its pertinent laws and regulations in recent years to encourage renting farmland from other farmers for larger scale operation. By means of land rental and custom hiring and renting of agricultural machinery operation, it can effectively enlarge the scale of land, improve the efficiency of agricultural machinery operation and utilization rate of agricultural machinery, as well as promote the development of large, efficient and advanced agricultural machinery.

Minimum Purchase Price of Main Crops

From the year of 2004 to present, the Chinese government has been implementing a minimum purchase price policy for wheat and rice annually. The minimum purchase prices for wheat and rice are determined based on multiple factors

including the inputs cost, supply and demand factors, as well as the market prices. The minimum purchase prices are released before the planting of wheat and rice respectively. The purpose of the minimum purchase price of main crops is to ensure the benefits of farmers in case the market prices are too low.

Agricultural Machinery Subsidy Policy

The national subsidy policy for agricultural machinery in China will continue and well-developed. In 2019, the central government allocates CNY 18 billion of subsidy funds and formulates the subsidy measures.

Prices of Agricultural Products and Farmers' Income

The price of agricultural products directly affects the income of farmers, incentives to carry out agricultural production, and the ability to purchase agricultural machinery. In order to improve farmers' willingness to grow grain, the government also subsidizes them, for agricultural machinery operations, for example deep ploughing.

Adaptability and Reliability of Agricultural Machinery

The adaptability and reliability of agricultural machinery are crucial factors for farmers to consider whether they should buy agricultural machinery. The poor adaptability of agricultural machinery affects the efficiency and quality of operation, affects the selling price of agricultural products, and leads to the decrease of income. The poor reliability leads to the high failure rate of machinery, big cost of maintenance, and delay of agricultural time, which ultimately leads to the decrease of income.

Financial Policy

For the purchase of large and efficient agricultural machinery, the investment amount is large, and the investment return time is long. For ordinary farmers with limited income, low-interest loan is a feasible option. But financing for agricultural production was not exactly convenient in China.

Labour Force

With a large number of farmers entering the city for work, farmers engaged in agricultural production are relatively aged. This gave rise to notable shortage of labour. Therefore, "Machine Replacement of Labour" has become a trend of development. It requires simple, intelligent, efficient and comfortable agricultural machinery. This development also encourages young people with knowledge and ability to stay in the countryside and engage in agricultural production.

Socialized Services and Standardized Production

Social service of agricultural machinery such as custom hiring can reduce the cost of operation, and the efficiency of agricultural machinery usage can be further improved. Standardized production in agriculture can improve the quality and efficiency of operation. These two factors can both promote the development of large and efficient agricultural machinery.

Manufacturing Level of Agricultural Machinery

The improvement of agricultural machinery manufacturing level and product quality is the key to realize agricultural modernization. Manufacturing enterprises should go deep into the countryside, study agronomy and manufacture advanced, applicable and efficient agricultural machinery. Only in this way can the agricultural machinery market be sustainable.

Supply Chain

The process of selling products and services

It is common that an intermediary links agricultural machinery product from manufacturers to end users. The intermediary includes agents, distributors, dealers and importers. Domestic manufacturers have many agents throughout the country that are responsible for sales and services in certain regions. The agents sell the products to the user through the distributors according to needs. In some infrequent circumstances, domestic manufacturers sell products to users directly, such as customized products, special products, or large-scale users to purchase products in bulk. When there is no dealer nearby, manufacturers also sell products to users directly. The products of foreign manufacturers are sold through import traders. The import traders may be independent traders or may be domestic agricultural machinery manufacturers or dealers. Of course, when foreign products arrive in China, they are also sold to users through domestic channels (described above).

According to Chinese laws and regulations, during the product warranty period, the responsibility of after-sales service of domestic and foreign products should be shouldered by the seller,

and they must repair and maintain the user's products; if the warranty period is expired, the user may choose the repair and maintenance service provider independently.

Repair and maintenance service providers may provide by manufacturers, agents or dealers, as well as independent repair and maintenance service providers.

Manufacturers

Through market or other investigation, manufacturers develop and produce agricultural machinery products, sell them via distributors, and make the production plan according to the sales. The after-sales service is generally entrusted to distributors, and the manufacturer gives technical and financial support; manufacturers also collect the use status of agricultural machinery, and timely adjust product design and sales policy.

Distributors

Distributors need to provide local market information to manufacturers to help them develop markets and increase market share, organize regular demonstrations and promotion meetings, facilitate farmers to access machinery repair and maintenance services, and assist them to apply for purchase subsidies. Distributors in China usually sell many brands of agricultural machinery products at the same time.

Development Trend

Consumers' needs for future agricultural machinery include comfortable driving environment, multi-functional agricultural machinery, automatic driving system, intelligent control system, high efficiency and fuel saving. We have conducted a survey on consumers of agricultural machinery cooperatives and the results are as follows.

The magazine “Agricultural Machinery Market” conducted a consumer survey with agricultural machinery cooperatives in 2018; and500 samples were obtained. The average age of consumers was 49 years old, 11% were women, and only 7% were university educated or above. More than 50% of respondents are willing to buy agricultural machinery in 2019. 55% of consumers choose to buy agricultural machinery with their own funds, and 45% choose to buy agricultural machinery with loans. Only 2% choose to buy agricultural machinery online. The quality and price are the most concerned factors for consumers.

When buying tractors, 40% of consumers want to choose the power-shift tractors, which reflect the demand for high performance. Almost all consumers think that compound, energy-saving, environmental protection and precision are the development direction of agricultural machinery. The return on investment takes more than four years, which occupies 53% of the consumers; for old machinery, 65% of consumers choose to sell to other farmers.

Sustainability: Economic, Social and Environmental

The Chinese government is making strong efforts to promote sustainable agriculture for achieving economic, social, and environmental benefits. The specific measures for the attainment of sustainable agriculture include: improving the level of agricultural production and developing high-efficiency agricultural machinery that meets the requirements of agronomy; promoting the development of ecological agriculture, as well as the circular economy of planting and husbandry; developing agricultural machinery for husbandry and livestock while developing agricultural machinery for farming; improving the quality of cultivated land and developing agricultural machinery with protective tillage functions; controlling the environmental pollution in agricultural production and developing agricultural machinery that can recycle and utilize agricultural waste.

As above, sustainable agricultural mechanization plays a key role in developing sustainable agriculture. In addition, agricultural mechanization and agricultural machinery are important foundations for improving rural productivity and are imperative for agricultural and rural modernization.

In recent years, China's agricultural machinery manufacturing level has steadily improved. The total amount of agricultural machinery has continued to grow, and the level of agricultural machinery operation has rapidly improved. Agricultural mechanization has entered a new stage. At present, the tillage and sowing of main crops have basically realized mechanization.

However, due to diversified demand of agricultural machinery products and other factors, the unbalanced development of agricultural mechanization and agric ultural machinery industry is more and more noticeable. Problems, such as the lack of innovation ability of agricultural machinery science and technology, insufficient supply of some agricultural machinery, insufficient combination of agricultural machinery and agronomy, and the lagging construction of agricultural

machinery operation infrastructure, are all to be addressed.

In addition, there are also some weak points of agricultural mechanization to be improved in China, which include mechanized planting of rice, rapeseeds and potato; mechanical harvesting of rapeseeds, potato, peanut and cotton; and the matching problems of plant protection machinery; straw treatment machinery with the tillage and sowing functions; and harvesting machinery.

In addressing these challenges and constraints, the Chinese governments outline the development direction of sustainable agricultural mechanization in terms of: developing machinery with large horsepower, better-performance and multiple functions; encouraging financial institutions to carry out mortgage loan business to support farmers' investment in agricultural machinery; supporting the phasing-out of agricultural machinery with outdated technologies; encouraging the forming of social service (custom hiring) entities so as to carry out various agricultural service activities; strengthening the construction of standardization of farmland; increasing subsidies for agricultural machinery in hilly and mountainous areas; guiding large and medium-sized agricultural machinery to equip with navigation, positioning, operation monitoring and automatic driving terminals.

All these efforts will help to develop the sustainable agricultural mechanization conducive to the achievement of sustainable agriculture with economic, social, and environmental gains.

Conclusion

In recent 5 years, the sown area and yield of rice, wheat, corn, soybean, potato, peanuts, rapeseed and cotton in China remain stable, and their output per unit area has grown steadily. This is due to the protection of cultivated land, the selection of picked seeds and the implementation of agricultural machinery.

In recent 5 years, thanks to the policy on agricultural machinery subsidy carried out by the government of China, the total power of agricultural machinery and the ownership of agricultural machinery products of China has increased steadily. In the meanwhile, the mechanization rate of tillage, planting and harvesting of rice, wheat, corn, soybean, potato, peanuts, rapeseed and cotton has been increasing gradually.

In recent 5 years, the newly-brought agricultural machinery shows characteristics of large-scale, high-efficiency, complex, intelligent and comfortable. The quality of agricultural machinery products keeps developing. And price is no longer the most important factor when farmers buy agricultural machinery.

However, the mechanical planting rate of rice, potato, peanuts and rapeseed is relatively low in China, so is the mechanical harvesting rate of potato, peanuts, rapeseed and cotton. So there is much room for development for the machinery mentioned above.

It is believed that the agricultural machinery industry of China should fully utilize the nation's policy. The manufacturers should make high-quality agricultural machinery products and do good after-sales services. Farmers should produce high-quality crops and other agricultural products with advanced agricultural machinery products. All relative sectors of the society, including agricultural machinery dealers, should provide a bridge and service role. Thus, the food security in China and the world will be ensured.

Recommendations

Developing agricultural mechanization sustainably requires joint efforts of all the stakeholders in the sub-sector. In specific:

For manufacturers:

- Besides selling agricultural machinery products, manufacturers should also provide the whole-process solution of mechanization to farmers according to land scale and variety of crops.
- They should strengthen the quality of their services, including the timeliness of service, the required time for accessories supplies, as well as the versatility of accessories.
- They should also develop safer, better adaptable and more reliable machinery. Intelligent control is also the direction of the future development.

For distributors:

- The distributors should provide regular trainings for farmers, including the knowledge of use, repair and maintenance. Repairing is the key problem to address.
- They should also provide technical support for the farmers in selecting agricultural machinery. Machinery suitable for local agronomy, products of reliable enterprises and those cost-effective ones should be recommended.

For the governments:

- It is necessary for the governments to play a guiding role in the sustainable development of agricultural mechanization. The governments should provide support in public facilities, such as high-standard farmland construction, field road construction, the campaign of farmland transformation to cater machinery in hilly and mountainous areas, and so forth.
- The governments should strengthen their efforts in human resource development, such as training practical and technical skills of agricultural machinery operations and maintenance.
- The governments should also implement the agricultural machinery purchasing subsidy policy continually and support the demonstration and promotion of agricultural machinery with high horsepower, high performance and multi functions.

For research institutions:

- The research institutions should develop various types of advanced and applicable agricultural machinery suitable for both national conditions and farmers' needs. It is not only necessary to research on large and medium-sized agricultural machinery that suitable for large-scale farmland, but to research on small-scale ones that adapt to small-scale farmland and hilly mountainous areas. They should also study the efficient and dedicated machinery for special crop production, fishery and husbandry.
- More attention should be paid in the weak points and links in agricultural machinery technology and products.

For associations of the industry:

- The associations shall be committed to deepen information exchange, education and training, market research, standard setting serving the needs of the enterprises within the industry.

Photo by Weichuan Qiu

3.2: India Country Market

3.2.1 Overview of the Country's Agriculture Profile

Main Crops and Cultivation Levels

As the world's second largest agricultural producer, India is now a leading exporter of food grains, cotton, horticultural crops, dairy and poultry, aquaculture, and spices. Agricultural production is valued at US$ 401 billion in 2017 (Singh, 2019). Over the three decades between 1970 and 2001, India's agricultural GDP rose from US$25 billion to US$101 billion, whereas between 2001 and 2017 it rose to US$401 billion. Currently, India is self-reliant in almost all the major agricultural commodities except for oilseeds. Significant land use changes have been observed in the last seven decades. Farming areas for rice, wheat, pulses, oilseeds, soybean, cotton, sugarcane have increased notably. However, areas for sorghum, coarse cereals, and groundnut have declined. Productivity of all crops showed an increasing trend during last seven decades, although the magnitude of increase varied among different crops and different periods. The production increase during the period 1950-51 and 1990-91 was considerably higher than during the period 1990-91 and 2016-17. Moreover, the change in farming area and production was not very significant during the period 2012-13 and 2016-17 (Table 3.2.1).

Table 3.2.1: Area and Production of Major Crops in India (Area in million ha; production in million tonnes; *Million bales of 170 kg each)

S. No.	Crop	Area/production	Years				
			2012-13	2013-14	2014-15	2015-16	2016-17
1.	Rice	Area	43.95	44.14	44.1	43.39	43.56
		Production	106.54	106.7	105.5	104.4	109.7
2.	Wheat	Area	31.19	30.47	31.46	30.23	30.58
		Production	95.91	95.9	86.5	92.3	98.5
3.	Maize	Area	9.43	8.96	8.55	8.69	10.24
		Production	24.35	24.17	22.5	25.9	28.72
4.	Total pulses	Area	25.23	25.21	23.55	25.26	25.85
		Production	19.27	19.3	17.2	16.4	23.1
5.	Groundnut	Area	5.53	5.5	4.77	4.6	4.15
		Production	9.67	9.7	7.4	6.74	5.48
6.	Rapeseed & Mustard	Area	6.7	6.65	5.8	6.51	6.89
		Production	7.96	7.88	6.28	6.8	8.5
7.	Soybean	Area	12.2	11.72	10.91	11.66	11.39
		Production	11.99	11.86	10.37	8.6	13.79
8.	Total oilseeds	Area	28.53	28.05	25.6	26.13	26.67
		Production	32.88	32.74	27.51	25.3	31.3
9.	Sugarcane	Area	5.01	4.99	5.07	4.95	4.44
		Production	350.02	352.1	362.3	352.16	306.1
10.	Cotton	Area	11.69	11.96	12.82	12.29	10.83
		Production*	36.59	35.9	34.8	30.15	32.6
11.	Total vegetables	Area	9.2	9.4	9.54	10.1	10.29
		Production	162.2	162.9	169.5	169	175
12.	Total fruits	Area	7.19	7.22	6.11	6.3	6.48
		Production	86.82	89	86.6	90.18	92.85

Source: Singh (2019); Singh (2016); Department of Agriculture, Cooperation & Farmers Welfare (Govt. of India), (2017 and 2017a).; Annual Report (2016-17)

In the past six decades, cropping intensity increased from 111 in 1950-51 to 141.6 in 2014-15, mainly due to the increase in gross irrigated area from 22.6 mha to 96.46 mha during the same period (Singh, 2019). In India, 63 percent holdings are below 1 ha, and that accounts for 19 percent of the total operated area, while over 86 percent holdings are less than 2 ha accounting for nearly 40 percent of the area. Fragmentation of operational farm holdings is another major concern in this respect and the average size of holdings has shrunk from 2.82 ha in 1970-71 to 1.15 ha in 2010-11 and to 1.08 ha in 2015-16 (Singh, 2019). The number of operational holdings increased by 105% in past five decades from 71 million in 1970-71 to 146 million in 2015-16.

The major food crops grown in India include rice, wheat, maize, millet, bajra, ragi, and pulses. Cotton, jute, sugarcane, oilseeds such as groundnut, linseed, rapeseed, etc are grown as cash crops. Major fruits and vegetables include apple, peach, pear, apricot, almond, strawberry, walnut, mango, banana, citrus fruits, potato, onion, and carrot. Major plantation crops include tea, coffee, spices (cardamom, chillies, ginger, turmeric), coconut, arecanut, and rubber (Table 3.2.2).

Table 3.2.2: Percentage of Different Crops to Total Cropped Area in India

Crop	1950-51	1990-91	2016-17
Rice	23.5	23	21.6
Wheat	7.6	12.9	15.4
Sorghum	11.8	7.6	2.2
Pearl millet	7.4	5.8	3.4
Maize	2.5	3.2	4.9
Total cereals	61.1	55.5	48.7
Chickpea	5.9	4	5
Pigeon pea	1.7	1.9	2.3
Total pulses	15.6	13.4	15.1
Total food grains	76.7	68.9	63.8
Groundnut	3.3	4.5	2.3
Rapeseed & mustard	0.8	2.8	3.6
Soybean	-	1.4	5.7
Total oilseeds	8.3	13.5	13.2
Sugarcane	1.3	2.1	2.7
Total fruits	0.6	1.4	3.4
Total vegetables	1.2	2.2	5.4
Cotton	4.3	4.1	6.3
Total fibres	5.1	4.7	6.7
Total cropped area (mha)	131.9	185.7	193.1

Source: Singh (2019)

It is clear from the past trends in cropping systems that expansion in area has occurred in favour of those crops which have either shown a higher growth rate of production due to technological development or whose relative prices with competing crops have moved in their favour.

3.2.2 Mechanization

3.2.2.1 Machinery statistics (Imports/Exports/Domestic production) for the last 5 years

Among various inputs for intensive agriculture, farm mechanization has made significant contribution in increasing agricultural production and productivity through timeliness in operations, efficient application of inputs, conserving soil and water resources; and reducing losses on the farms, pollution and drudgery apart from increasing cropping intensity. Mechanization in association with improved crop inputs have shown improved yields by 10-15%. Amidst growing concerns about manpower availability and shrinking profitability of agriculture as enterprise, the need has been felt for appropriate, affordable and energy efficient equipment and technology for cost effective production and processing of crops. These equipment and technology increased yield, reduced cost of cultivation, prevented losses and added values through location specific management practices. The farmers have realized these advantages and mechanization is in an increasing trend in most parts of the country (Table 3.2.3). However, the type of equipment suitable for cultivation and the rate of introduction of new equipment are to be considered with multidisciplinary approach specific to the site needs.

Table 3.2.3: Level of Farm Mechanization in India (Overall mechanization is about 55%)

Operation	Percentage
Soil working and seedbed preparation	60
Seeding and planting	40
Plant protection	50
Irrigation	45
Harvesting and threshing	70-80% for wheat and rice and less than 25% for others

Source: Singh and Singh (2018)

3.2.2.2 Trend of tractor sales

Domestic sale trend revealed a continuous upward during 2004-05 to 2013-14 and slightly decreased during 2014-15 & 2015-16 and again got momentum in 2016-17 (Fig. 3.2.1). Domestic sale during 2004-05 was 247,351 units increased to 607,000 units during 2011-12 and registered cumulative annual growth rate (CAGR) of 12.73%. Sizeable rising sale trend was again maintained up to 2013-14 with 696,828 units and shown a CAGR of 10.18%. CAGR for the overall period (2005-06 to 2016-17) was found 5.83%. The production and sale of tractors during 2016 and 2017 is given in Table 3.2.4. The increasing trend in sale of tractors over the years indicated a rising acceptance of agricultural machines and equipment with the Indian farmers. Leading tractor manufacturers during 2016 and 2017 are listed in Table 3.2.5. Export trend of tractor during the period 2004-05 to 2016-17 was analysed and shown in Fig. 3.2.1. Export of various hp of tractors during 2004-05 was 20,076 units increased to 62,591 units in 2016 -17 registered a CAGR of 5.93%.

Figure 3.2.1. Domestic Sale and Export of Tractor for India since 2004-05 till 2016-17

Source: Singh (2016), Singh (2016a)

Among all the tractor manufacturers of the country, the top five manufacturers in sales of tractors during the last five years were the Mahindra & Mahindra group, TAFE group, Escorts, Sonalika and John Deere (Table 3.2.5). These five manufacturers constituted more than 90% of total tractors sold during the period 2009-10 to 2012-13 and about 85% in 2015-16. Mahindra & Mahindra group ranked first with about 40% of the total tractors sold as far as the individual manufacturer is concerned, followed by TAFE group (22-25%), Escorts (10-13%), Sonalika (8-10%) and John Deere (7-10%) during the period of five years. The share of other manufacturers namely New Holland, SAME DEUTZ-FAHR, VST, HMT and Force Motors together contributed 9 -15% of the total tractors sold during the period of 2009-10 to 2015-16. Horsepower wise tractor sold by different manufacturers was also analysed (Table 3.2.4). In the range of < 20 hp, Mahindra & Mahindra Group ranked first followed by VST and Sonalika during 2015-16. In the range of 21-30 hp, Mahindra & Mahindra group again registered first rank followed by TAFE group and Sonalika. Mahindra & Mahindra group again ranked first with over 72,000 units sold followed by TAFE group, Escorts and Sonalika during 2015-16 in the 31-40 hp range. Range of 41-50 hp tractors were the most preferred in 2015-16 in which Mahindra & Mahindra group stood first followed by TAFE group, Escorts, Sonalika and John Deere. In high hp range >50 hp, John Deere ranked first followed by Sonalika, Mahindra & Mahindra group and New Holland for the year 2015-16.

Table 3.2.4: Sale of Different Range of Tractors (in numbers) in India from 2016 to 2017

Manufacturers	hp range	Production		Sale		Export		Total	
		2016	2017	2016	2017	2016	2017	2016	2017
VST	< 20 hp	5147	6280	5458	5873	33	92	5491	5965
ESCORTS		588	1300	587	1297	0	0	587	1297
Mahindra		11989	10389	10636	10362	7	13	10643	10375
TAFE Group		0	112	0	104	0	0	0	104
Sonalika		2313	2659	2068	2261	325	278	2393	2539
Total		**20037**	**20740**	**18749**	**19897**	**365**	**383**	**19114**	**20280**
FORCE Motors	21-30 hp	1755	1594	2051	1853	11	0	2062	1853
ESCORTS		197	276	197	279	0	0	197	279
VST		1704	1825	1575	1810	2	20	1577	1830
Mahindra		14797	15313	12003	14909	38	26	12041	14935
TAFE Group		5780	7352	6272	7923	66	59	6338	7982
Sonalika		2975	3544	2221	2331	888	1283	3109	3614
Total		**27208**	**29904**	**24319**	**29105**	**1005**	**1388**	**25324**	**30493**
FORCE Motors	31-40 hp	209	113	177	207	2	0	179	207
ESCORTS		19970	26426	20009	25643	152	192	20161	25835
Mahindra		71669	75811	69471	77304	2802	2394	72273	79698
TAFE Group		44869	48303	44252	60576	704	802	44956	61378
John Deere		7703	9997	7231	11997	0	0	7231	11997
New Holland		3859	4211	3733	3994	208	242	3941	4236
SAME		171	151	63	133	106	0	169	133
SONALIKA		20782	21440	20577	21976	538	555	21115	22531
Total		**169232**	**186452**	**165513**	**201830**	**4512**	**4185**	**170025**	**206015**
FORCE Motors	41-50 hp	550	418	491	531	6	7	497	538
ESCORTS		26521	26876	25284	25186	274	410	25558	25596
Mahindra		102649	127119	101777	123260	5047	5564	106824	128824
TAFE Group		50050	56970	45445	38699	5786	6588	51231	45287
John Deere		19834	26356	18367	23959	0	0	18367	23959
New Holland		12184	12851	10141	11351	1878	1769	12019	13120
SAME		2462	3138	882	1389	1264	1920	2146	3309
Sonalika		24888	30493	22405	27413	2327	2930	24732	30343
Total		**239138**	**284221**	**224792**	**251788**	**16582**	**19188**	**241374**	**270976**
ESCORTS	> 51 hp	2345	3208	1997	3029	252	801	2249	3830
Mahindra		14403	15867	9110	10765	3154	3826	12264	14591
TAFE Group		6294	7599	869	1159	5386	6017	6255	7176
John Deere		16080	23657	7795	9277	8972	11109	16767	20386
SAME		7395	4708	431	589	7060	4369	7491	4958
Sonalika		12612	13850	7329	9224	5145	4187	12474	13411
New Holland		9447	10862	3086	3968	6475	7138	9561	11106
Total		**68576**	**79751**	**30617**	**38011**	**36444**	**37447**	**67061**	**75458**
All manufacturers and all hp range									
ESCORTS	All horsepower range	49621	58086	48074	55434	678	1403	48752	56837
FORCE Motors		2514	2125	2719	2591	19	7	2738	2598
Sonalika		63570	71986	54600	63205	9223	9233	63823	72438
Mahindra		215507	244499	202997	236600	11048	11823	214045	248423
TAFE Group		106993	120336	96838	108461	11942	13466	108780	121927
John Deere		43617	60010	33393	45233	8972	11109	42365	56342
New Holland		25490	27924	16960	19313	8561	9149	25521	28462
SAME		10028	7997	1376	2111	8430	6289	9806	8400
VST		6851	8105	7033	7683	35	112	7068	7795
Total		**524191**	**601068**	**463990**	**540631**	**58908**	**62591**	**522898**	**603222**

Source: Tractor Mechanization Association (TMA), Singh (2016a)

Table 3.2.5: Leading Tractor Manufactures during 2016 and 2017

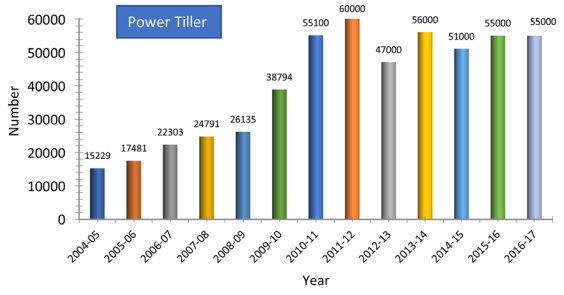
Manufacturers	2016		2017	
	Total production	Share in production, %	Total production	Share in production, %
M&M Group	214045	40.93	248423	41.18
TAFE Group	108780	20.8	121927	20.21
Sonalika	63823	12.21	72438	12.01
ESCORTS	48752	9.32	56837	9.42
John Deere	42365	8.1	56342	9.34
New Holland	25521	4.88	28462	4.72
SAME	9806	1.88	8400	1.39
VST	7068	1.35	7795	1.29
FORCE Motors	2738	0.53	2598	0.44
Total	522898	100	603222	100

Source: Tractor Mechanization Association (TMA); Singh et al. (2015)

3.2.2.3 Trend of power tiller sales

The production of power tillers started in 1961 with license to manufacture 12 models. The manufacturers started offering these to farmers in various states covering upland and wetland farming conditions. Their introduction coincided with that of agricultural tractors, which were more suitable for upland work and provided more comfortable work environment to the operators. The power tiller models being manufactured and imported are being marketed for wetland, stationary, and haulage work. The available models have a drawbar power between 5.3 kW to 10.7 kW. The year-wise sale of power tiller is given in Fig. 3.2.2 and production and import data in Table 3.2.6.

Figure 3.2.2: Power Tiller Sales Data in India since 2004-05 till 2016-17



Source: Singh (2016), Singh (2016a)

Table 3.2.6: Production and Import of Power Tillers (Two-wheel tractors)

Year	Production (Numbers)	Import (Numbers)	Export (Numbers)	Domestic sale (Numbers)	Total sale (Numbers)
2010-11	38500	16500	-	55000	55000
2011-12	39482	17392	-	56874	56874
2012-13	32812	13288	-	46100	46100
2013-14	40748	11103	-	51851	51851
2014-15	39500	11500	-	51000	51000
2015-16	40500	14500	-	55000	55000
2016-17	42500	12500	-	55000	55000

Source: Singh (2016); VST Tillers Tractors; Power Tillers Manufacturers Association (PTMA)

3.2.2.4 Production of Machineries in India

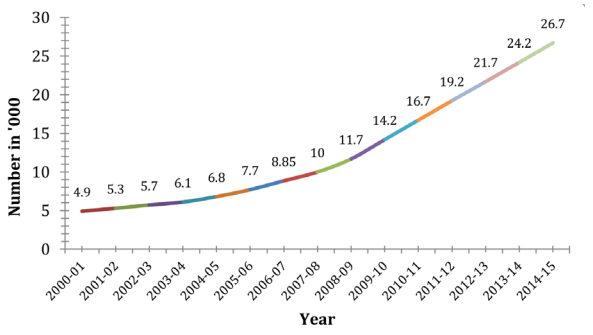
As farmers are becoming more able to appreciate the advantage of using machineries in agricultural production, recent years have seen a notable increase in agricultural mechanization levels in many parts of the country. However, the type of equipment suitable for cultivation and the rate of introduction of new equipment are to be considered with multidisciplinary approach specific to the site needs. During the past four decades a large number of farm tools, implements and machines have been developed for different farm operations such as land levelling, seed bed preparation, sowing and planting, weeding and hoeing, plant protection, harvesting, threshing, de-husking, and decorticating (Table 3.2.7). Trend in self-propelled combine harvester is increasing; and the growth was significant since 2005-06 (Fig. 3.2.3).

Table 3.2.7: Population of Farm Machines in India for Year 1992-93, 2003-04 and 2013-14

Farm Machinery	Number of farm machines available ('000)				
	1992-93	2003-04	% Increase over 1992-93	2013-14	% Increase over 2003-04
Manual Operated Machinery					
Sprayer	1827	2046	12	2214	8.2
Animal Operated Machinery					
Wooden plough	43464	44267	1.8	44997	1.6
Steel plough	12649	19622	55	25972	32.4
Seed drill/ Seed-cum-fertilizer drill	472	963	104	1474	53.1
Wet land puddler	5151	8550	39.7	11640	36.1
Animal cart	15220	16577	8.9	17663	6.5
Tractor/power operated machinery					
Power operated sprayer/duster	303	561	85.1	796	41.9
MB Plough	408	852	108.8	1328	55.9
Cultivator	706	949	34.4	1170	23.3
Disc harrow	531	913	71.9	1260	38
Seed cum fertilizer drill	390	1011	159.2	2852	182.1
Planter	54	75	38.9	92	22.7
Leveller	1057	1827	72.8	2343	28.2
Thresher/Multi crop thresher	2597	5309	104.4	7775	46.4
Combines (Both tractor-drawn and self-propelled)	8.5	20	135.3	59	195

Source: Livestock Census (2003); Tyagi et al. (2010)

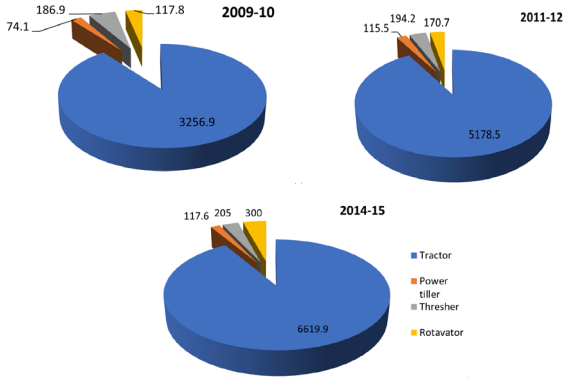
Figure 3.2.3: Trends in S-propelled Combine Population in India since 2000-01 till 2014-15.



Source: Singh (2016a)

Agricultural machinery market is estimated to grow at a cumulative annual growth rate (CAGR) of about 10% in next 10 years. The market for threshers (multi-crop and paddy), rotavator, planters and zero till drill in India is highly un-organized and is dominated by large number of small and medium scale enterprises (SMEs). By far the sale of tractors has been the highest among all types of machinery and it was of the order of US$ 3,256.9 million in 2009-10 increasing to US$ 6,619.9 million in 2014-15 (Fig. 3.2.4). Similarly, market size of threshers was US$ 186.9 million in 2009-10 which increased to US$ 205 million in 2014-15; that of rotavator was US$ 117.8 million in 2009-10 and increased to US$ 300 million in 2014-15. The high rate of subsidies up to 50% provided by the government is expected to encourage large number of farmers to purchase farm equipment in coming years. Table 3.2.8 gives year-wise population of some of farm equipment. Except rotavator production of other equipment is as per demand. However, 8-10% of rotavator production is exported.

Figure 3.2.4: Market Share of Different Farm Equipment (US$ million)



Source: FICCI India (2015)

Table 3.2.8: Population of Agricultural Machinery in India since 2006-07 till 2015-16

Name of equipment	Year				
	2006-07	2007-08	2008-09	2009-10	2010-11
Rice transplanter[1]	-	-	-	-	377
Self-propelled/tractor operated reaper[2]	-	-	1492	3676	5926
Reaper binder[3]	210	640	1105	1545	2145
Rotavator[4]	11500	16500	23000	30000	46000

Name of equipment	Year				
	2011-12	2012-13	2013-14	2014-15	2015-16
Rice transplanter[1]	753	1157	1979	2913	-
Self-propelled/tractor operated reaper[2]	8776	11976	15536	19386	-
Reaper binder[3]	2805	3855	4855	6235	7575
Rotavator[4]	71000	111000	161000	221000	291000

Source: [1]VST Tillers Tractors Ltd.; [2]Reaper manufacturers assessment; [3]BCS India Pvt. Ltd.; [4]Farm Implements (India) Pvt. Ltd.

The scenario of farm mechanization has certainly changed as the Indian agricultural equipment market has experienced a rapid growth with expected strong potential for future growth as well. There has been a surge in demand over the past few years for tractors, power tillers, combine harvesters, rotavators, threshers and rice transplanters. The current annual market for tractors is more than 500,000 and power tillers more than 55,000 units (Table 3.2.9). The combine harvesters' market is estimated at 4,000 units annually. It is estimated that the annual requirement for rotavators, threshers and power weeders is 120,000; 70,000 and 40,000, respectively. The sales of machinery like MB plough (50,000), laser guided land leveller (3,000) and planter (20,000) are growing fast for custom hiring purposes even though prices are high. Given the constraint of limited days for usage of machinery, the operational and capital costs may be optimized for the farmers by making the machinery available on custom hiring. Thus, even small farmers are able to get the benefit of agricultural mechanization. Setting up custom hiring services will be able to provide the machinery on need basis to the small and medium farmers.

The production and sale of farm equipment is given in Table 3.2.9. The variation of these figures is driven primarily by rainfall and weather conditions. If rainfall is good, production and sale increase. Indian farm machinery market is mostly met from local production except for sprayers, power weeders, small combine harvesters and power tillers.

Table 3.2.9: Annual Market of Major Farm Machinery Used in India for Year 2015*

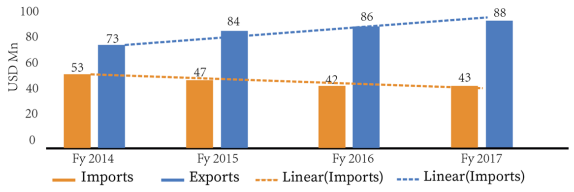
Item	Estimated quantity sold (thousand)	Item	Estimated quantity sold (thousand)
Tractors	500	Power tillers	55
MB plow	50	Rotavator (Rotary tiller)	120
Cultivators	175	Harrows	130
Seed-fertilizer drills	70	Planters	20
Rice transplanters	2.5	Power weeders	40
Reapers	12.5	Threshers	70
Combine harvesters	4	Trailers	160
Sprayers (TD)	12.5	Laser land levellers	3
Potato diggers	30		

** Average figures*
Source: Singh (2016); Singh (2016a)

3.2.2.5 Import & export scenario of farm equipment

Historically, India has been a net exporter of farm equipment. Its export has continued to grow, while its import has experienced a steady decline. However, its export demand has seen many fluctuations due to seasonal changes and agricultural growth. Nevertheless, India is a strong exporter in agricultural machinery with a CAGR of 6.2 per cent between 2014 and 2017 as depicted in Figure 3.2.5 (FICCI, 2017). India's leading export market for agricultural machinery continues to be the United States, despite a decrease in the percentage of exports from 23.2 per cent in2016 to 20 per cent in 2017. In contrast, the import for agricultural machinery has seen a CAGR of around 6.8 per cent. China continues to be India's leading partner for imports with 10.2 per cent of total imports for agricultural machinery.

Figure 3.2.5: Import and Export of Agricultural Machinery



Source: FICCI (2017)

3.2.2.6 Trend analysis: Tractors

The Indian Tractor Industry is the largest in the world. It accounts for approximately one third of global production in recent years. The growth of sales volume of tractor industry in the past two decades shows an annual growth rate of 5.81 percent, despite seasonal variations that cause natural fluctuations in the demand of tractors. The various factors which affect the farmers' decision to purchase a tractor in a particular year include the term and conditions of tractor financing by the financial institutions, minimum support price for major crops, extent of deviation from normal rainfall, irrigation intensity, agricultural credit availability per hectare and fuel cost and availability of agricultural labour for various

time bound operations etc. In India, mechanization became successful when Government allowed the private sector to fully operate the agricultural machinery market including import and domestic trade. Agricultural machinery supply chains are operated entirely by the private sector. The market is highly developed and is equipped with well-supported and connected financing channels. Doing business in this market is similar to do business in other machinery and automobile market.

3.2.2.7 Mechanization clustered by application stages

Mechanization status crop-wise and operation-wise is given in Table 3.2.10. Seedbed preparation for most of the crops is almost 70-95% mechanized. Rice transplanting is only 10% mechanized whereas seed sowing for wheat, maize, potato is mechanized by 85%. Weeding and inter-culture is also mechanized by 65-85%. Harvesting of wheat, rice and potato is also mechanized by 75-85%.

Table 3.2.10: Present Status of Mechanization of Cultivated Crops (2013-14)

Crops	% Operations mechanized*			
	Seedbed preparation	Sowing/planting /transplanting	Weed & pest control	Harvesting & threshing
Paddy	85	10	85	75
Wheat	95	85	75	85
Potato	90	85	85	75
Cotton	90	55	55	0
Maize	90	85	75	55
Gram (chickpea)	90	55	65	35
Sorghum	85	40	65	25
Millets	85	35	65	25
Oilseeds	85	35	70	25
Sunflower	85	45	85	65
Fodder crops	85	30	85	15
Vegetable crops	75	10	85	<1
Horticultural crops	65	35	45	<1

**Estimated figures*
Source: Singh (2016a)

3.2.2.8 Gaps in mechanization by application stages

Cotton picking is totally manual in India (Table 3.2.10). Similarly harvesting of vegetables and fruits is done manually. Rice transplanting needs attention. Seeding and planting of vegetable and fruit seeds mostly done manually.

3.2.3 End-User Profile

Table 3.2.11 provides details of average size holding for different categories of farmers. Average size holdings by categories have gone down year by year. Average holding size for all categories of farmers was 2.28 ha in 1970-71 and further to 1.08 ha in 2015-16 (Singh, 2019). On the other hand, a number of operational holdings has increased (Table 3.2.12). For example, for all categories of farmers the operational holding was 71.01 million in 1970-71 and increased to 145.73 million in 2015-16.

Table 3.2.11: Average Size of Holdings by Different Size Classes

Major size classes		Average size of operational holdings (ha)				
		1970-71	1990-91	2000-01	2005-06	2010-11
Marginal	< 1 ha	0.4	0.39	0.4	0.38	0.39
Small	1 - 2 ha	1.44	1.43	1.42	1.38	1.42
Semi-medium	2 - 4 ha	2.81	2.76	2.72	2.68	2.71
Medium	4 – 10 ha	6.08	5.9	5.81	5.74	5.76
Large	10 ha & above	18.1	17.33	17.12	17.08	17.38
All size classes		2.28	1.55	1.33	1.23	1.16

Source: Department of Agriculture & Cooperation, Govt. of India (2014)

Table 3.2.12: Changes in Number of Operational Holdings

Major size classes		Number of operational holdings (million)					
		1970-71	1980-81	1990-91	2000-01	2010-11	2015-16
Marginal	< 1 ha	36.2	50.12	63.39	75.41	92.36	99.86
Small	1 - 2 ha	13.43	16.07	20.09	22.7	24.71	25.78
Semi-medium	2 - 4 ha	10.68	12.46	13.92	14.02	13.84	13.78
Medium	4 – 10 ha	7.93	8.07	7.58	6.58	5.86	5.48
Large	above 10 ha	2.77	2.17	1.65	1.23	1	0.83
All size classes		71.01	88.88	106.64	119.93	137.76	145.73

Source: Singh (2019)

India's small farms usually do not possess the economic condition to use agricultural machinery extensively. Given the constraint of limited days usage of machinery, the operational and capital costs may be optimized for the farmers by making the machinery available to the farmers on custom hiring. Thus, even small farmers may be able to get the benefit of agricultural mechanization. Setting up custom hiring services will be able to provide the machinery on need basis to the small and medium farmers. The investment capacity of majority of the farmers is poor. These farmers cannot own expensive farm power units and machinery. However, they are making use of modern technology like combine harvester, tillage equipment and planting/sowing machinery through custom hiring. This has helped them to improve the timeliness of operation, to increase land productivity and increase economic returns. India's granaries like Punjab and Haryana have set an example by establishing "Custom Hiring Centres". Diversification of agriculture need for and introduction of new machines and the trend among the farmers to use increasingly larger tractors will vastly expand the scope for custom hiring of farm equipment because in future multi farm use will be the only way to keep the operating cost of farm equipment at a reasonable level.

3.2.3.1 Current unmet needs by application for different types of crops

Major gaps are transplanting of rice, cotton picking, and mechanization of fruit and vegetable crops. Direct seeding of paddy both in lowlands and dry uplands with drum seeders is being popularized. Manual and power operated transplanters are promoted. Self Help Groups with entrepreneurship goals are encouraged to run the power-operated transplanters to work on custom hiring basis (Department of Agriculture & Cooperation, Govt. of India, 2018). Mat type nurseries are raised on a large scale to cater to the requirements in villages.

Enterprising farmers are encouraged to raise large-scale nursery farms on commercial basis. Sugarcane cutter planter and sugarcane harvester is introduced through the custom hiring schemes of sugar mills. Power weeders for intercultural operations and standard/improved spraying equipment for plant protection operations are being popularized for adoption in row crop and fruits and vegetable crops.

3.2.3.2 Demand

Farm equipment market in India is currently estimated at USD 8.8 billion in 2017 and it is expected to reach USD 12.5 billion by 2022 (Thornton, 2017). The availability and accessibility to adequate, timely and low-cost credit is crucial for sustainable and profitable farming systems. Policy measures over the years have focused on improving the accessibility to the institutional sources of credit for protecting the farmers from the illegal, money lenders' trap of usurious rates of interest. The small and marginal farmers, in particular, often face serious difficulties in accessing low cost institutional credit, which in turn hinders their ability to adopt modern technology and improved agricultural practices required for increasing agricultural production and productivity. In light of this, the key objective of the policy measures has been to progressively increase the allocation towards institutional credit for agriculture sector, with a focus on small and marginal farmers.

The Government of India fixes agriculture credit disbursement targets for the banking sector every year and banks have consistently surpassed these targets. The details of Agriculture Credit Targets fixed by the Government and the achievement by the Banks, for the last three years (2014-15 to 2016-17) as reported by National Bank for Agriculture and Rural Development (NABARD) are given in Table 3.2.13.

Table 3.2.13: Credit Target & Achievement in Agriculture by Government of India (1 USD = INR 70)

Year	Amount in INR million	Target allotted by GoI achieved INR million	Percentage achievement of target
2014-15	8,000,000	8,453,282	105.67
2015-16	8,500,000	9,155,099	107.71
2016-17	9,000,000	10,657,557	118.42

Source: National Bank for Agriculture and Rural Development (NABARD)[5]

The activity of money lending is regulated by the Indian State-specific money lending laws. The National Sample Survey Office (NSSO) conducted Situation Assessment Survey (SAS) of Agricultural Households during NSS 70th round (January- December 2013) in the rural areas of the country for reference period of the agricultural year July 2012- June 2013 which reveals that about 52 percent of the agricultural households in the country are estimated to be indebted. Across India about 60 percent of the outstanding loans were taken from institutional sources which included Government (2.1 percent), Co-operative society (14.8 percent) and Banks (42.9 percent) (Anon. 2019). Government/Reserve Bank of India (RBI) has taken several measures to increase institutional credit flow and bringing more and more farmers including small and marginal farmers within the fold of institutional credit. These measures inter alia, include the following major steps to provide hassle free crop loan to farmers including small and marginal farmers (SF/MF).

As per RBI directions, Domestic Scheduled Commercial Banks are required to lend 18% of the Adjusted Net Bank Credit (ANBC) or Credit Equivalent to Off-Balance Sheet Exposure (CEOBE), whichever is higher, towards agriculture[6]. (A sub-target of 8% is also prescribed for lending to small and marginal farmers (SF/MF) including landless agricultural labourers, tenant farmers, oral lessees and crop sharers. Similarly, in the case of Regional Rural Banks 18% of their total outstanding advances is required to be towards agriculture and a sub-target of 8% has been set for lending to small and marginal farmers.

With a view to ensure availability of agriculture credit at a reduced interest rate of 7% p.a. to the farmers, the Government of India in the Department of Agriculture, Cooperation and Farmers' Welfare launched an interest subvention scheme for short term crop loans up to Rs. 3.00 lakh. The scheme provides interest subvention of 2% per annum to Banks on use of their own resources. Besides, additional 3% incentive is given to the farmers for prompt repayment of the loan, thereby reducing the effective rate of interest to 4%. Further, in order to discourage distress sale of crops by farmers, the benefits of interest subvention has been made available to small and marginal farmers having Kisan Credit Card for a further period of up to six months (post-harvest) at the same rate as available to crop loan against negotiable warehouse receipts to store their post-harvest produce in Warehouses accredited by Warehousing Development Regulatory Authority (WDRA).

[5] Website: https://www.business-standard.com/article/news-cm/agriculture-credit-to-farmers-118032300412_1.html, accessed 25 July, 2019.

[6] Website: https://www.business-standard.com/article/news-cm/agriculture-credit-to-farmers-118032300412_1.html, accessed on 25 July, 2019.

The Government introduced the Kisan Credit Card (KCC) Scheme, for issue of KCC to farmers for uniform adoption by the banks, so that farmers may use them to readily purchase agriculture inputs such as seeds, fertilizers, pesticides etc. and draw cash for their production needs. Under the KCC Scheme, a flexible limit of Rs. 10,000 to Rs. 50,000 has been provided to marginal farmers based on the land holding and crops grown including post-harvest warehouse storage related credit needs and other farm expenses, consumption needs, etc., plus small term loan investments without relating it to the value of land. RBI has conveyed to Banks to waive margin/ security requirements of agricultural loans up to Rs.1,00,000/-. The requirement of 'no due' certificate has also been dispensed for small loans up to Rs. 50,000 to small and marginal farmers, sharecroppers and the like. Only a self-declaration from the borrower is required to bring small, marginal, tenant farmers, oral lessees, etc. into the fold of institutional credit, Joint Liability Groups (JLGs) have been promoted by banks. One of the main objectives of financing through JLGs is to augment flow of credit to landless farmers cultivating land as tenant farmers, oral lessees or sharecroppers and small/ marginal farmers as well as other poor individuals taking up farm activities, off-farm activities and non-farm activities. As of 31st March 2017, cumulatively 24.53 lakh Joint Liability Groups (JLGs) have been provided Rs. 26,848.13 crore loan by banks across the country.

As reported by NABARD, the share of SF/MFs accounts in total number financed by all agencies grew from 60.07 per cent in 2015-16 to 72.06 per cent in 2016-17[7] (. More importantly, in terms of the amount disbursed, the share of SMFs grew from 41.51 per cent (in 2015-16) to 50.14 per cent (in 2016-17). In actual terms, the agriculture credit disbursement towards SF/MF grew from Rs. 380 thousand crores in 2015-16 to Rs. 534 thousand crores in 2016-17, while the number of SF/MF accounts grew from 5.40 crore to 7.71 crore during this period (1 crore = 10 million).

Since the purchasing power of Indian farmers is generally low, the government has provided subsidy (Table 3.2.14) and credit at reduced rate to the farmers, who are economically and socially at disadvantageous position to adopt modern technologies. The long-term credits are usually applicable to the purchase of mechanization inputs and short term for the purchase of seed, fertilizer, etc. This is one of the indicators of progressive attitude of farmers. The agricultural machines and tractors are purchased through credit, available from organized financial institutions. The Government also provides incentives to farmers for the modernization of agriculture. This is linked to crop specific programs operated by state governments.

Table 3.2.14: Subsidy Given to the Farmers on Tractors and other Agricultural Machineries (INR 1.0 lakh = approx. US$ 1450)

Type of Agricultural Machinery	For SC, ST, Small & Marginal farmers, Women and NE States beneficiary		For other beneficiary	
	Maximum Permissible subsidy per Machine/ Equipment per beneficiary	Pattern of Assistance	Maximum Permissible subsidy per Machine/ Equipment per beneficiary	Pattern of Assistance
Tractors				
(i) Tractor (08-15 PTO HP)	Rs. 1.00 lakh	35%	Rs. 0.75 lakh	25%
(ii) Tractor (15 -20 PTO HP)	Rs. 1.00 lakh	35%	Rs. 0.75 lakh	25%
(iii) Tractor (Above 20-40 PTO HP)	Rs. 1.25 lakh	35%	Rs. 1.00 lakh	25%
(iv) Tractor (40-70 PTO HP)	Rs. 1.25 lakh	35%	Rs. 1.00 lakh	25%
Power Tillers				
(i) Power Tiller (below 8 BHP)	Rs. 0.50 lakh	50%	Rs. 0.40 lakh.	40%
(ii) Power Tiller (8 BHP & above)	Rs. 0.75 lakh	50%	Rs. 0.60 lakh.	40%
Rice Transplanters				
Self-Propelled Rice Transplanters (4 rows)	Rs.0.94 lakh	50%	Rs. 0.75 lakh	40%
Self-Propelled Rice Transplanters (i) above 4-8 rows (ii) above 8-16 rows	Rs. 2.0 lakh.	40%	Rs. 2.0 lakh.	40%
Self-Propelled Machinery				
Self-Propelled Machinery (i) Reaper cum Binder	Rs. 1.25 lakh	50%	Rs. 1.00 lakh	40%
Specialized Self-Propelled Machinery (i) Reaper (ii) Post Hole Digger/Augur (iii) Pneumatic / other Planter	Rs. 0.63 lakh	50%	Rs. 0.50 lakh	40%
Self-Propelled Horticultural Machinery (i) Fruit Plucker (ii) Tree pruners (iii) Fruit Harvesters (iv) Fruit Graders (v) Track Trolley (vi) Nursery Media Filling Machine (vii) Multipurpose Hydraulic System (viii) Power operated horticulture tools for pruning, budding, grating, shearing etc.	Rs. 1.25 lakh	50%	Rs. 1.00 lakh	40%

Source: Department of Agriculture & Cooperation (Govt. of India) (2014)

[7] Website: https://www.business-standard.com/article/news-cm/agriculture-credit-to-farmers-118032300412_1.html, accessed on 25 July, 2019.

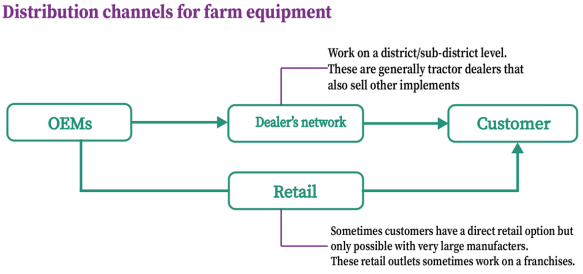
3.2.3.3 Consistency of demand

Tractor and agricultural machines market structure in India is open. All medium and large-scale manufacturers of tractors, power tillers, combine harvesters, and agricultural machinery have their dealer network throughout the state/country. Farmers/users are free to select their own brand of machines. Finance is available with the dealers also, which is 2-3 percent higher than commercial banks. However, farmers are free to go to commercial banks to get the loans. The major advantage is that the interest rate is charged at reducing rate by the commercial banks and account can be closed any time without any extra charge. That is not true with private financers. Market fluctuates a lot depending on the rain, minimum support price and demand.

3.2.4 Supply Chain

It is well recognized that to address the demands for agricultural machines there is a need to strengthen the network of regulated markets in the country and augment it with alternative marketing channels. The farm machinery supply chain is a sequence of processes (including decision-making and execution) and flows of materials, information and monetary resources that aim to meet farmers' requirements and needs. It refers to all power resources: human, animal and motorized. The farm power and machinery supply chains involve a range of stakeholders from manufacturers and importers through dealers, hire service providers, repairers and farmers (Fig. 3.2.6). The purpose of the input supply chain is to provide efficient and quality mechanization services to farmers for agricultural production and processing. How well agricultural equipment manufacturers are in this competitive market depends in part on a disparate group of factors, everything from weather and population trends to crop prices and technological developments. To accommodate this growing market demand, agricultural equipment OEMs (Original Equipment Manufacturers) have to maintain their production facilities to respond speedily and in a flexible manner.

Figure 3.2.6: Distribution Channel of Farm Equipment



Source: FICCI (2015)

The increasing demand for agricultural outputs requires support for aggregation of farm operations for increased and sustained productivity. Such aggregation can either be achieved through physical aggregation of farms or aggregating operation through cooperative/community farming or creation of farmer institutions such as Farmer Producer Organizations (FPOs) or Farmer Producer Companies (FPCs), The Federation of Indian Chambers of Commerce and Industry (FICCI). On the supply side, India presents abundant sources of raw material to meet the demands of the food processing industry. The production advantages are remarkable. However, the level of processing for perishables continues to be highly miniscule at around 10% and even lower for fruits and vegetables (less than 2%). On the other hand, the level of wastage of agricultural production is high and is estimated to be over INR 15 billion (0.2 billion USD) annually due to the dilapidated supply chain network. Warehousing and supply chain capacity in India has not kept pace with the production and procurement increase. The government buys grains from farmers but does not have adequate and proper space to store them. The preponderance of middlemen and agents in Indian agriculture renders the farmers and farming situations, still worse. Farmer needs on the demand-side are controlled by middlemen and agents who own the fragmented supply chains. They even control the produce pricing. Such a convoluted supply chain with poor infrastructure needs digital and disruptive solutions for improvements.

3.2.4.1 How do producers approach end-users?

The overall level of farm mechanization in India is about 55 percent. The Indian Council of Agricultural research (ICAR) has initiated Front Line Demonstrations of Improved Machinery for piloting the technology with the assistance of Department of Agricultural Cooperation of Ministry of Agriculture and Farmers Welfare, Government of India. Receptive farmers are provided implements, service and training to create awareness. Prototype workshops have been established for developing commercial grade machines for pilot introduction. The ICAR through All India Coordinated Research Projects (AICRPs) on Farm Implements and Machinery conducts demonstrations on farmer’s field under front line demonstrations on newly developed machinery. The ICAR has established more than 600 Farm Science Centres (Krishi Vigyan Kendras) almost one in each district in the country. These KVKs are mandated for verification of the technology in addition to providing skill workshops to the farmers and village artisans. State Agricultural Universities also provide extension services to farmers for mechanization activities.

3.2.4.2 Accessibility to products (for end users)

Agricultural machinery market is open and accessible throughout the country. Farmers can access a wide range of equipment, for example, through Krishi Vigyan Kendras (KVKs, Agricultural Science Centers). Until 1950, very few farmers possessed prime movers like tractors, engines and motors. Heavy agricultural tractors and machinery were imported by Government organizations mainly for land reclamation and development of large farms. The picture changed quickly during the early sixties with introduction of high yielding varieties of wheat and rice which needed irrigation facilities. Early trend of mechanization began with the use of stationary power sources such as engines and electric motors for pumps, tube wells, and threshers. In the late fifties India's first power thresher was innovated in Punjab (India) in 1957 and then after animal operated seed drills, diggers weeders etc (IASRI New Delhi, 2006). Mechanization of a crop or operation always began from Punjab and spreads to adjoining states and then to whole country. The farmers soon realized that the traditional water lifts which were driven by draught animals or operated manually could not meet the water requirement of high yielding varieties of wheat and rice. Therefore, lift operation was quickly mechanized through use of diesel engines or electric motors powered pumps. This made a sharp increase in wheat production and farmers suffered heavy losses because crop could not be harvested within normal harvesting period during late sixties and early seventies. Large scale adoption of threshers operated by electric motors, diesel engines and tractors that followed in early seventies onwards was a result of the need to complete threshing operation quickly. Then came the extensive use of tractors for tillage and transport and use of tractor operated and self-propelled harvesting equipment.

In the mid 1940's, surplus tractors and bulldozers resulting from the second world war were imported for land reclamation and cultivation. In 1947 central and state tractor organizations were set up to develop and promote the supply and use of tractors in agriculture. Up to 1960, the demand was met entirely through imports. There were 8,500 tractors in use in 1951, 20,000 in 1955 and 37,000 by 1960 (Singh et al., 2009; 2009a; 2011). Use of tractor for agriculture in India started during the '50s with annual introduction of about 8,000 imported units. Indigenous manufacture of tractor in India started in 1961 by 5 manufacturers with aggregate capacity of 11,000 units. Annual production was 880 units in 1961 and rose to over 5,000 units by 1965.

Subsequent to green revolution in mid-sixties, the farmers increasingly realized the advantages of using tractors for timely completion of operations. Availability of improved farm technology, government policy support, rise in awareness and resource availability among the farmers generated additional momentum to demand of tractor consequently stepping up of indigenous production to meet the requirement. Since late sixties, new manufacturers entered the market. By the seventies, annual production was around 20,000, and grew rapidly with sustained agricultural credit being offered by the government.

In the early eighties, the growth fluttered due to fluctuation in credit allocation resulting into survival of eight manufacturers by 1986. During remaining part of the decade, sale of tractor again gained momentum to an average of about 75,000 units per year and continued in the nineties with production of more than 150,000 units per year. Six new manufacturers were established during 1971-80. Credit facilities for farmers continued to improve and the tractor market expanded rapidly. A further five manufacturers began production during 1981-90 but only one of these survived in the increasingly competitive marketplace. Then India - a net importer up to the mid-seventies - became an exporter in the 1980s mainly to countries in Africa.

Since 1992, it has not been necessary to obtain an industrial license for tractor manufacture in India. By 1997 annual production exceeded 255,000 units and the national tractor population passed the two million mark. India now emerged as one of the world leaders in wheeled tractor production. M/S VST Tillers and Tractors Ltd was the only company who manufacture tractors of below 20 hp ranges and rest of the companies were selling the models of 21-30 hp, 31-40 hp, 41-50 hp and > 51 hp tractors.

Department of Agriculture & Cooperation (DAC), Government of India took initiative in promoting agricultural mechanization and in this direction the Department established four Testing and Training Institutes in the country. DAC also launched various promotional schemes providing subsidy to the farmers/users, and bank loans. It is well established that agricultural mechanization in India is driven by the needs and demands of the farmers, and that it is an essential input for the modernization of agricultural production. Medium and large farm holders can access agricultural machinery of better standard through self-financing or through the aid of custom hiring. Small farm holders due to their limited resources depend

on traditional equipment and methods of crop cultivation. Because of the low productivity of their lands, they also use low amount of crop inputs and do not adopt high yielding varieties of the seeds. The Government of India realizes the importance of agriculture to the development of the nation and hence has adopted several initiatives and programmes for this sector's continuous growth. Notable among them are Rashtriya Krishi Vikas Yojana (RKVY, State Plan Scheme of Additional Central Assistance); National Food Security Mission (NFSM); National Horticulture Mission (NHM); Gramin Bhandaran Yojana (capital investment subsidy scheme); Integrated Scheme of Oilseeds, Pulses, Oil palm, and Maize (ISOPOM), and lately the Sub-Mission on Agricultural Mechanization (SMAM) etc (Kale, 2015).

3.2.4.3 Services Support: Spare parts and technical support

The large and medium scale manufacturers have well organized distributors and dealers throughout the country to undertake the advertising and product promotion in their respective territories; conduct product awareness training programs for the prospective customers; provide after-sales-services to the customers including free services, repair and maintenance, supply of parts, etc. Therefore, this organized sector has country-wide market, which increased their production volumes and their information feedback. A few small-scale industries have established their local marketing network and therefore provide service support in their premises. In the absence of standardization of parts and components, farmers are compelled to carry their machines to the manufactures for repair and replacement of parts and components. Due to this constraint, their market size is limited to their proximity, and they are not able to develop their business. The village artisans on the other hand are located in the villages and therefore provide immediate attention to the needs of the farmers in their immediate neighbourhoods. Therefore, the tools and implements, etc. made by them are against specific requirements of individual customers.

3.2.4.4 Financing support availability: Types and mechanisms

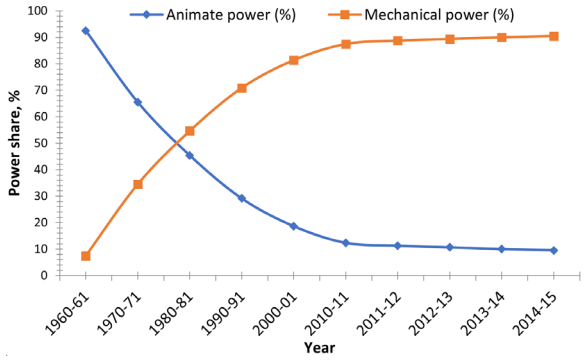
Agriculture accounts for 14 per cent of GDP. Recognizing the importance of agriculture sector in India's sustainable development, the Government and the Reserve Bank of India (RBI) have played a vital role in creating a broad-based institutional framework for catering to the increasing credit requirements of the sector. Agricultural policies in India have been reviewed from time to time to maintain pace with the changing requirements of the agriculture sector, which forms an important segment of the priority sector for lending of scheduled commercial banks (SCBs) and target of 18 percent of net bank credit has been stipulated for the sector. Two innovations, viz., micro-finance and Kisan Credit Card Scheme (KCCS) have emerged as the major policy developments in addressing the infirmities associated with the distributional aspects of credit in the recent years. The KCCS has emerged as the most effective mode of credit delivery to agriculture in terms of the timeliness, hassle-free operations as also adequacy of credit with minimum of transaction costs and documentation. The cooperative banks had a major share (51.5%) in providing loans to farmers followed by commercial banks (36.9%). It is estimated that as much as 95 percent of tractor sales are conducted on credit each year. Credit is extended by commercial banks, State Land Development Banks, and Regional Rural Banks.

3.2.4.5 Sustainability Issues

The relentless development efforts on farm management by extension services has increased the use of machines in agricultural operations. But the focus now needed is on customized mechanization with matching skill sets and taking note of the gender dimension. For example, in 1960-61, about 92.30 percent farm power was coming from animal sources, in 2014-15 the contribution of animal sources of power reduced to about 9 percent and that of mechanical and electrical sources of power increased from 7.70 percent in 1960-61 to about 91 percent in 2014-15 (Fig. 3.2.7). The process of agricultural mechanization in India is constrained by increasing fragmentation of land holdings which makes individual ownership of agricultural machinery difficult; domination of small and marginal farmers with limited capital availability, lack of finances; skill barriers to provide adequate support to modern technology; increasing environmental considerations, etc. In future, it is, therefore, necessary to establish a link between the possibility of sustainable development of agricultural mechanization without neglecting the lack of energy and environmental degradation due to low availability of fossil fuels and its high cost. Moreover, innovative solutions like customized farm machinery and equipment for different regions to cater to the needs of minimum tillage as well as inter-cultivation practices are important for tackling the emerging challenge in promoting farm mechanization. Financing of agricultural machinery is yet another area of concern. At present, only the tractor segment has access to long-term institutional credit; it has to be gradually extended to other categories of farm machinery to cater to the changing

needs of farmers. With a view to promote agricultural mechanization among small and marginal farmers and in the areas where the level of mechanization is very low, Government has started the Sub-Mission on Agricultural Mechanization in the year 2014-15. The scheme not only includes the traditional component of training, testing, demonstration of agricultural machinery and procurement subsidy but also includes Farm Machinery Banks for custom hiring, Hi-Tech High Productive Equipment Centres on custom hiring model, and farm mechanization in selected villages for enhancing productivity and creating ownership of appropriate farm equipment among small & marginal farmers. In addition, farm mechanization is being promoted through various other schemes and programmes of the Ministry of Agriculture.

Figure 3.2.7: Animate and Mechanical Power Scenario in Indian Agriculture



Source: Singh and Singh (2016)

3.2.4.6 Addressing the gaps

Major gaps are transplanting of rice, cotton picking, and mechanization of fruit and vegetable crops. Government agencies and ICAR Institutes and State Agricultural Universities are working on technologies that suit above. Direct seeding of paddy both in lowlands and dry uplands with drum seeders is being popularized. Manual and power operated transplanters are promoted. Self- help groups with entrepreneurship goals are encouraged to run the power-operated transplanters to work on custom hiring basis (Department of Agriculture & Cooperation, Govt. of India, 2018). Mat type nurseries are raised on a large scale to cater to the requirements in villages. Enterprising farmers are encouraged to raise large-scale nursery farms on commercial basis.

Sugarcane cutter planter (tractor drawn) and sugarcane harvester are being introduced under custom hiring schemes through sugar mills. Power weeders for intercultural operations and earthing up equipment are also being introduced. Tractor drawn groundnut harvester and groundnut wet pod thresher needs to be popularized. Power weeders for intercultural operations and standard/improved spraying equipment for plant protection operations may be popularized for adoption in cotton crop. Equipment for harvesting, retrieval, densification, fortification, handling and transport of crop residues is required to be introduced in large numbers for making best utilization of straw and other crop residues for feed, fodder and energy. Identification/development and promotion of high capacity, energy efficient equipment to do timely operations to reduce cost of operation and specific energy requirements needs to be done.

Promotion of custom hiring of high capacity equipment is proposed, so that marginal, small and medium categories of farmers can also take the advantage of mechanization. Power-operated weeders for narrow and wider row crops need to be introduced and popularized. High clearance tractors with narrow tyres will be required to be introduced for intercultural operations. Aero blast sprayers, orchard sprayers and electrostatic spraying equipment are being introduced for proper spraying in field and tall crops/orchards and for better deposition of chemicals. Combines and harvesters for crops such as sorghum, pearl millets, maize, pulses, oil seeds, sugarcane, cotton, safflowers, sunflowers, castor, etc. need to be introduced and popularized for timely harvesting. Equipment for mechanization of orchard crops - pit making, transplanting of saplings, pruning, spraying in tall crops, harvesting of fruits etc. need to be identified/ imported/ designed, introduced and popularized. Vegetable crop production has to be mechanized for which equipment from seed bed preparation, planting, transplanting of seedlings, inter culture, irrigation, spraying harvesting, picking/digging has to be identified/designed and introduced. In view of the large population of milk cattle and draft animals, it is necessary to introduce appropriate farm equipment for seeding, harvesting, baling, silage making, and machinery for making feed blocks and pallets.

3.2.5 Conclusion

India is second worldwide the leading producer of food grains, cotton, horticultural crops, dairy and poultry, aquaculture, and spices. Agricultural production is valued at US$ 401 billion in 2017. Over the three decades from 1970 to 2001, India's agricultural GDP rose from US$25 billion to US$101 billion, whereas from 2001 to 2017 it rose to US$401 billion. Productivity of all crops showed an increasing trend during last seven decades although magnitude of increase varied among different crops and that during the period 1950-51 and 1990-91 was considerably higher than during the period 1990-91 and 2016-17.

During the past six decades a large number of farm tools, implements and machines have been developed for different farm operations such as land levelling, seed bed preparation, sowing and planting, weeding and hoeing, plant protection, harvesting, threshing, de-husking, decorticating, etc. Trend in self-propelled combine harvester is increasing and increase was significant since 2005-06. Agricultural machinery market is estimated to grow at a Cumulative Annual Growth Rate (CAGR) of about 10% in future. The market for threshers (multi-crop and paddy), rotavator, planters and zero till drill is highly un-organized and is dominated by large number of small and medium scale enterprises (SMEs). Market share of tractors has been highest, to US$ 6619.9 million in 2014-15. Similarly, market share of thresher was US$ 205 million; that of rotavator US$ 300 million in 2014-15. The high rate of subsidies up to 50% provided by the government is expected to encourage large number of farmers to purchase farm equipment in coming years.

Tractor and agricultural machines market structure in India is open. Medium and large-scale manufacturers of tractors, power tillers, combine harvesters, and agricultural machinery have their own dealer network throughout the state/country. Farmers/users are free to select their own brand of machines. Finance is available with the dealers also which is 2-3 percent higher than commercial banks. Market fluctuates a lot depending on the rain, minimum support price and demand. The large and medium scale manufacturers have well organized distributors and dealers throughout the country to undertake the advertising and product promotion in their respective territories, conduct product awareness training programs for the prospective customers, provide after-sales-services to the customers including free services, repair and maintenance, supply of parts, etc. The village artisans located in the villages provide immediate attention to the needs of the farmers in their immediate neighborhoods.

Major gaps in mechanization are transplanting of rice, cotton picking, and mechanization of fruit and vegetable crops. Direct seeding of paddy both in lowlands and dry uplands with drum seeders is being popularized. Sugarcane cutter planter (tractor drawn) and sugarcane harvester is being introduced under custom hiring schemes through the sugar mills. Power weeders for intercultural operations and earthing up equipment are also being introduced. Tractor drawn groundnut harvester and groundnut wet pod thresher needs to be popularized. Equipment for harvesting, retrieval, densification, fortification, handling and transport of crop residues is required to be introduced in large numbers for making best utilization of straw and other crop residues for feed, fodder and energy. Identification/development and promotion of high capacity, energy efficient equipment to do timely operations to reduce cost of operation and specific energy requirements needs to be done. Promotion of custom hiring of high capacity equipment is proposed, so that marginal, small and medium categories of farmers can also take the advantage of mechanization.

3.2.6 Recommendations

- **For Private Sector**
  - The manufacturers should consider the standardization of farm equipment not only on components and spare parts but also on safety, end performance and environment. But, presently the standardization has been mainly on construction of the machinery rather than the above. This will help in the innovation of new technologies; upgradation of technologies and R&D. Standardization must also be considered on linkage between the implement & the prime mover (tractor) like power take-off shaft (PTO Shaft).
  - It is well recognized that to address the demands for agricultural machines, there is a need to strengthen the network of regulated markets in the country and enhance the industry's marketing channels. Manufacturers should make sure that their products are easily available to the users.

- **For Government**
  - Easy financing to farmers and industry: Farmers are not able to get financial support for the implements except tractors, power tillers and combine harvesters. Loan for agricultural machinery below INR 200,000 should be immediately financed by all the banks to the needy farmers. Banks should not insist on collateral security for loan less than INR 200,000. Agricultural industry is engaged in serving purely agriculture, so they should be provided all financial assistance for establishment and upgradation of infrastructure and technologies at the interest rate at par to that of agricultural loans. On the same line, Government should come up and work with manufacturers in strengthening the infrastructure for the agricultural machinery industries in terms of "Technology Up Gradation Fund" (TUF), more customized "Common Facility Centres" (CFC) etc.

- Formation of marketing board for export of agricultural machinery: There should be some agency to identify the demand for agricultural machines – in the country & abroad, where the machines can be easily adopted. Enquiries from abroad are not able to be finalized due to absence of authenticity by any Govt. agencies, especially African countries. Specialized Marketing Board/Agencies be formed to promote sale of agricultural implements and machinery manufactured in India by MSMEs.
- Exports: While the global agricultural machinery markets are valued at US$ 160bn, India's export share is a miniscule today only with the domestic market of around US$ 8bn. If properly supported on infrastructure, modernizing, innovation and marketing support, our industry can take a share of the growing global agricultural machinery market. Hence, various ministries and their support programs shall strengthen the capacity and capabilities of the industry to explore oversea market.
- There is a need to strengthen the network of regulated markets in the country. Government should make sure that market is properly regulated, and products are available to users at nearby market.

- **For Institutions**
  - Strengthening manufacturing and R&D: The institutions engaged in R&D of agricultural machinery should come forward to take up the advancement in the new technologies in agricultural machineries globally like automation, innovation, robotics, GPS, more electronic controls etc. Above all, the agricultural machinery industry should take up the Industry 4.0 directions and move along with it.
  - Since it is lagging behind in mechanizing transplanting of rice, cotton picking, and mechanization of fruit and vegetable crops, government agencies including the institutes under Indian Council of Agricultural Research, and state agricultural universities should promote technological innovation in these areas.

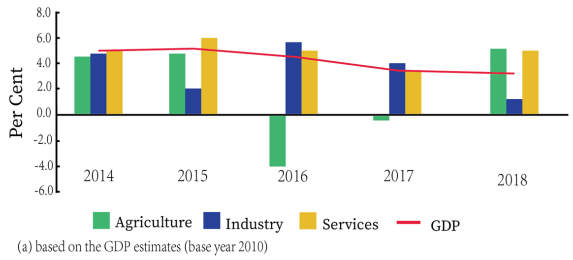
Photo by Fu Tang

3.3: Sri Lanka Country Market

General Overview

Sri Lanka, officially known as the Democratic Socialist Republic of Sri Lanka, is an island country in South Asia, located in the Indian Ocean to the southwest of the Bay of Bengal, below the southern tip of India. Consisting of an area of 65,610 km^2 and a population of 21.6 Mn (2018), the country has a literacy rate of 92.6% (2018). Its GDP at current market prices stood at US$ 88.9 bn whilst its GNI at current market prices stood at US$ 86.5 bn. Its GDP per capita stood at US$ 4,102 in 2018. Of the total employed, 25.5% are in agriculture. The economy grew moderately by 3.2% in 2018 compared to 3.4% in 2017 in the face of turbulences from a challenging domestic and external environment[8]. Adequate and timely precipitation during major cultivation seasons facilitated robust recovery in agriculture cultivation and production during the year, resulting in bumper paddy harvests. Service activities, which contributed 57.7% to the country's economy, were led by growth in wholesale & retail trade activities, tourism and financial services.

Table 3.3.1: Annual GDP Growth Rate (a): 2014 to 2016



(a) based on the GDP estimates (base year 2010)

Source: Department of Census and Statistics

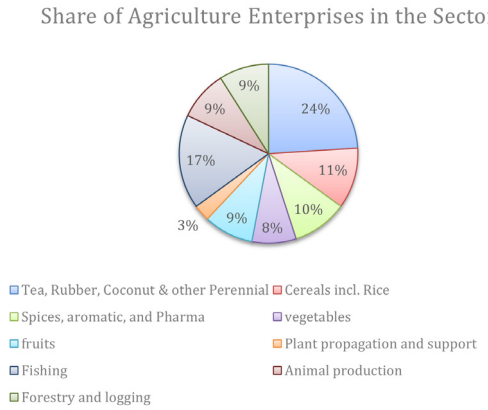
Source: Central Bank of Sri Lanka | Annual Report 2018

Overview of the Agriculture Sector

Overview

Agriculture continues to be one of the most important sectors of the Sri Lankan economy. Its contribution to the GDP has declined over the past 5 years, yet the sector still provides employment to 25.5% of the workforce, majority of which are from rural Sri Lanka. The sector is divided between traditional and non-traditional agriculture. Traditional agriculture consists of the production tea, rubber and coconut, whilst the non-traditional sector includes paddy, fruits, vegetables, yams, pulses & seeds, spices, other export crops and foliage plants. Sri Lanka's primary food crop is paddy. Paddy is cultivated during two seasons, namely 'Yala' (May-August) and 'Maha' (September-March). Expanded cultivation during the last decade, supplemented by higher yields, has allowed Sri Lanka to reach near self-sufficiency in paddy production. Tea, which is the major export crop, is cultivated in the central highlands and is a major source of foreign exchange. In recent years, there has been a significant growth in the production of maize in the country, the output of which is targeted at the growing animal husbandry industry.

Figure 3.3.1: Sectoral Representation as of 2018



Source: Central Bank of Ceylon, Annual report 2018

Overall, the agriculture sector has undergone a major structural change. The combined agriculture, forestry and fisheries contribution to GDP has shrunk from 17.5% in 2005 to 7% in 2018, whilst the contributions from manufacturing and services have increased to 83.8%. Services in particular has increased significantly, which is a reflection of the current state of the economy. However, with approximately 70% of the population living in rural and plantation areas, and engaged in agriculture for their livelihood, agriculture continues to be the backbone of the Sri Lankan economy. The agriculture sector is largely carried out by independent farmers and private sector organisations, whilst the government is mostly engaged in providing the requisite infrastructure, formulating regulatory

[8] Central Bank of Ceylon Annual Report (Vol 1) for the year 2018, accessed at https://www.cbsl.gov.lk/sites/default/files/cbslweb_documents/publications/annual_report/2018/en/3_KEI.pdf; on 12th July 2019

frameworks and in research and development. The area where government intervention is seen in a free market is the cash grant offered for fertilizer subsidisation and purchase of paddy production (in limited quantities) at a pre-determined pricing to augment rural farmer income. The other aspects of the value chain, namely agricultural production, processing, value addition and marketing, are mostly handled by independent farmers and private sector corporates.

Within the agricultural sector, one can observe a decline in the volume index for the traditional crops tea, rubber and coconut, whilst the volume index for the rest of the crops show an increase over the previous years (Table 3.3.2).[9]

Table 3.3.2: Volume Index of Agricultural Production 2008 - 2018

Items	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1. Tea	101.6	93.5	106.9	106.0	106.4	109.74	109.03	105.18	94.38	99.25	98.00
2. Rubber	141.4	150.2	169.0	174.4	166.4	144.8	108.90	97.84	87.38	91.77	91.21
3. Coconut	117.9	112.3	94.2	114.2	119.6	102.20	116.71	124.03	122.45	99.43	106.67
4. Paddy	135.5	127.7	150.4	139.5	134.5	161.56	118.21	168.51	154.55	83.33	137.41
5. Coarse Grain	372.6	423.9	524.3	443.2	641.5	711.28	770.94	833.35	780.00	626.35	857.00
6. Other Food Crops	114.3	116.2	118.6	120.3	141.7	143.72	154.1	157.40	158.50	124.82	139.06
7. Vegetables	145.0	148.8	145.5	154.2	177.9	106.87	197.13	196.23	208.61	177.14	213.07
8. Fruit	104.0	99.9	111.6	232.9	121.5	123.48	120.42	162.39	154.68	174.83	196.82
9. Livestock & Livestock Products	125.1	128.8	134.1	136.3	148.5	157.49	148.93	162.10	162.70	169.26	169.79
10. Minor Export Crops	103.9	109.6	117.3	117.2	119.9	122.1	122.38	161.95	160.67	167.02	190.55
OVERALL INDEX	120.4	117.3	124.8	156.8	153.8	177.87	153.01	184.30	179.40	138.77	172.68

BASE PERIOD - (2002=100)

Source: Department of Census & Statistics

The agriculture sector showed recovery in 2018 from the negative growth recorded in 2016 and 2017 due to adverse weather conditions. The year 2018 reflected a contribution of agriculture to GDP of 7% and a growth rate of 4.8% over the previous year[10]. Of this contribution, fisheries sector contributed 1.2% and livestock sector accounted for 0.6%.

Table 3.3.3: Production of Major Crops for the period 2012-2017

Crop	Production, '000 metric tons (MT)					
	2012	2013	2014	2015	2016	2017
Paddy	3,846	4,621	3,381	4,819	4,420	2,383
Other Field Crops						
Manioc	291	303	310	324	324	306
Maize	202	209	241	261	244	196
Potatoes	72	79	83	97	96	73
Big Onions	84	70	111	89	65	53
Red Onions	74	56	63	61	64	58
Groundnuts	22	27	25	29	24	22
Minor Export Crops						
Cinnamon	17	18	18	18	20	22
Pepper	19	28	19	28	18	30
Cloves	4	6	3	5	2	6
Plantation Crops						
Tea	328	340	338	329	293	308
Rubber	152	130	99	87	79	83
Coconut	351	379	716	552	765	466

Source: Central Bank of Sri Lanka. Economic and Social Statistics 2018.

Of the non-traditional sector, rice production is the most prominent sub-sector. Over one million farmers (mostly rural) are directly and indirectly engaged in paddy production. A noteworthy feature is that paddy production has grown from 3.652 Mn MT to 3.930 Mn MT over the last decade. Yield per hectare has also increased from 4,337 kg/h in 2009 to 4,443 kg/h in 2018. Rice today, has reached near self-sufficiency.

Other field crops (OFC) also have grown in production over the last few years, yet the quantities produced are not sufficient to meet local demand and therefore are imported to meet the shortfall (Annex 1). OFC production grew from 509,076 MT in 2017 to 606,926 MT in 2018. A noticeable growth is seen in the cultivation and production of maize which has risen from 67,219 hectares (ha) in 2014 to 70,895 ha in 2018. Regarding spices, Sri Lanka is the largest producer and exporter of Cinnamon, which is ranked no.1 in the world for its inherent qualities. Overall, the agriculture and fisheries production index grew by 10.7% over the previous year (Table 3.3.4).

Despite these progressive developments, the sector is not without its fair share of problems. Majority of the producers are small scale farmers who have limited access to quality inputs, financing facilities, marginalised land holdings, and marketing channels. Their income levels are low and borrowing from informal channels is their major source of financing. Consequently, they are frequently in debt. The declining interest of youth in traditional agriculture has also created a shortage of labour in the industry. Mechanization has played a significant role in this regard, particularly in land preparation and harvesting. A duty-free policy by the Government for importation of agriculture machinery has helped populate the mechanization of agriculture to an extent. The world bank-initiated agriculture modernisation project along with several other initiatives undertaken by the Government

[9] Agriculture and Environmental Statistics division, Department of Census & Statistics, Colombo, http://www.statistics.gov.lk/agriculture/indices/VolumeIndex.html ; accessed on 12th July2019

[10] Central Bank of Ceylon Annual Report (Vol 1) for the year 2018, accessed at https://www.cbsl.gov.lk/sites/default/files/cbslweb_documents/publications/annual_report/2018/en/3_KEI.pdf; on 12th July 2019

to improve the infrastructure facilities in the sector, including the modern climate-controlled warehousing project, are currently in progress and augurs well for the industry.

Table 3.3.4: Agriculture Production Index (2007-2010 =100)

Item	2017(a)	2018(b)	Growth Rate (%) 2016/17(a)	Growth Rate (%) 2017/18(b)
Agriculture and Fisheries	113.6	125.8	-10.7	10.7
1 Agriculture	104.3	119.2	-13.6	14.3
1.1 Agriculture Crops	96.5	112.5	-16.8	16.6
Paddy	63.7	105.1	-46.1	65.0
Tea	98.5	97.5	4.9	-1.0
Rubber	61.9	61.5	4.9	-0.6
Coconut	86.5	92.6	-18.6	7.1
Other Crops	135.7	152.8	-9.7	12.6
o/w Vegetables	123.4	145.3	-12.6	17.7
Fruits	164	183.9	12.5	12.1
OFC	117.9	134.2	-14.9	13.8
1.2 Livestock	166.6	172.6	5.3	3.6
2 Fisheries	159.2	158.0	0.1	-0.8

Source: Central Bank of Sri Lanka | Annual Report 2018

Mechanization

Sri Lanka has experienced a gradual transmission to mechanization, from its traditional animal plus manual farming methods since 1952. Massey Ferguson, made its first entry into Sri Lanka, signalling the beginning of mechanization with the introduction of the 'Grey Furgie' tractor. Since then, we have seen a gradual proliferation of various machineries and implements that has served to facilitate the mechanization of agriculture in Sri Lanka. The most commonly used machineries in the country include tractors, combined harvesters, power-tillers, sprayers, coupled with implements such as the nine-tine tiller, rotary and disc ploughs. Since of late Rice Trans-planters have been introduced, the crops that are being mechanised include Paddy, maize, sugar cane, and other field crops, such as vegetables and yams. . For the production of these crops, mechanization is mostly seen in land preparation, crop management, harvesting and, to a limited extent, in planting.

The major manufacturing sectors in the country are apparel, food & beverage, and tobacco with minimal exposure to industrial manufacture. Up to the present, almost 95% of the agricultural machinery requirements are imported. The only local manufacture that takes place in agriculture are basic implements, such as the nine-tine tiller and trailers for non-traditional agriculture. For the traditional agricultural sub-sectors, such as tea production, there are quite a number of industrialists manufacturing for the local industry as well as for export markets. Stainless steel sprayers are manufactured in Sri Lanka in significant quantities, but the local industry is currently under competition with imported plastic sprayers that come with a relatively lower cost.

Like many other countries in the Asia-Pacific region, Sri Lanka too is faced with a couple of challenges in its food production. One of the key challenges come from shortage of labour. Most of the rural labour have either gone overseas for foreign employment or gone in search of better income to other industries (particularly in construction) in the country. Consequently, the traditional family unit and its village community that was engaged in the agriculture production has diminished. Second, we observe the 2nd and 3rd generations moving away from agriculture and going in search of other industrial jobs. Thus, the number of individuals/families engaged in agriculture has reduced in numbers. Third, land holding per individuals are also marginalising. This is due to lands being transferred down generations and divided amongst the siblings causing the ownership per individual to be too small for farming to be economical. We now observe such individuals leasing out their lands to those who choose to remain in agriculture, and they choose to move into blue/white collar jobs. Fourth, by far the biggest challenge concerns the chaotic weather patterns that climate change entails. Not so long ago, one could predict the onset of the monsoons fairly accurately with a plus or minus of seven-day variance. Thus, farmers used to have sufficient time for planning and preparation. However, in recent years, we are experiencing not only unpredictable weather patterns, but also prolonged droughts which has brought the farmers and consumers with devastating effects.

On the positive side, declining labour market and adverse weather patterns have driven the desire to work speedily, improve productivity and cultivate/harvest within small windows of opportunity. These contexts have incentivised farmers to turn to mechanization. In addition, considering the frequent periodical droughts that we have been experiencing in recent years, water management is also becoming a critical aspect. The leasing of lands by those who are leaving the industry is creating a new group of large-scale farmers, who are now able to enjoy economies of scale in cultivation.

Tractors, predominantly in 47 to 55hp category, are mostly used in land preparation as well as for logistics. They have become quite useful, when transporting combined harvesters from one location to another. Tractors used in cultivation are coupled with rotavators in majority usage, whilst in some instances are also used with disc ploughs and nine-tine tillers. The majority usage of tractor is in the application of land preparation. Power-tillers, once the most extensively used machinery, has begun to decline in demand, especially considering the requirements for speedy response in land preparation. The commonest power-tillers in use are 12hp

followed by 8hp and 5hp. The use of 8hp and 5hp are geographic specific. Power-tillers are used once again in land preparation and is coupled with a rotavator. The 5hp machine, which is used in hilly topography, adopts a mould board plough for land preparation and, subsequently, a leveller to level the cultivated land.

A government initiative was introduced to promote the mechanization of the seeding process through the introduction of paddy trans-planters to the farmers. Specifically, in addition to the previous strategy of marketing only, the government launched a subsidised scheme to incentivise the farmers to adopt machinery. The outcome of the programme has not been very positive as the monetary cost and efforts required for mechanization process have continued to be high.

Water pumps (engine driven) and sprayers are widely used in crop management. Both products are locally manufactured as well as imported. There are a few significantly large and established players in both, water pumps and stainless-steel sprayers. The use of sprayers is extensive, since Sri Lanka is a tropical country and attracts weeds and pests under humid conditions. Also, a traditional practice of flooding induces farmers to use water pumps together with alkaline pipes to flood irrigate their lands to retain moisture conditions in the soil. However, with water sources gradually dwindling, low cost irrigation systems are beginning to enter the market to supplement water management. Considering the large costs associated with fully integrated irrigation systems, farmers are resorting to adaptive systems of their own to suit their budgets and availability of water.

The harvesting of crops, except for paddy, is generally manual in the country. While combined harvesters have taken over the manual harvesting and threshing of paddy, it is safe to say that almost 90% of harvesting & threshing is done today with combined harvesters. Lands with difficult access, small plot sizes are perhaps the exception. In such instances, manually harvested paddy are threshed using threshers and winnowers and sun-dried. Threshers and winnowers are both locally manufactured as well as imported.

Table 3.3.5: Import of Tractors, 2014-2018

	2018	2017	2016	2015	2014
India	3046	4068	5358	3618	1190
China	2	3	22	19	101
Japan	690	1078	670	476	191
Pakistan	1	36	20	18	58
Thailand	21	27	109	30	0
Others	22	136	33	5	17
Total	**3782**	**5348**	**6212**	**4166**	**1557**

Source: Author, adapted from Department of census & statistics

Table 3.3.6: Import of Combine Harvesters, 2014-2018

	2018	2017	2016	2015	2014
China	727	360	1504	900	454
Japan	20	10	5	33	95
India	1	23	106	89	0
Thailand	159	28	170	9	0
Others	3	5	60	48	48
Total	**910**	**426**	**1845**	**1079**	**597**

Source: Author, adapted from Department of census & statistics

Table 3.3.7: Import of Power Tillers, 2014-2018

	2018	2017	2016	2015	2014
China	380	1253	1521	4200	1547
India	52	13	184	47	38
Japan	690	996	724	724	1089
Singapore		100	0	0	0
Thailand	96	44	368	2	0
Vietnam	810	1667	2170	3136	1368
Others	23		60	0	7
Total	**2051**	**4073**	**5027**	**8109**	**4049**

Source: Author, adapted from Department of census & statistics

Trend analysis

- *Tractors*

The market for tractors has lost its growth momentum and shows signs of saturation. At present, the purchases of new tractors are shifting towards the replacement market as opposed to purchases by new customers, which are not the major. Almost 95% of the tractors sold in Sri Lanka are in the 47 to 55 hp range. Due to the soft soil conditions in paddy cultivated lands, the last 3 years saw growing demand for 4-wheel drive tractors. However, farmers today are experiencing high cost of maintenance for such 4-wheel drive tractors. With the word spreading around fast in the farming community, farmers are now considering transitions to other economic options. One of the most popular option is mini tractor in the 25 to 30 hp range. For those who yet possess a power tiller, and who wishes to upgrade to a tractor, this alternative is particularly suitable for small land-holding farmers.

- *Combine Harvesters*

The market is near saturation and is mostly a replacement market. Today, nearly 95% of the paddy harvesting is carried out by combine harvesters. Due to the limited lifespan of a combine harvester, unlike that of a tractor, the total annual demand would remain just under 1000 units. In view of fierce competition, current importers have continued to introduce combine harvesters with various new features to create a difference and attract customers.

- *Power tillers*

Power tiller, once the lead product in the industry, has gradually declined and have come down to one of its lowest levels in the past two decades. The market will continue to decline with considerable consumer shifting to tractor purchase or hire. Given the current weather conditions and availability of

of financing schemes (even at a cost) have meant that the opportunity to own a tractor has increased.

Table 3.3.8: Mechanization Clustered by Application Stages - Major Crops

	Land Preparation	Bund & Bed making	Seeding/Planting	Crop Management	Harvesting	Post-Harvesting
Paddy	• Tractors • Power-tillers • Rotary • Ploughs/Discs	None	Trans-planters	• Sprayers • Water Pumps • Micro Irrigation	• Combined Harvesters • Threshers • Winnowers	None
Maize	• Tractors • Power-tillers • Rotary • Ploughs/Discs	None	None	• Sprayers • Water Pumps	• De-huskers • Threshers	None
Sugar Cane	• Tractors • Rotary • Ploughs/Discs	None	None	• Sprayers • Water Pumps	None	None
Potato	• Tractors • Power-tillers • Rotary • Ploughs/Discs	None	None	• Sprayers • Water Pumps	None	None
Onions	• Tractors • Power-tillers • Rotary • Ploughs/Discs	None	None	• Sprayers • Water Pumps	None	None
Yams	• Tractors • Power-tillers • Rotary • Ploughs/Discs	None	None	• Sprayers • Water Pumps	None	None
Other Vegetables	• Tractors • Power-tillers • Rotary • Ploughs/Discs	None	None	• Sprayers • Water Pumps	None	Drying (limited scale)
Fruits	• Tractors • Power-tillers • Rotary • Ploughs/Discs	None	None	• Sprayers • Water Pumps	None	Drying (limited scale)

Gaps in mechanization

An observation of the table above indicates the gaps vis-à-vis crops and relevant applications. It is quite evident that most of the mechanization is yet concentrated in the paddy sector. Across the crop sectors, we also observe that there are several applications that can be mechanised such as bund and bed making, seeding and planting, harvesting and post-harvesting.

- *Land Preparation*

Whilst land preparation appears to be well covered by mechanization, there are still opportunities for further mechanization. Tractors, followed by power-tillers, dominate land preparation in the country. Tafe from India leads the market, followed by Mahindra & Mahindra and Kubota. There is a myriad of Indian tractor brands that dominate the Sri Lankan market. In the power-tiller market, Vykino from Vietnam and Sifang from China are the preferred brands amongst customers, whilst there are a number of private branded power-tillers of Chinese origin too in the market. Unlike most other countries in Asia-Pacific, for instance like Thailand which has vast flat lands for farmland, Sri Lanka usually consist of undulating and uneven surfaces of soil. This prescribed geographical constraint inevitably affects seeding/planting, germinating and water management in the country. As research has found that laser levelling can increase paddy yields by approximately 8% on average,[11] laser levelling appears to be an ideal solution that allows farmers to acquire superior returns while conserving water resources and reducing greenhouse gas emissions at the same time.

- *Bed making and Bund preparation*

Beyond tilling the land, rest of the work such as, bund making, bed making etc are still carried out manually. This is an area to be further mechanised. There are few isolated instances where mechanised bund making is carried out, which is insignificant. This process is labour intensive, but farmers keen to adopt technologies and mechanize the processes. In one of our field visits, a farmer was describing how a nine-tine tiller has been modified to make the bund, which is a crude version of a bund maker. For fairly medium to large scale cultivation of vegetable and yams, bed-making involves substantial cost. Introduction of bed makers and bund makers appears to be an ideal way to streamline the processes.

[11] https://ccafs.cgiar.org/research-highlight/laser-land-levelling-how-it-strikes-all-right-climate-smart-chords#.XVETLS0Q200 accessed on 5th August 2019

- *Seeding and Planting*

Farmers can choose between direct seeding and trans-planting. At present, barring paddy is carried out on a very limited scale, while seeding and trans-planting are carried out without the intervention of machines. Machines for seeding have been introduced from time to time, but results have not been successful. The reason behind this limited success is multi-fold. One of them concerns the generally uneven levelling of soil in the country. What is required is a systematic and a scientific approach to introducing appropriate machines that will work in the local environment.

- *Crop Management*

This is the stage where various practices are used to improve the growth, development, and yield of agricultural crops. Application of fertilizers, control of pests and weeds, management of water are some of the key phases in managing the crop prior to harvesting. The use of adequate tools and equipment can help accomplish the task faster and with less manpower, increase the time efficiency, and improve the productivity of the farmer. Currently, the type of mechanization in place are the use of sprayers and water pumps in most instances and the installation of micro irrigations systems to a limited extent. With the emergence of medium to large scale cultivations, opportunities for introducing fertiliser spreaders, precision sprayers and boom sprayers, as well as cost effective micro irrigation systems for specific crops can be seen.

- *Harvesting*

As mentioned earlier, mechanization of harvesting is significantly well covered in the paddy sector. The market is well supplied with a range of products and the penetration is near 99%. Kubota and Yanmar are two leading brands that supply paddy combined harvesters followed by a few Chinese brands, including Zoomlion and World. The other crops in terms of sizeable volumes that will require mechanised harvesting are mmaize, potato, sugar cane, onion, cassava (tapioca), peanut, sesame to name a few. Market sizes for these crops will vary especially at the beginning, but it is a chicken and egg story. A positive approach to take is to introduce appropriate harvesting machinery for these new crops, which in turn will stimulate cultivation. Most farmers stay away from growing profitable crops such as maize, potato, peanut etc, due to labour constraints connected with harvesting. Introduction of harvesting machinery, therefore, may act as a stimulus for farmers to move into production. A similar trend was seen in paddy cultivation about a decade ago.

- *Post Harvesting*

This segment of the application is still at a formative stage. Again, the paddy sector is taken care in post-harvest mechanization, mostly by large millers who have drying and storage facilities. However, an area of neglect is the small-scale farmer, who is forced to sun dry their paddy most of the time in makeshift situations. For instance, we see a majority of them sun drying their new paddy harvest on the roads where vehicles ply. The same goes for other crops too. The National Institute of Postharvest Technology (NIPHT), established under the aegis of the Ministry of Agriculture, has embarked on a process of improving the postharvest technology of rice/other grains, field crops, fruits/vegetables and spices through research, training/extension, consultancy/advisory and other development activities. The research & development centre of the institute has developed a range small scale machinery for post-harvest processing of paddy, grains, fruit/vegetables and oil crops. Commercial scalability is lacking, and potential opportunities exist for established firms to work in cooperation with the NIPHT and introduce solutions in post-harvest processing technologies.

End-User Profile

The total extent cultivated in Sri Lanka is said to be 5,643,277 acres (2,283,803 hectare), which is approximately 36% of the country's landholding. Of this total, the extent of small holdings of 40 perches or less is 239,677 acres (96,996 hectare), small holdings of more than 40 is 4,404,599 acres (1,782,517 hectare) and total extent of plantation sector is 999,001 acres (404,290 hectare)[12]. Of the total agricultural land 86 percent is utilized for crop and livestock while the rest of the area within the agricultural holdings is distributed among forest, pasture, meadows and land under houses and roads.

Table 3.3.9 indicates the land usage by categories. It is noteworthy that there has been an increase in the cultivated period from 2002 to 2103/14. It also signifies the fact that majority of the land holding is in the hands of small holders.

Table 3.3.9: Land Utilization within Agricultural Holdings (Both Sector) – 2014

Extent in Acres

Land use Groups	2013/14						2002	
	Total		Small Holdings		Estates		Extent	%
	Extent	%	Extent	%	Extent	%		
Arable Land	2,151,034	39.8	2,116,052	48	34,892	3.5	1,592,575	34.7
(a) Asw eddumized Paddy	1,712,585	31.7	1,706,410	38.7	6,175	0.6	1,228,219	26.8
(b) Other Temporary Crops	438,449	8.1	409,642	9.3	28,807	2.9	364,356	7.9
Land under Permanent Crops	2,481,792	45.9	1,761,721	40.0	720,071	72.1	2,260,923	49.2
Forest, Pasture, Meadows and abondoned paddy land	440,960	8.2	277,096	6.3	163,864	16.4	322,120	7.0
All other Land	329,814	6.1	249,730	5.7	80,084	8.0	419,204	9.1
Total Area of Holdings	5,403,600	100.0	4,404,599	100.0	999,001	100.0	4,594,822	100.0

Source: Department of Census and Statistics

Categories of farmers and scale

The major groups of farmers can be categorised as marginal farmers (those with land holdings less than ¼ acre), small farmers holding lands above ¼ acre and medium scale farmers, holding 20 to 49 acres of land and large-scale plantations and commercial farmers holding 50 acres and more. The enumerations carried out by the census department has grouped all the farmers and plantation companies together as those holding 20 acres and above. Accordingly, we can cluster the farmer community as:

- *Marginal farmers, with land holdings less than ¼ acre*
  - These groups of individuals are mostly engaged in agriculture for home consumption (e.g. home garden plots) and not necessarily for commercial use.

- *Farmers, small scale, holding ¼ acre to 19 acres*
  - This group consists of the major category of farmers in Sri Lanka. A majority of these farmers have received land under major settlement schemes, based on availability of irrigation facilities. The Mahaweli scheme is one of the largest settlement schemes in Sri Lanka. Under these numerous irrigation scheme settlements, farmers are allocated lands beginning from ½ acre to 5 acres of land for wetland and dry cultivations. Wetland cultivation is predominantly paddy, whilst dry cultivation are non-paddy crops such as maize, vegetables, pulses, seeds, yams etc. The type of cultivation also depends on the availability of water for distribution for agriculture purposes. These groups of farmers, mostly work with small machineries, such as power-tillers or rent out the machinery for their agriculture production.

- *Farmers, medium scale, holding 20 acres to 49 acres*
  - Farmers in this category are generally more affluent and operate on the threshold of becoming commercial scale farmers in the near future. Some own their lands, whilst some others lease land from those who have given up agriculture production, so as to have a contiguous block of land of a sizeable unit. These farmers, mostly individuals and some family owned, use larger machineries in their production process. Most of them own at least a tractor and in some cases a combined harvester too. In addition, they may also possess suitable implements, sprayers, water pumps etc. The early stages of adapting to micro irrigation systems are also seen amongst this group. They can also be considered early adapters of new technology in mechanization of agriculture and can be considered major influencers of the community in the village.

- *Farmers, large scale, holding 50 acres and above*
  - Those who carry out agriculture production in this segment consists of corporates and individuals. With sufficient resources they engage in commercial scale cultivation and are seen in tea, rubber, coconut (the traditional crops) as well as in fruits & vegetables, spices and other field crops. The agriculture practices are more scientifically carried out with professional input and with the extensive use of mechanization. Mechanization is seen mostly in land preparation, and to a lesser extent in seeding/planting, crop management, harvesting and post-harvesting. There is room for improvement in the application of mechanization so as to enhance productivity. It must be noted that the number of players in this segment is relatively smaller compared to the small-scale farmers. A few international players have entered this segment, notably ‘Dole” and will create a knock-on effect with their modernised agricultural practices.

- *Plantation companies, with large extents of land holdings, generally well above 500 acres*
  - Plantation companies managed by private enterprises, where the Government is also a stakeholder, mostly cover tea, rubber and coconut the traditional crops of Sri Lanka. These are large contiguous blocks of land which were originally established during the British rule over Sri Lanka. This sector is also plagued with shortage of labour and rising cost of production and are struggling to maintain their profitability. Efforts are being made to mechanise harvesting and crop management, where labour intensity is high. The slow adaptation is largely due to difficulty in changing the mind-set of the traditional beliefs and other cultural inhabitations, yet eventually the companies will have very little choice unless they begin to mechanise their labour-intensive processes.

Current unmet needs

From the foregoing and taking into consideration the analysis provided in table 3.3.8 the opportunity to enhance mechanization exists in all areas of application in the value chain of agricultural production. Most of the mechanization has been concentrated in paddy whilst in all other crops, there

is plenty of scope to introduce mechanization across different applications. In this context, the Government has increased several field crops other than paddy to drive its national food production programme. These crops include, maize, green gram, soya, finger millet, cowpea, black gram, onions and potato, where nearly 42% of the annual country requirements are imported. Except for crops such as potato and onions, most of the other field crops are produced by small scale farmers, of which the family unit is the main provider of labour. Mechanization in these crops, if at all, are confined only to land preparation, whilst seeding, planting, weeding, some aspects of crop management and harvesting are carried out largely manually. The opportunity to mechanise other field crops are wide open. A focused effort to adopt mechanization into this segment of agriculture production will yield positive results and will result in a win-win situation to both, farmers as well as providers of mechanization. A study carried out by a team from Hector Kobbekaduwa Agrarian Research and Training Institute on the mechanization of other field crops (Kumara, Weerasinghe and Epasinghe, 2016), reveal the following constraints:

- Supply side constraints
  - Incompatibility of machines supplied vis-à-vis the crops
- Demand side constraints
  - Lack of knowledge/awareness of available technologies
  - Farmer attitudes towards adopting new technology (negative)
- Cost of machinery and financing options

Interviews with farmers reveal challenges faced by themselves, which are in effect opportunities for mechanization. Some of these key challenges are as follows:

- Soil conditions are eroding and becoming soft. Farmers have turned to use 4-wheel drive tractors but finds it too costly to maintain. Some are now returning to tilling their land with a power-tiller.
- Overall operational costs for cultivation of paddy are high. In particular, bund preparation and cleaning, which is mostly manual, is a costly process.
- Transplanting has been found to be cumbersome and difficult to operate under different conditions. Farmers have returned to sowing seeds in the traditional manner, whilst some farmers have resorted to improvised ways of sowing, i.e. the parachute method and found it to be very productive and effective.
- Weeding during growing periods are carried out manually. Pest and weed management are another substantial cost component in the total cost of production.
- Harvesting, except in the case of paddy, are carried out manually. Here again, the cost of labour remains a key issue.

Overall, cost of labour and the effectiveness of the machineries in use (in some cases) are two primary concerns that needs improvement. Financing is of equal importance, since the farmers have very little choice when it comes to funding their procurement of machineries, which comes at a high cost.

Sri Lanka needs to embrace smart production methodologies by introducing new technology based agricultural mechanization, that is appropriate to the type of land topography and financial feasibility. Whilst basic mechanization through tractors, power-tillers, implements, combined harvesters and the like have contributed a significant extent, the adequacy of these machineries to meet the future challenges of a changing environment demands thoughtful consideration. Labour is not the only challenge today. Challenges, such as availability of water, changing agricultural time zones for cultivation, eroding soil conditions, marginalisation of lands, all demand novel solutions. Starting from land preparation and right up to post-harvesting, the Sri Lankan farmer has to reconsider appropriate and modern technology driven machinery.

Demand

Demand for agriculture mechanization has been driven specifically by need, as consequences to the challenges faced by farmers as aforementioned. The Sri Lankan Government does not have a subsidy scheme for agricultural mechanization. There have been ad-hoc programmes, albeit short term, that have provided subsidies to encourage farmers to embrace mechanization, but certainly not on a regular and consistent basis, as seen in countries such as China and India. A case in point is the subsidy offered to paddy transplanters about two years ago for a stipulated time period.

The major stimulus for mechanization is the shortage of labour followed by the availability of shorter windows for cultivation and harvesting consequent to erratic weather patterns. The shortage of labour is forcing the farmers to look for alternative means, viz., mechanization. Along with the shortage of labour, the increased cost of labour is also another stimulant for farmers to turn to mechanization as a solution. Mechanization

has proven to be far more productive than the use of manual labour, in terms of cost, efficiency and convenience. The only barrier that stood between opting to mechanise or not was primarily the availability of finance.

In the 1990s, majority farmers would purchase their machinery through savings, whilst a few would resort to taking a loan from a commercial bank. The entrance of finance and leasing companies changed the landscape of financing options available for agriculture machinery. Whereas a commercial bank would take anything from one week to a month to provide a financing facility, the financing and leasing companies began to provide such facilities from within two days to one week the most. Further, they also offer flexible and lower down payments, compared with a minimum 40% insisted by commercial banks, which began to simulate the purchase of machinery by farmers. These institutions also changed the way repayment was to be made, by offering seasonal repayments as opposed to monthly repayments that was offered by commercial banks. This simulated farmers to purchase machinery for their use with a minimal down payment and repayment settled after harvest. Today, this context has become a major advantage to farmers, who otherwise would have to depend on a few rich merchants who would hire their machines at exorbitant prices. Apart from pricing, the timely availability is also a major challenge. However, the benefit of such financing comes at a cost. The interest rates charged by financing & leasing companies are by far excessive when compared with commercial bank lending rates.

The other major simulant is disposable income levels. The choice of machinery and the price to pay is decided mostly by affordability. Whilst there exists demand for premium brands such as Kubota, the majority of the market is divided between average to low priced machines. Certainly, the quality and the associated standards are corelated to the price charged.

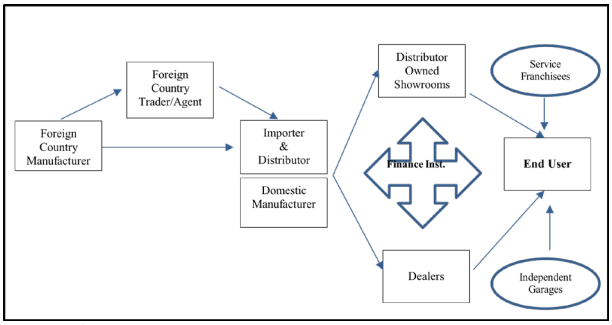
Consistency of demand

The demand for agricultural machinery is largely determined by the extent of land that is cultivated. It also depends on the availability of water during land preparation, seeding/planting and climatic conditions (dry weather) during harvesting. In the last decade, demand has been erratic due to unexpected changes in weather conditions. This generated a plethora of problems to different stakeholders. For the farmers, such conditions affected their cash flow and their livelihood. For importers and distributors, they were left with excessive stock build-up, which in turn affect their working capital and finance costs. For the finance and leasing companies, as unsatisfactory performance of the loans had led to appropriation of the borrowers' collateral, namely their machineries, the companies tended to sell those machineries back to the market. This then impacted the sale of new machineries in the forthcoming seasons. Further, when such a cycle occurs, the financing and leasing companies tend to increase the down payment required, and thereby stifling demand in the short run. Overall, it could be said that the demand for appropriate mechanization is steady since the Sri Lankan farmer is generally open for adaptation of new technologies, provided proper demonstrations are carried out and results shown. The cyclical nature of demand cannot be overlooked given that agriculture by nature is exposed to the vagaries of the weather.

Supply Chain

The supply chain for the flow of agriculture machinery from producer to end-user in Sri Lanka is captured in the diagram produced below.

Figure 3.3.3: Supply Chain



Source: Author

The supply chain for the distribution of agricultural machinery is structured and well-established in the country. Majority of the market is dominated by importers cum distributors and there are few domestic manufacturers, who are producing the light-weight machines, such as trailers, bowsers, nine-tine tillers, husking machines, hullers, and thrashers.

The heavy machines are all imported. Most of the major importers represent leading global brands as well as respective country brands in Sri Lanka. The importers/distributors (herein after referred to as distributors) import direct from manufacturers and in some instances through established trading companies. The imported machinery (knock-down or fully assembled form) are made ready for marketing in the distributor's warehouse and then delivered to the market through established dealers, which is the primary channel. In some instances, the products are marketed through the distributor's

warehouse and then delivered to the market through established dealers, which is the primary channel. In some instances, the products are marketed through the distributor's own branch network. It should be noted that there are no exclusive dealers, dealing in only a specific distributor's products. All dealers deal with multiple brands, and this practice enables them to offer the customer a choice, depending on their affordability or choice of brand. Except cash transaction, which is very rare these days, the financing facility for completing the sale is facilitated by the distributor's representative or the dealer himself with a finance company. A documentation process follows, and the initial down payment made before the customer can take delivery of the machine. It should be noted that financing facilities are not provided for implements and small machinery such as sprayers, water pumps etc. The spare parts also traded and financed through the same channel. Credit facilities for the purchase of spare parts are a personal matter between the customer and dealer and depends on their personal relationship.

After-sales services transpire in several ways. Service during warranty period is undertaken directly by the distributors and supported by their own service team. Post-warranty maintenance and repair services are provided by service franchisees or independent service centres run by private individuals. Service franchisees are supported by the distributor for technical know-how, training of mechanics and the supply of genuine parts. Independent service providers can decide for themselves, and they mostly cater to the customer according to his affordability. None of these channels precludes customers form dealing directly with the distributor, especially when there are major technical failures. The distributors also carry out national level mobile service campaigns from time to time, where inspection and labour is provided free and the customer has the choice of getting his/her machine attended to by paying only for the parts replaced. These programmes are very popular amongst farmers, since such campaigns happen in their vicinity.

Reaching the customer

Distributors can access their customers in several ways to create awareness of their existing products and new technologies. Listed below are tactics adopted by distributors for promoting their product/brand, technology and benefits to farmers:

- Direct sales visits by company sales representatives
- Field day activities including demonstrations to farmer societies in different parts of the country. Sometimes these activities are carried out with the support of the Department of Agriculture or with the local Agrarian Service Centres.[14]
- Small group presentations & discussions with farmer societies educating them on the technology, benefits and then giving the farmers the opportunity to raise questions and seek clarity
- Special financing schemes with selected financial institutions during seasons
- Street campaigns in the village, with a float carrying the product
- Distribution of product leaflets
- Merchandising at dealer locations
- Media advertising newspaper, TV and Radio

With the growth of the market for mechanization in agriculture, competition has intensified among the major distributors. This has resulted in a hype of activities for each distributor to market its product portfolio and brands to the farmer community and has raised the awareness levels significantly. Farmers are quite knowledgeable about brands and their respective performance levels and in a market, which is relatively small, bad news travels very fast! Hence, underperforming products have very limited life span.

The dealer network is fairly developed throughout the country. Farmers have easy access to these locations to select their choice of machinery. Most towns have several dealers representing a variety of products and brands, affording the customer an excellent choice.

Spare parts are imported by the distributor himself/herself (genuine parts) and distributed via the dealer network as well as there exist specialise spare part importers, who not necessarily bring down the original parts but low-cost duplicates as well. There are dealers who specialise in the sale of spare parts and lubricant only and in some instances, the machinery dealers themselves stock spare parts. In summary, it can be said that the availability of spare parts, both genuine and duplicates are well-represented for the available brands.

Financing

As aforementioned, financial institutions and the banking sector are well represented in both urban and rural Sri Lanka. Therefore, for a customer, proximity is no longer an issue,

[14] The main purposes of the agrarian service centre are providing services to the farmers in a specific region on; crop cultivation programming, water management, fertilizer application, pest management, harvesting, and post-harvest handling, transportation of food and the products. There are around 529 agrarian service centres located island wide.

provided that he/she has the capacity to borrow and pay-back. The banking sector follows the traditional established mechanisms in processing loans for agricultural machinery as per the laid down rules and regulations of the bank and such process can take as long as one week to two months. This is definitely not convenient to the local farmer. It works well with corporate farmers. This is where the finance/lease companies come to the fore. Their speed of processing is short as two days to a maximum of seven days, provided the required documentation is clear. However, such speed and convenience come at a cost, and this is where the average rural farmer suffers as they often have to pay a substantial component as interest at the end of the loan period. There are instances when farmers find it difficult to settle their loan commitments on time; instances such as drought affected season; crop damage due to an uncontrollable pest or weed infestation or sometimes flood situations. In situations such as these, although financial restructuring is an option, finance companies are quite clinical when it comes to recoveries. The finance companies either insist on seizing the machine for non-payment or proceed to recover an asset that may have been taken as mortgage, which places the farmer in a very awkward position.

The cost of funds leads to another issue: the question of sustainability. Repayment of loans, which are normally spread over 3 to 4 years means that most of the profits made by the farmer are consumed by interest charged. This has been raised at different forums by different stakeholders, especially at government level, but a sustainable solution is yet to be found. The government has from time to time offered re-financed schemes with low interest, but these are channelled through the banking system, which never reaches the rural farmers. This phenomenon is largely resulted from the bureaucratic procedures adopted, including the demanding of business proposals with financials, which are beyond the capability of a rural farmer. The beneficiaries of these schemes are ultimately the corporate farmers.

Sustainability: Economic, Social and Environmental

In July 2019, the Department of National Planning released its final draft of the Overarching Agriculture Policy for the country in response to the evolving priorities and challenges at global, regional and national levels. The policy is designed in alignment with the national vision of transforming Sri Lanka into a “knowledge-based, export-oriented competitive economy at the centre of the Indian Ocean”. The draft policy is designed a focus on the modernization of the agriculture sector towards enhancing and realizing the potential of agriculture to support sustainable national development and prosperity. Inter-alia, the draft paper focuses on increasing productivity, improvement in water management.

However, policies designed to focus on sustainable issues such as using more precise and energy efficient production technologies (such as reduced and no-tillage/direct seeding practices), emission standards, conservation agricultural practices are notably absent.

Gender

In general, women and youth constitute the largest segments of the population but are under-represented in both the economic and political spheres in the country. The female population is more than the male population. But the economic participation of women remains at a low level (i.e. 35%). Aspirations of moving into blue collar, urban base employment vis-à-vis low income prospects makes it difficult for the agriculture sector to attract youth, especially young women, to join the industry. Micro-scale farm operations also remain a major constraint for the promotion of technology-driven agriculture. Engagement of youth in modern agriculture can help the promotion of new technologies, for example, in the mechanization of largely manual sub-sectors.

Conclusion

Mechanization of agriculture in the paddy sector is by far the most advanced amongst all agricultural sectors in Sri Lanka. The trend that paddy has become and will continue to be the country’s main agricultural crop is highly understandable and expected. Yet there still exist rooms for further mechanization, for example, in bund-making and cleaning, seeding and planting, weeding, and post-harvest processing, during the crop’s production processes.

Sectors that are more opportunistic for mechanization are found in OFC’s and in traditional crops such as tea, rubber and coconut. The Government is keen to achieve self-sufficiency in OFC’s, where bulk of the country’s requirement remain imported. Whilst there have been introduction of machinery and equipment from time to time to this sector, the use of such equipment & machinery has not firmly established in applications. The Farm Mechanization and Research Centre (FMRC) of the Department of Agriculture (DoA), too has produced several prototype machines for commercialisation, but have met with limited success. In the mechanization of the OFC sector, there lay several major challenges. Transfer of

technology to grassroot level farmers, directly by distributors as well as through the extension services of the DoA, adapting existing machineries to suit present farm conditions, influencing the way of thinking of the farmer through demonstrations and confidence building by working alongside him in the installation programme, offering affordable and appropriate machinery and funding are some of the key aspects needed to be addressed. These concerns apply to the plantation sector as well. Whilst funding may not be an issue as much as for the traditional small-scale farmer, change of mindset of both the management and the worker in the plantation sector is critical to the higher adoption of technologies during the agricultural production processes.

The dilemma between "farms suited for appropriate mechanization" versus "mechanization to suit existing farms" can go on and on without a solution. Farmers are smart. They are in fact entrepreneurs with a good understanding of risks associated with agriculture. However, especially for the case of traditional small-scale farmers, they often consider conventional agricultural practices that were passed by generations. In light of the farmers' tendency to adhere to traditional practices, the private sector must act with empathy to understand the apprehensions a farmer may have and to dispel them with patience so as to create a win-win situation. Follow-up programme on how to use the machine, minimum maintenance procedures, continuous support will help reinforce the level of confidence the farmer will eventually build on the application of machinery. Once these effects are transferred, one could observe a snowball effect in the adoption of mechanization in the respective sectors. A case in example is the combine harvester. The first ever mechanization of paddy harvesting was the introduction of an 8hp harvesting machine, which would harvest the paddy and could be stored into a bag. Given the conditions at that time (1999/2000) the machine did overcome the initial issue of labour shortage during harvesting times but were riddled with many technical problems. The machine had issues with durability, continuous change of bags, difficulties in negotiating over bunds and so on. There were many complains. But there were no better choices at that point of time. The 8hp was supplanted by a 12hp harvester to increase the power of the operations. This was definitely an improvement from the original, but not without operational problems. Threshing had to be done separately, either manually or mechanised. After several years of operations, the farmers and the private enterprises engaged in the distribution of the harvester, realised that the time was right to introduce a bigger and an integrated machine, the combine harvester. There began the next phase in incorporating mechanization into paddy harvesting and threshing. Bigger and more efficient machines were introduced, starting from 65hp onwards with improved technology and better standards, the market today is well supported. It took almost a decade for the concept of the combine harvester to be truly acceptable to the farming community. There were issues, but with time and the level of confidence increasing, the community has adopted itself to this newer technology.

Another recommendation for Sri Lankan enterprises is to form joint ventures with overseas manufacturers and manufacture equipment and machinery suitable to meet the Sri Lankan farm requirements. Whilst the core components, such as engines and gear boxes, can be imported, the rest of the manufacture can be carried out within Sri Lanka to suit local conditions. Close dialogues with the farmer community, cooperation with local research and development institutions coupled with the marketing capabilities of the distribution firms can result in greater penetration of mechanization in non-paddy sectors.

In conclusion, sustainable agricultural mechanization has been and will continue to be one of the most important measures to ensure food security in the context of climate change. To this end, an integrated approach to adopting climate-smart production through public-private partnerships will be particularly useful.

Photo by Hubin Yu

3.4: Thailand Country Market

Overview of the country's agriculture sector

Thailand is one of the ASEAN countries which has tropical climate. Agriculture is the main occupation in terms of number of people and land use. The total Gross Domestic Production (GDP) is 16 trillion Thai Baht (THB) in 2018 increasing by 4.7 percent per year in average from the last 5 years. While the Agricultural GDP is THB 1.3 trillion in 2018 increasing by 5.2 percent by year in average from the last 5 years, as shown in Table 3.4.1.

Table 3.4. 1 Thailand's GDP based on Current Market Prices (Million THB)

	2014	2015	2016	2017	2018
Agriculture	1,335,153	1,219,798	1,229,961	1,286,586	1,324,369
Agriculture, Forestry, and Husbandry	1,225,199	1,116,773	1,120,051	1,172,474	1,215,580
Fishery	109,954	103,025	109,910	114,112	108,789
Field outside agriculture	11,895,149	12,523,666	13,324,608	14,165,374	14,992,048
Gross Domestic Product	13,230,302	13,743,464	14,554,569	15,451,960	16,316,417

Total agricultural products export value in 2018 was around THB 1.4 trillion. The main export was to East Asia with the value of around THB 532,061 million, which saw a decrease from THB 570,274 million or 6.7% from the year before. The second highest export was to ASEAN with value of around THB 355,404 million which had seen an increase from THB 334,747 million or 6.14%. The export was to America with the value of around THB 160,277 million which had seen a decrease from THB 171,285 million or 6.43% from the year before. The export to EU with the value of around THB 116,894 million which had seen a decrease from THB 118,267 million or 1.16% from the year before (OAE, 2018).

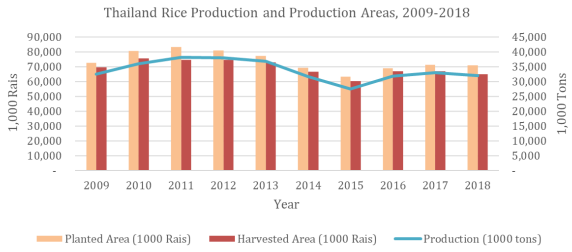
The most important crops of Thailand are para rubber with a total value of THB 221,412 million, with rice closely behind with the worth of THB 199,392 million. Other crops include fruits, cassava, sugarcane, and vegetables worth THB 142,310, 98,504, 97,018, and 29,040 million respectively. In terms of machinery, sugarcane and cassava are crops that rely more on agricultural machinery compared to para rubber since they are annual crops that requires more prompt and tedious attention of farmers.

Rice

Thailand rice production represented 3.9% of global yields, following after China, India, Indonesia, Bangladesh and Vietnam, respectively producing 29.8%, 22.5%, 7.5%, 7.0% and 5.6% of the world share. As for export, Thailand is the top exporting countries of the world for ten years except in 2015, 2016 and 2018. The production was around 31, 28, 32, 33, and 32 million tonnes in 2014, 2015, 2016, 2017, and 2018, respectively.

Rice production areas are 60 million Rai (6.25 rai is equal to 1 hectare) out of 149 million Rai of total agricultural land. In addition, there are additional 10 million Rai with irrigation are also used for rice production for off-season rice. Amounting to a total of around 70 million Rai of land were used for rice cultivation in 2018. The average yield is around 30-32 million tonnes per year, or 20-21 million tonnes of milled rice. Figure 3.4.1 shows that the trend had been steadily growing until 2012. After that, the production decreased briefly between 2012 and 2015 due to hot and drought climate. Since then, the production has returned to a steady growth.

Table 3.4. 1 Thailand's GDP based on Current Market Prices (Million THB)

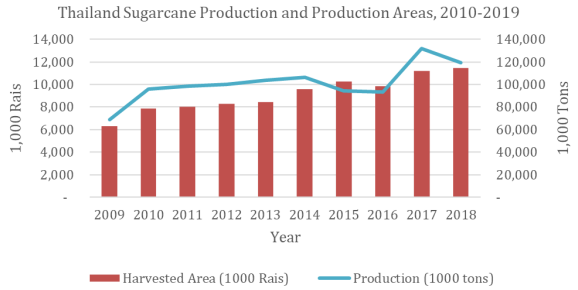


Source: Office of Agricultural Economics, 2019)

Sugarcane

The harvested area of sugarcane is steadily growing from 6 million Rai in 2010 to 11 million Rai in 2018/19 due to increasing sugar mills throughout the country, together with favourable policy in promoting to grow sugarcane in the paddy land. The production of sugarcane was steady from 2011 until the year 2016 where the production dropped. But the industry soon picked up in 2017/18. It decreased again in 2018/19 due to the dropped price. In particular, in 2017/2018, the sugarcane production was recorded at 127 million metric tonnes due to favourable weather. The details are shown in Figure 3.4.2.

Figure 3.4.2 Thailand Sugarcane Production and Production Areas, 2010-2019

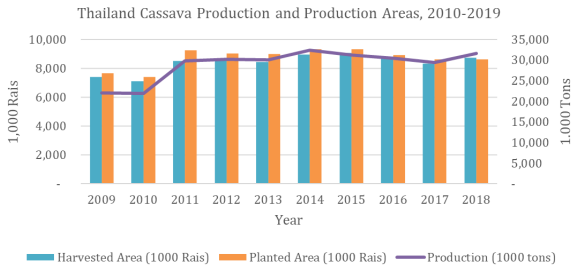


Source:(Office of Agricultural Economics, 2019)

Cassava

Both the cassava planting and harvesting areas remained roughly the same between 2012 and 2018. While the cultivation areas of cassava are around 9 million Rai, its production is around 27-30 million tonnes. Without significant changes, the production of cassava is stable and reliable. The details are shown in Figure 3.4.3.

Figure 3.4.3 Thailand Cassava Production and Production Areas, 2010-2019



Source: Office of Agricultural Economics, 2019

Agricultural Machinery uses in Thailand

Farmers in Thailand generally use small machineries. The most common machineries in use include 24-50 horsepower machinery, 10-12 horsepower machinery, pedestrian tractors which can travel in the small field and areas with rough trails. These machineries are often manufactured locally.

The survey of farmers who had voluntary registered under 'Farmer Identification Database' performed by the Department of Agricultural Extension found that machinery is used in every farming stage including land preparation, planting, crop caring or maintenance, and harvesting. The trend shows a significant increase year by year. The types of machinery use are classified in Table 3.4.2.

Table 3.4. 2 Quantity of Agricultural Machinery, 2017-2019*

Agricultural Machinery 2017-2019	2017		2018		2019*	
	Total	Per household	Total	Per household	Total	Per household
Tractors						
Pedestrian tractors	6,452,003	0.92	6,665,284	0.92	6,661,365	0.89
24-50 hp	958,725	0.14	1,100,780	0.15	1,332,152	0.18
51-80 hp	252,343	0.04	280,640	0.04	378,211	0.05
81-100 hp	122,742	0.02	143,085	0.02	189,712	0.03
100+ hp	65,720	0.01	70,821	0.01	87,314	0.01
Machinery						
Land Preparation	2,884,711	0.41	2,945,124	0.41	3,150,688	0.42
Planting	1,465,372	0.21	1,596,652	0.22	1,600,369	0.21
Maintenance	5,758,305	0.82	6,293,951	0.87	6,486,676	0.86
Harvesting	907,305	0.13	1,018,201	0.14	1,086,624	0.14
Total number of households	7,010,191		7,271,759		7,522,003	

Remarks

- *The survey was conducted from 2017to July 2019.*
- *The data were from the surveyed farmers.*
- *Land preparation includes ploughs, rotary tiller, padder, ripper etc.*
- *Planting includes rice transplanters, sugarcane planter, broadcasting blower, cassava planter etc.*
- *Maintenance includes water pump, sprayer, mechanical weeder etc.*
- *Harvesting includes rice harvester, sugarcane harvester, combine harvester, cassava harvester etc.*

Source: Department of Agricultural Extension of Thailand, 2019

In terms of tractors, farmers in Thailand still prefer to use small horsepower tractors. The pedestrian tractors are usually used in light duty activities, such as padding rice field, pumping water with its engine, and pull small trailer. Big and heavy tractors could not work in soft rice paddy field due to its weight particularly in central region. Given the mentioned reason and machinery price, most rice farmers would choose the machinery with maximum 50 hp horsepower. As rice is the main crop in Thailand, these contexts explain the dominance of small horse-power tractors in Thailand. In particular, the quantity of small horse-power tractors (less than 50hp) in use has grown 7.96% from 2017 to 2019, among which the quantity pedestrian tractors and 24-50 hp in use has grown by 3.24% and 38.95% respectively. According to the table, the number of pedestrian tractors actually have a decrease in growth from 2018 to 2019. The 51-80 hp, 81-100 hp and > 100hp tractors a growth rate of 49.88%, 54.56% and 32.86%, respectively, from 2017 to 2019. Their usage is particularly common in the production of sugarcane and cassava.

The quantity of land preparation machineries, planting machineries, plant maintenance machineries, and harvesting machineries in use saw growth rates of 9.22%, 9.21%, 12.65%, and 19.76%, respectively, from 2017 to 2019.

Import and Export of Agricultural Machinery

Due to Free Trade Policy, Thailand is open to import agricultural machinery from across the world. The country maintains Free Trade Agreements (FTA) with a wide array of countries, not limited to the ASEAN, ASEAN+3, ASEAN+6 countries, Australia, New Zealand, and India. The import values of agricultural machineries are shown in Table 3.4.3, while the sources of import are shown in Table 3.4.4. The data reflects that Japan has dominated Thailand's tractor import market; China has dominated its market for land preparation

and plant protection machineries; and Brazil has dominated its harvesting machinery market.

Table 3.4.3 The Import Value of Thai Agricultural Machineries, 2014-2018

Machineries	2018	2017	2016	2015	2014
Tractors	12,811,820,000	13,963,398,000	6,279,563,000	6,482,592,000	6,645,000,000
Land preparation	742,710,000	776,340,000	675,191,000	704,024,000	982,000,000
Maintenance	3,712,741,000	3,387,317,000	3,546,084,000	3,982,071,000	4,177,000,000
Harvesting	3,503,316,000	3,449,345,000	2,434,541,000	2,410,972,000	1,852,000,000

Source: Centre for Agricultural Information, Office of Agricultural Economics, 2018

Table 3.4.4 The Source Countries of Import, 2014-2018

Machineries	Major Countries	2018	2017	2016	2015	2014
Tractors	Japan	6,229,603,000	7,526,488,000	4,165,411,000	4,310,649,000	3,749,043,000
	India	2,046,043,000	1,456,166,000	554,074,000	595,667,000	670,067,000
	Mexico	634,748,000	373,102,000	63,174,000	162,506,000	433,404,000
	China	777,599,000	877,463,000	332,838,000	162,053,000	252,000,000
	United Kingdom	706,394,000	1,158,162,000	368,339,000	549,571,000	777,554,000
	Others	2,417,433,000	2,572,017,000	795,727,000	702,146,000	762,932,000
Land preparation	China	372,503,000	310,707,000	230,103,000	177,380,000	971,734,000
	India	131,471,000	120,754,000	125,353,000	120,538,000	38,834,000
	South Korea	49,429,000	64,217,000	69,571,000	41,291,000	58,023,000
	Italy	15,302,000	16,345,000	16,066,000	12,617,000	43,365,000
	Taiwan	8,655,000	36,463,000	20,215,000	48,064,000	43,433,000
	Others	165,350,000	227,854,000	213,883,000	304,134,000	55,586,000
Maintenance	China	1,526,137,000	1,522,273,000	1,549,483,000	1,474,680,000	1,640,924,000
	Japan	706,425,000	534,298,000	573,650,000	944,640,000	845,555,000
	USA	491,029,000	423,021,000	422,818,000	496,283,000	527,903,000
	Germany	140,899,000	155,051,000	142,589,000	160,727,000	286,645,000
	Taiwan	112,305,000	147,217,000	124,373,000	130,244,000	142,745,000
	Others	735,946,000	605,457,000	733,171,000	775,497,000	733,228,000
Harvesting	Brazil	1,117,675,000	1,011,540,000	110,214,000	436,683,000	218,143,000
	China	932,394,000	960,520,000	915,906,000	821,144,000	618,575,000
	Japan	399,740,000	581,533,000	445,180,000	243,366,000	119,546,000
	USA	247,729,000	243,501,000	430,482,000	461,601,000	455,031,000
	Malaysia	189,600,000	181,321,000	153,280,000	144,010,000	179,678,000
	Others	616,178,000	470,930,000	379,479,000	304,168,000	261,027,000

Source: Centre for Agricultural Information, Office of Agricultural Economics, 2018

In terms of export, Thailand is exporting and re-exporting agricultural machinery to many countries. Table 3.4.5 shows the exporting value, while Table 3.4.6 shows the exporting countries. The data shows that Thailand is a major exporter to ASEAN countries. The major reason behind is trend is that Thailand maintains a relatively higher level in logistics and techniques for the concerned machineries.

Table 3.4.5 Export Value of Thai Agricultural Machineries, 2014-2018

Machineries	2018	2017	2016	2015	2014
Tractors	19,995,711,000	19,105,032,000	8,835,170,000	8,937,203,000	8,131,991,000
Land preparation	1,964,367,000	1,919,702,000	1,817,251,000	1,429,645,000	1,210,975,000
Maintenance	739,980,000	804,141,000	842,495,000	880,469,000	732,479,000
Harvesting	9,360,001,000	9,411,986,000	9,938,016,000	7,112,795,000	3,571,987,000

Source: Centre for Agricultural Information, Office of Agricultural Economics, 2018

Table 3.4.6 The Exporting Countries from Thailand, 2014-2018

Machineries	Major Countries	2018	2017	2016	2015	2014
Tractors	Cambodia	5,782,296,000	4,843,705,000	2,926,950,000	4,286,758,000	4,238,802,000
	India	4,044,991,000	4,302,224,000	654,476,000	652,405,000	636,615,000
	Philippines	3,270,110,000	2,855,880,000	684,019,000	427,053,000	188,145,000
	Vietnam	1,647,990,000	1,432,558,000	375,206,000	234,577,000	25,887,000
	Indonesia	1,274,410,000	1,127,863,000	546,397,000	511,958,000	119,089,000
	Others	3,975,914,000	4,542,802,000	3,648,122,000	2,824,452,000	2,923,453,000
Land preparation	Myanmar	782,094,000	802,246,000	792,908,000	577,831,000	373,812,000
	Cambodia	546,785,000	507,718,000	450,917,000	485,686,000	457,044,000
	Philippines	275,224,000	220,006,000	131,403,000	34,940,000	6,295,000
	Indonesia	197,356,000	154,423,000	170,127,000	79,923,000	10,842,000
	Lao PDR	76,584,000	96,981,000	113,878,000	124,256,000	267,391,000
	Others	86,324,000	138,328,000	158,018,000	127,009,000	95,591,000
Maintenance	Mexico	121,534,000	122,337,000	135,218,000	180,263,000	100,189,000
	Japan	57,447,000	62,663,000	118,026,000	72,517,000	74,259,000
	Vietnam	43,667,000	39,533,000	47,565,000	52,860,000	60,325,000
	Brazil	52,269,000	39,286,000	70,671,000	68,056,000	52,831,000
	USA	46,556,000	37,418,000	46,923,000	71,043,000	27,358,000
	Others	418,507,000	502,904,000	424,092,000	435,730,000	417,517,000
Harvesting	Myanmar	2,607,115,000	1,754,816,000	3,354,179,000	1,505,759,000	1,066,892,000
	Cambodia	2,340,905,000	2,832,879,000	2,861,705,000	3,235,016,000	1,523,441,000
	Philippines	1,520,046,000	1,943,440,000	1,093,572,000	505,190,000	14,041,000
	Vietnam	1,207,398,000	1,567,101,000	1,246,867,000	1,273,894,000	294,034,000
	India	836,144,000	266,808,000	310,213,000	326,029,000	289,714,000
	Others	848,393,000	1,046,942,000	1,071,480,000	266,907,000	383,865,000

Source: Centre for Agricultural Information, Office of Agricultural Economics, 2018

Change in Labour and Machine Use

Figure 3.4.3 shows that on average there is a 77% decrease in labour across Thailand from 2003 to 2013, which reflects the increase in machinery use during that period. The use of machinery increased by 18% during the same period, with most of the increase from North, North-Eastern, and Southern part of Thailand. Almost all farmers use machinery, but traditional machines (labour intense machinery such as walking tractors, manual sprayer etc.) are still dominating the market by far, with the exception in the Southern and Eastern part of Thailand. Traditional machineries refer to those that still require intensive manpower to operate.

Figure 3.4.4 Change in Labour and Machine Use 2003-2013

Source: Attavanich, Chantarat and Sa-ngimnet, 2018

Primary Machinery use during different applications by crop

Rice

Rice production cycle in Thailand is around 4 months. There are 2 to 3 crop cycles per year in areas with access to irrigation. The majority of rice farmers produce only 1 crop per year in rainy season from May to October. The main harvesting period is from October to December. Land preparation implements include disc ploughs, rotary tiller, and padder. Disc ploughs are mainly used in rain-fed areas. Rotary tiller and padder are mainly used in irrigated areas. Tractors size are between 36hp to 50hp together with pedestrian tractors. Most rice farmers use blower to broadcast seedlings. Rice planters are used in some areas, mostly in irrigated areas. Insecticide chemical are applied by using knapsack blower. Almost all harvesting is done by using combine harvester.

Sugarcane

The crop cycle of sugarcane is around 12-14 months. Most farmers prepare the land from September to October, and plant from October to December. The harvesting period is between December and April.

Disc ploughs is the most commonly used implement for land preparation. Farmers normally use 3 to 4-disc ploughs for the primary tillage. For the secondary tillage, farmers usually use 6-7-disc ploughs and use tractors ranging from 48hp to 135hp. Almost all sugarcane planting in Thailand uses the double-row whole stalk planter. Farmers are now starting to use Billet sugarcane harvester.

Cassava

Cassava's crop cycle is around 12 months. Land preparation are done between April and June. Farmers usually start planting from May to June, and harvest between January and March. Tractors used for this purpose are between 48hp to 75hp, mostly for land preparation and ridging. Labour are normally used for planting. Cassava planters are in development and farmers are starting to use them. Farmers usually use mechanical weeder for plant protection. Insecticide and herbicide chemical are applied by knapsack blowers. Farmer mostly use tractor trailed harvesters and labour to carry them onto farm trucks/trailers.

Applications where mostly manual labour is still in practice

Rice

Plant protection and planting are still using manual labour. During the plant protection stage, farmers would usually operate equipment to spray chemicals and apply fertilisers. For planting, manual labour are used to operate broadcasting equipment.

Sugarcane

In most farms, the harvesting of sugarcane is still done manually. This phenomenon persists because sugarcane harvesters are expensive and that typical sugarcane farmers could not afford them. Furthermore, using the sugarcane harvester requires the farmer to have the distance between rows at a further distance of which the farmers in Thailand does not want to do. The reason being that it would mean have less rows of sugarcane, thus less production.

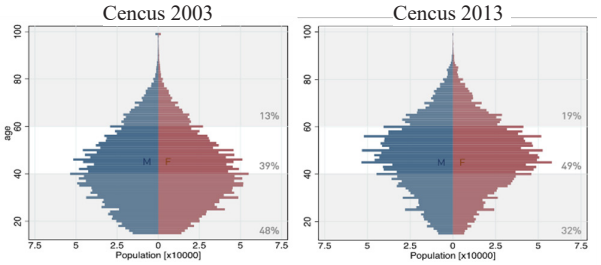
Cassava

Harvesting and planting stages are still mostly manual. During harvesting, Manual labour are also used during harvesting to transport the harvested crops onto the on-farm trailers/trucks.

Labour

The total number of agricultural labourers in Thailand was around 10 million in 2013. Figure 3.4.13 shows that Thailand is facing an ageing farming population. It shows that farmers between the age of 40-60 had increased from 39% in 2003 to 49% in 2013, which is similar to the ratio of labours over the age of 60 and the labours between the age of 15-40 had drastically decreased from 48% in 2003 to 32% in 2013. The ageing farming population is a major problem for the agricultural industry. As one of the biggest problems of Thailand, aging of the farm population can be seen as an obstacle for the adaption of new technologies. Increasing the number of young farmers and the level of education of farming labourers will play critical roles in helping farms to adopt new technologies.

Figure 3.4.5 Total Number of Agricultural Labour in 2003 and 2013



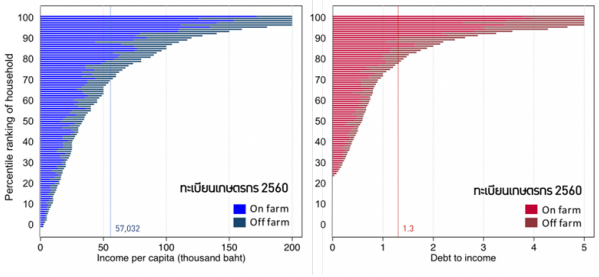
Source: Attavanich, Chantarat and Sa-ngimnet, 2018

Geographic Distribution of the main crop commodity

Figure 3.4.6 shows that rice is the dominant crop in Thailand. While rice paddies are located mostly in the North-Eastern and Central part of Thailand, rubber dominates the Eastern and Southern part of Thailand. However, the mechanization level for rubber production is low in general because there by far exists very limited technology that can effectively replace manpower in its production. Its harvesting stage consumes most of the labour required for its production. The work on para rubber are considered a time-consuming job but not a physically toll to farmers. The nature of the work is that labourers have to slash the para rubber tree and collect the harvest from each tree one by one. The work also has to be done very early in the morning. That is why it is costly to hire considerable manpower to carry out the task. Machinery is needed to solve the mentioned problem urgently due to the aging agricultural labour.

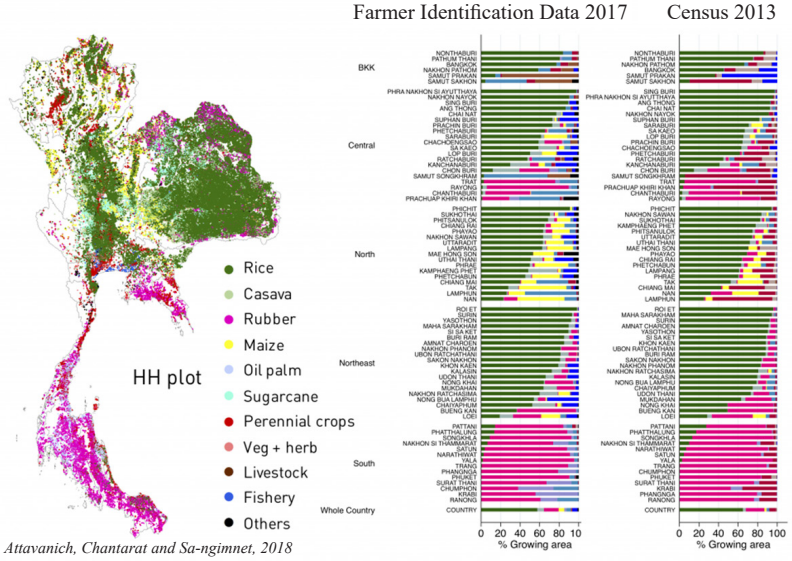
Farm income averaged at 57,032 baht per household in 2017, which is below the government's target of 60,000 baht by 2021' said Witsanu Attavanich, economics professor at Kasetsart University. Figure 3.4.7 and Figure 3.4.8 show that the income per capita are generally higher near Bangkok, in the middle part and in some areas of the southern part of Thailand. The debt burden of the sector is another key challenge, with 30% of farming households having debt of above the average annual farming income per person, 10% with debt of higher than three times, and 50% having debt below 0.6 times. Figure shows that debt to income are higher in the countryside areas.

Figure 3.4.7 Farmers Income and Debt



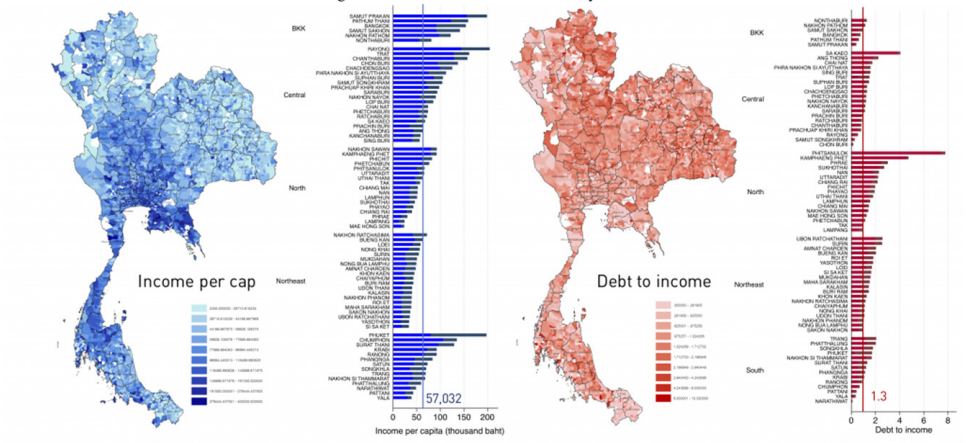
Source: Attavanich, Chantarat and Sa-ngimnet, 2018

Figure 3.4.6 Geographic Distribution of the Main Crop Commodity



Source: Attavanich, Chantarat and Sa-ngimnet, 2018

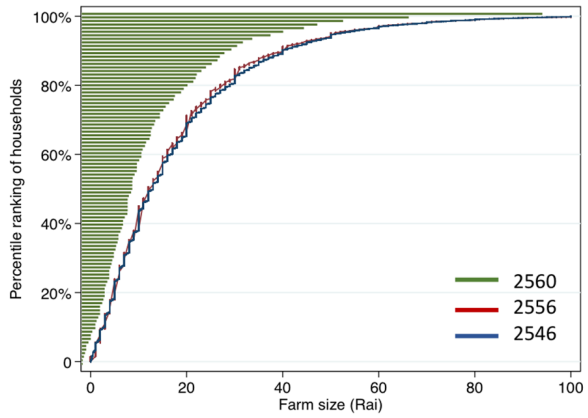
Figure 3.4.8 Farmers Income and Debt by Area



Source: Attavanich, Chantarat and Sa-ngimnet, 2018

In 2017, half of farming households owned below 10 rai of farmland per household, and 80% of the households own less than 20 Rai, with an overall average of 14.3 rai owned for each agricultural family. Figure 3.4.9 also shows that the land owned by farming households are gradually decreasing.

Figure 3.4.9 Land Owned by Farming Household

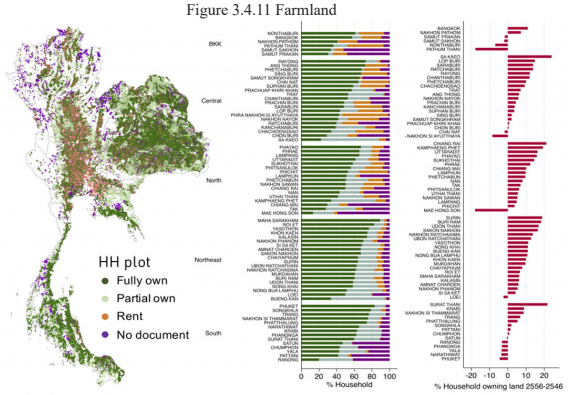


Source: Attavanich, Chantarat and Sa-ngimnet, 2018

Figure 3.4.10 shows that most of the big holding area (over 40 Rai) are found in Central and Lower North Thailand. As mentioned earlier that around half of farming household own below 10 Rai, and the trend also suggests a continuous decrease.

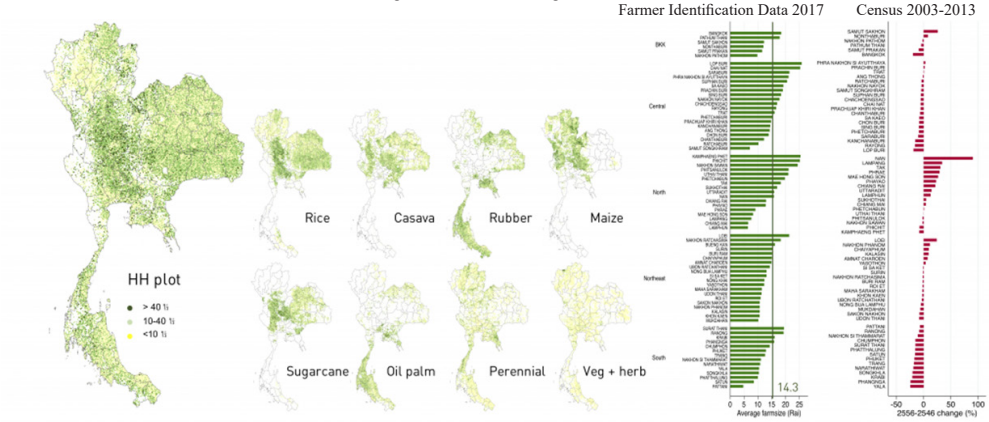
The Cluster Farm Policy is designed and implemented to tackle the land fragmentation issue. The Cluster Farm Policy. by simple terms, is to gather several small plots of lands that grow the same crop in proximity and to form a collaboration. This way they will have the fund to buy agricultural machinery in the future. The collaborated farmers will act as a single 'entity'. The machinery bought will be owned by all of them and they are free to setup their own rules. Figure 3.4.11 shows that most of the fully owned lands are in the North-East part of Thailand, while the rented farmland is mostly located in the Central part of Thailand. It should also be noted that most of the big holding areas (over 40 Rai) are also located in the Central part of Thailand, since most of the big holding areas are rented land in the Central part of Thailand.

Figure 3.4.11 Farmland



Source: Attavanich, Chantarat and Sa-ngimnet, 2018

Figure 3.4.10 Farm Holding Size



Source: Attavanich, Chantarat and Sa-ngimnet, 2018

End user by implements

Farmers usually own their own tractors and land preparation equipment such as ploughs, but Farmers normally does not own planting or harvesting equipment themselves. Farmers usually plant and harvest via hiring contractors. By which contractors are also farmers that own the machines and work for several farms after they had finished with their own in a season. Contractors are usually paid per Rai. This also raise another issue that contractors do not do a good enough job on the field as they would want to finish the job as quickly as possible and does not care for the yield as the pay is per Rai. Detail shows on Table 3.4.7.

Table 3.4.7 End User by Implements

Farming stage	Equipment	End user
Land preparation	Plough	Farmer
Rice Planting	Broad casting equipment	Contractor
Rice Harvesting	Combine Harvester	Contractor
Cassava Planting	No machinery (Labour)	Contractor
Cassava Harvesting	Cassava Harvester (Digger)	Contractor
Sugarcane Planting	Sugarcane Planter	Contractor
Sugarcane Harvesting	Sugarcane Harvester	Contractor

Source: Author

Needs of farmers

Farmers require affordable automatic mechanization such as high clearance tractors for spraying, fertilizing, weeding as crops are mostly untended for a long period of the time due the height of the crop after the crop has reached a certain height where tractors cannot enter the field. By using high clearance tractors farmers can tend to the crops for an extended period of time and reduce the risk of crops not having enough nutrients. It would also replace manual labour for spraying or mechanical weeding.

For cassava planter, there has not been a design that is efficient enough for farmers to switch from manual labour to machinery. Regarding cassava harvester, and on-farm transportation, the process needs to offload the harvest directly onto the on-farm trailer/truck in one step. At the moment, cassava harvester available on the market still requires manual labour to load the harvested cassava onto the on-farm truck/trailer.

Other needs of farmers include:

- Rice chemical sprayer for health reasons
- Sugarcane billet planter to replace the use of traditional planting machinery
- Sugarcane billet seed cane harvester for use of billet planter
- Sugarcane Harvester – affordable sugarcane harvesters are needed as the ones in the market are high priced.

Supply Chain of Agricultural Mechanization in Thailand

End users are usually made to aware of new products and new technologies via promotion and advertisements by the manufacturers and dealers. Government entities also play a part in promoting new products and technologies by demonstration. Additionally, exhibition and seminars have served as accessible platforms for manufacturers and dealers to display products and technologies. Products and technologies are sometimes featured in agricultural magazines, booklet, or newspapers which farmers easily have access to.

The supply chain of agricultural machineries in Figure 3.4.12 shows that manufacturers usually purchase or order specific parts from suppliers and produce other parts for assembly on their own in their factory. After that they would send the assembled product to dealers, who will deal with users.

Figure 3.4.12 Product Supply Chain

As shown in Figure 3.4.13 and Figure 3.4.14, there exist two models for the supply chain of service support. The first model is a common way of operation used by large manufacturers. The manufacturer would train their dealers to provide after-sales service and leave it to the dealers to manage customers in their respective areas. The second model is that manufacturers would have teams of after-sales service that deal directly with end users.

Figure 3.4.13 Service Supply Chain – Model 1

Figure 3.4.13 Service Supply Chain – Model 2

Agricultural machinery manufacturers have to invest low switching costs in case they make a decision to change their suppliers due to the low variation of raw materials. The prices of raw materials fluctuate by time. Market players usually enter long-term contracts with suppliers when possible in order to minimize price fluctuations. Supplier has significant saying as for the case of engineered components. A lot of players rely on single suppliers. Some agricultural equipment companies rely on single suppliers, particularly for specially made components. Now a days, the influence of individual supplier is decreasing due to the competition of foreign suppliers from countries, such as China and India.

The players in this market are mostly established companies with certain years of history and diverse product ranges. All these factors discourage new entrants. Large investment is needed to set up manufacturing factories. This kind of manufacturing requires large fixed assets and scale economies should the company wishes to stay profitable. It is therefore very difficult to enter the market as a small company. Agricultural machinery manufacturing companies usually relies on a wide dealer network; developing such distribution system is also a barrier to enter in this industry. The ability to invest significantly in R&D and develop products with sound understanding of the market, is a competitive advantage of players. Therefore, it is fair to say that entering to this industry is comparatively difficult for newcomers.

The agricultural machinery market in Thailand is dominated by a small number of large multinational players, such as Kubota, Yanmar, Case New Holland, and John Deere. Competition is high among these multinational companies.

Accessibility of Products

Nowadays, farmers have access to the internet which enables online purchasing. This allows farmers to far more options to suit their need. The online market not only includes new machinery and implements, but also the second-hand ones. There are also various dealers across Thailand selling a wide range of implements, equipment and tractors. Local government entities usually promote new technologies in their respective region and advise on choices of equipment. Farmers also have access to booklets and leaflets, which provide detailed information on new products and implements of various manufacturers. Agricultural Exhibition is another way farmer can gain access to products. There are several exhibitions throughout the year with different focuses. There are large number of small buyers in the market, which means low purchasing capacity. Brand reputation is very important, meanwhile the price of the products is also crucial. In addition, buyers usually will re-choose the dealers who can provide sound after-sales services. Buyer power is strengthened due to the relatively low switching costs from dealer to dealer and the limited number of sources of these products. Overall, the purchasing capacity of the farmers in Thailand is limited. Companies also choose to promote their products via road shows. They would demonstrate their products in provinces where farmers are likely interested in their products.

Financing

Farmers can get access to available financing from various sources. The Bank of Agriculture and Agricultural Cooperatives (BAAC) is a bank specialized in helping farmers get loan for buying agricultural machinery and implement. Other types of financing are also available such as financial leasing companies. Most agricultural machinery brands cooperate with financial leasing companies so that that farmers can have access to the machinery in time. Some companies, such as Kubota, even have their own leasing division. Many of machinery companies also give out loans by collaborating with financial companies to provide loan directly to farmers. This is a huge advantage as their process in acquiring loan would be so much easier and quicker.

Thai government does not provide subsidy following the WTO agreement, but in order to help the farmers' accessibility to machinery in order counter the labour issue, they provide low interest rate loans for collaborative farm program. The collaborative farm is a program which pulls farmers together as one entity in order for small scale farmers to manage together, where the farmers would apply for the loan together, then, manage and jointly use the machineries that are bought under this program.

Economic Sustainability

For the farmers, BAAC credit loan helps farmers with their loans for agricultural machineries. Regarding the agricultural sector, Thailand 4.0 is a government initiative that aims to use technology to implement 'smart farming' and to replace the traditional ways of farming by using advance and higher-level technologies in areas such as feed, seeding, machinery, through biotech. Which has been included in the 20-year Strategic plan 2017-2036 stating that the plan is to integrate new technologies and innovations into agriculture in the form of smart farming in order to increase the production and value. It has also stated that by promoting the usage of precision agriculture technologies such as various sensors, greenhouse, data gathering etc. with better management, as well as supporting knowledge transfer to farmers will help achieving the goal of increased production and value of agricultural products. BAAC also has a low interest rate loan program for agricultural machineries for Collaborative farm members in order to support the government's program. Beside this, the government strives to provide knowledge to farmers through both local and foreign universities, together with financial support and investment funded by the government.

Machinery is becoming vital to the agricultural production in Thailand, especially to cope with labour shortage and to improve productivity. In principle, there are no alternative products that could replace agricultural equipment. The main substitutes are service hiring and the used machineries. These are significant substitutes which effects market sales. In turn, some manufacturers defend their income by offering these alternatives to new equipment themselves, by buying and also selling used tractor/machineries to farmers. The threat from substitutes is moderate across the sector.

Environmental sustainability

One of the targets of 20-year Strategic Plan 2017-2036 initiated by the Thai government is to make Thailand the centre of agriculture and food with eco-friendly technologies. The plan is designed to equip farms with better professional and industrial knowledge with which they can improve the management of their farms. Ultimately, the initiative strives to transform traditional farms into 'Smart Farmers' through the promotion of sustainable agriculture and environmentally-friendly investments. Relevant efforts also include the promotion of equality in resource access through the enactment of the Water Resource Act and land reform. In light of the increasing impacts of climate change, agriculture practice with low carbon emission is also one of targets of government policies in attainment of the Sustainable Development Goals (SDGs) of the United Nations.

Social Sustainability

As Thailand has the history of being an agricultural country and most people living outside the city still has the social culture on the level of a middle size family which usually include 3 generations living under the same household. Farmers usually earn their farm earnings in the way as a family business. Nowadays, there are young farmers which are the next generation farmers with has a higher education compared to the previous. They want to improve agriculture using new technologies and innovations for their family, including themselves. Many young farmers had received education in science and other technologies but has the motivation to go back their family business hence there are more and more technologies being integrated into agriculture.

The Thailand government strives to support youth and women in SME businesses by enhancing their accessibility to technology through funding. The government supports new generation farmers to develop themselves following the Young Smart Farmer Program which is run by the Office of the Permanent Secretary for Ministry of Agriculture and Cooperatives which is a program that intends to develop new generation farmers into entrepreneurs. The Bank of Agriculture and Agricultural Cooperatives has given the mentioned program up to 10 years of support for new generation farmers. For current generation of farmers and their family, the government supports local activities to develop into community enterprises, which has been found that many of the successful community enterprises had come from the management of female managers which some are the wives of famers. Hence, the The Bank of Agriculture and Agricultural Cooperatives also give out loans to community enterprises as well.

Conclusion

Thailand is the one of agricultural countries in ASEAN. While the country's total GDP stood at 16 trillion Baht in 2018, agriculture accounted for 1.3 trillion THB of the total GDP. While the growth of Thailand's GDP was at 5.2%, the agricultural sector grew by 4.7% in 2018. The country's agricultural products export is valued at 1.4 trillion THB in 2018, and the exports mainly go to East Asia, ASEAN, USA, and EU. The major crops include para rubber, rice, fruit, cassava, sugarcane and vegetables. Rice, sugarcane and cassava are the crops that rely more on agricultural machinery. Rice is the most important crop, followed by sugarcane and cassava in terms of farmer quantity, production area, and machinery requirement. Para rubber is also important for mechanization since it entails high manpower and time for harvesting.

In terms of agricultural machinery, small horsepower tractors (less than 50hp) are the most commonly used machinery in Thailand. There is also significant growth in every tractor horsepower group, except for pedestrian tractor in the past 3 years. The quantity of machinery used in land preparation, planting, plant maintenance and harvesting grew by 9.22%, 9.21%, 12.65%, and 19.76%, respectively, from 2017 to 2019.

Thailand is an importer of agricultural machinery. The total agricultural machinery import was valued at 20.7 trillion THB in 2018. They mainly came from Japan, India, China, and Brazil. The country also export machinery to ASEAN countries. Its total agricultural machinery export was valued at 32.1 trillion THB in 2018. The needs to further mechanized the Thai agricultural industry is expected to address the issue of aging population in the past 10 years. As the number of senior

farmers had been increasing, the quantity of agricultural machinery in use has grown by 11.88% and the quantity of laborers involved has declined by 77%. The younger farmers aged 15-40 declined from 48% to 32% between 2003 and 2013. Aging farming population is one of the biggest challenges facing Thailand in the coming decades. However, the younger generation farmers with higher education level will more willing to adopt new technologies and present opportunities to the agricultural industry.

One of the agricultural machineries that is the most important in Thailand is small-sized tractors between 24-50 horsepower that are used for the production of various crops, such as rice, sugarcane, and cassava. The land preparation machineries which are commonly used in Thailand are disc ploughs, rotary harrow, and paddler for rice. As planters are important for most types of crops grown, Thailand still needs more efficient planters to streamline its agricultural production. The most commonly used machineries for fertilizing and spraying are knapsack blowers and sprayers. The last group of machinery which has a high importance in Thai agriculture is harvesting machineries. For rice production, most farmers use combine harvesters. The harvesting of sugarcane and cassava still requires considerable manpower to operate the machineries.

The Cluster Farm policy is tackling some of the most pressing challenges of Thailand's agricultural industry. The Cluster Farm policy, by simple terms, is to gather several small sized plots that grow same crop in proximity and form a collaboration. In this way, the farmers will have the fund to buy agricultural machinery in the future. Apart from that, there are also policies encouraging and supporting the use of machinery to address the issue of burning in the agriculture conducsive to the achievemtn of SDGsThe target of the government policies is to make Thailand the centre of agriculture and food with eco-friendly technologies, and to transform into 'Smart Farmers', etc.

The Thai agricultural machinery industry is competitive and difficult for new firms to enter due to high entry requirements in terms of high fixed assets, high entry barriers, and the dominance of large companies. The players in this market are mostly long-established companies, with diverse product ranges, well-known brands, large scale, and multinational reach. Most buyer are small scale farmers which the brand, price and after sales service becomes the major factor in purchase decision. The players rely mostly on single suppliers. Nowadays there are more suppliers from foreign countries. The players in this market are mostly long-running companies, with diverse product ranges, well-known brands, and large scale. All these factors can discourage new entrants. Investment to set up manufacturing factories is needed for new entrant player. The main substitutes are rental and the second-hand machinery. These are significant substitutes which effects the market sales.

There is an increasing trend for modern agricultural machinery following the need of farmers. The trend for the need for machineries follows the national policy of modern, but also has to be affordable automatic mechanization. Types of mechanization and technology that has high probability in entering the market are high clearance tractors for spraying, fertilizing, weeding as crops are mostly untended during a long period of the time due the height of the crop, more qualitative Cassava planter, Cassava harvester, and on-farm transportation, Sugarcane billet planter, Sugarcane billet seed cane harvester, affordable Sugarcane Harvester etc

End users are usually made aware of new products and new technologies via promotion and advertisements of manufacturers and dealers. Government entities also play a part in promoting new products and technologies by demonstrating them to farmers in their respective areas. Exhibition and seminars are also a floor for manufacturers and dealers to display products and technologies. Even so, the finance system and credit loan are the important factor chase.

Photo by Qinger Shao

Chapter 4:
Summary of Findings, Conclusions and Recommendations

This study was conducted to facilitate a sound understanding of the market dynamics of China, India, Sri Lanka and Thailand in relation to trade in agricultural machinery and implements. It provides insights into the demand and supply for agriculture machinery, industrial behaviour of the farmers, current usage in the different stages of application, and emerging trends of the market. China and India followed by Thailand are major producers of numerous agriculture machinery and implements, whilst Sri Lanka is a net importer of machinery. The knowledge gathered in this study is intended to help in particular suppliers, buyers and end-users to develop a more holistic understanding of the degree of mechanization in a wide range of crops as well as the potential for filling gaps, and extend the efforts of all stakeholders towards enabling sustainable agricultural mechanization. The conclusions captured under each country profile provide observers with a snapshot of the overall market conditions in the respective countries. Here, we will draw conclusions from our overall analysis relating to the common threads we observe as well as some of the country market specificities.

The agriculture industry in China is valued at USD1 trillion, in India at USD 401bn, in Sri Lanka at USD0.875 bn and in Thailand at USD 43.3 bn. This provides us with an overview of the scale at which agriculture is practiced in the countries covered in this study. Wheat, paddy, corn, cotton and sugar crops are the main commercial crops in China and India, whilst it is paddy, sugarcane and cassava in Thailand and in Sri Lanka it is paddy followed by corn. The crops and the volumes explain the development and the usage of specific machinery, their capacities and the level of technology. Consequently, we observe large capacity and technologically advanced machinery in use in China and India. The scale and technology in use is much lower in Thailand, whilst in Sri Lanka machinery in use are mostly tractors, power-tillers and combined harvesters and that too in the paddy segment. However, in spite of these varying degree of differences in terms of scale and technologies, the study found several commonalities that run across these economies which are informative and useful for the different stakeholders engaged in sustainable agriculture mechanization. These commonalities are outlined below.

Factors influencing sustainable mechanization of agriculture

In all the countries covered in this study, governmental thrust to increase production of the major crops in line with the global drive to enhance food security is evident. Given the challenges they face and the need to drive production and productivity, the respective countries are cognizant of the critical importance of mechanization.

A common threat to agricultural production is the migration of labour to non-agricultural sectors. The interest of youth is moving away from agriculture and has created shortage in labour across all the country markets, albeit at varying degrees. Mechanization of agriculture, therefore, can offset this constraint to a great extent. Mechanization coupled with new technologies can also attract youth back into agriculture as they are more adaptable to new technologies when compared with the previous generation of farmers. Smart agriculture and mechanization, therefore, appears to be the way forward considering the shift in labour to non-agricultural sectors.

Governments in both China and India provide subsidies to farmers for purchase of agricultural machinery and for the growth of mechanization through wider adoption. However, we do not see this practice in Sri Lanka and Thailand. The markets in Sri Lanka and Thailand are driven purely by the forces of demand and supply. The absence of subsidies in these two markets implies that the end-users meet the full cost of the machine. Given the limited availability of funds in the hands of the farmers affordability, other forms of financial support can help overcome financial constraints in the procurement of machines.

India and China have taken the initiatives in promoting custom hiring centres, an alternative option to those farmers who cannot afford to purchase a machine. The Government of India has undertaken measures to provide seed capital to set up such custom hiring centres and have partnered with major manufacturers in the country to manage the operations. The project is in its infancy and will be a major boon to farmers who cannot afford to own a machinery but are motivated to adopt mechanization as an input into their agriculture practices.

Prices of agriculture produce as well as weather conditions also influence the demand conditions for agricultural machinery. Good crop prices together with supportive (and timely) rainfall and weather conditions support the adoption of mechanization for agriculture. All four Governments in this study do practice minimum guaranteed prices for staple crops from time to time, but China and India in particular have several schemes that are drawn up by the national Governments to mitigate the risks associated with crop failures and price declines. The Sri Lankan Government too steps in on a need basis whenever farm gate prices do not yield the desired levels and offers minimum guaranteed prices to farmers, which eventually stimulates the overall market.

The supply chain of agriculture mechanization is well structured and established in all of the four country markets. There is a good flow of machinery from manufacturers to the end-users, with different stakeholders playing their respective roles. The intermediaries in particular play an important role by bridging the gap between manufacturers and end-users. On the one hand they have to identify the needs of the end-users and then proceed to procure machinery that are appropriate for such applications. On the other hand, intermediaries play a prominent role in introducing technology to the end-user, by creating the necessary awareness, conducting trials to verify the suitability of the relevant machinery and promoting the application of mechanization in general. In most instances, the intermediaries also act as facilitators in assisting the end-users in securing financing for their purchase. The addition of 'custom hiring centres' in the supply chain in India and China is noteworthy as this augments the accessibility to mechanization for those who cannot afford to purchase machinery on their own. In addition, provision of after-sales-services including the supply of spare parts is an integral part of supply chains which are working well in all markets, although room for improvement exists.

Challenges for Mechanization

Two critical factors appear to be the key challenges in the process of mechanization, viz., marginalisation of land and the cost of financing to procure agricultural machinery.

Land size is a critical factor in introducing machinery due to economies of scale. Most of the traditional farmer settlements inherited land that on average is around 1 to 2 hectares in size. Over time and through generations the land has got further divided and become marginalised. Introducing small scale machinery into these land sizes has become a challenge. Some small-scale machinery such as power tillers, compact tractors have helped in such situations but this is not a full solution. In some countries of the Asia-Pacific region, consolidating farmer groups or clusters into composite groups through national intervention to make cultivation of viable scale and then sharing agriculture production in a cooperative manner has been tried.

Cost of financing is definitely one of the major obstacles in promoting the mechanization of agriculture. The subsidy schemes offered by the Governments of China and India seek to help farmers addressing this obstacle. There is no dearth of funding from other channels, such as local banks, leasing companies and the non-banking financial sector, who willingly come forward with short term funding. However, such funds come at a substantial cost, with interest rates ranging from 18% to 28%. The traditional banks provide funds at relatively lower costs but access to those funds by farmers, who have to meet stringent and very specific criteria, is difficult. The Government in India has taken a lead role by stipulating that a pre-determined quantum of funds is disbursed by the domestic banks to farmers and within that a sub-target of 8% is prescribed for lending to small and marginal farmers which is encouraging. It has also offered short term crop loans at subsidized interest rates, effectively bringing down the interest rates to around 4%. Thailand has developed the cluster concept where farmers are grouped into clusters and they have to purchase machinery for use in the group, so that they can overcome the affordability factor. China made modification in its pertinent law and regulations in recent years to encourage renting farmland from other farmers for larger scale operation. Going forward, one of the routes to introducing low-cost funding is through national intervention. The risks associated with agriculture are often natural risks and market risks (price fluctuations) and therefore traditional financing institutions shy away from providing funds unless there is substantial collateral to back it up. A majority farmers (except for commercial scale

farmers) are unable to meet this criteria and therefore become vulnerable to high cost financing. Governments can step in to absorb part of the risk considering the importance of food production. Insurance schemes are also available in different markets although their cover often comes at a high cost.

Growth sectors

Mechanization of the non-paddy segment, transplanting/seeding, land levelling for better water management, bed preparation, crop management, harvesting (particularly in the non-paddy segment) and straw/residual treatment are areas for growth in mechanization. Each of the country specific reports deal with gaps in their respective markets, yet taken as a whole this appears to be the story. Opportunities to introduce horticultural machinery, particularly with the small-scale farmer in mind has great potential. This is an important area to focus on, since many women are employed in this segment. Such small-scale machinery will be user friendly as well as handler friendly when considering and will be an incentive to grow more food. Demand is also shifting to high performance driven, compact, safer and energy economising machinery as farmers become more technology-savvy and embrace mechanization. Manufacturers in particular should pay attention to these areas of interest by farmers.

The damages caused to smallholder production systems in particular as a result of erratic and unpredictable weather conditions and the need to reduce emissions of greenhouse gases caused by agriculture machinery has given rise to interest in climate-smart agriculture and environment friendly mechanisation. Towards this endeavour the practice of conservation agriculture is now being promoted, which advocates minimum or no tillage. In other words, seed, fertilizer and transplants are placed in the desired position in the soil profile with the least amount possible of disturbance to the soil. Here direct seeding and planting is the primary aim. Conservation agriculture also includes maintaining permanent organic soil cover and maintaining biodiversity in crop production. Conservation agriculture does not mean the end of mechanisation, rather the type of machinery and implements in use are different, such as types of seeders and planters, vertical types of discs and chisel tines rippers that cause minimal damage to the soil. Therefore, partners along the supply chain, i.e. from manufacturers through importers/distributors to end-users, should further engage in exploring appropriate machinery and implements that can enhance conservation agriculture practices, address the risks arising from inconsistent weather patterns, and help mitigate climate change through reduced greenhouse gas emissions.

Recommendations

Based on the findings across the four country markets, this study proposes the following recommendations. These recommendations cover the key links along the supply chain.

Taking technology to the farmer

The gap between product design and usage by farmers needs to be reduced. A closer dialogue between manufacturers, intermediaries and the end-users (farmers) will mean mechanisation solutions can be found which are more appropriate in terms of land suitability, usage, technology level and cost effectiveness. Timely communication on emerging technologies, their applications and benefits will facilitate not only increased penetration levels but also greater adaptability of such technologies. What comes out of this study is the need for key partners in the supply chain to work closely and share information bidirectionally without any restriction, so as to find more effective solutions for sustainable agricultural mechanization. The communication networks must also engage national level policymakers, scientists and other relevant stakeholders, so as to ensure a holistic approach.

Gender friendly product development

The women workforce in agriculture is substantial and its vital contribution to the sector should be better recognized. Women play a critical role working along-side their male counterparts in contributing labour as well as enterprise to agricultural production. They undertake operations including sowing, seeding, weeding, harvesting, threshing, and winnowing. However, it would not be wrong to say that agricultural machinery is frequently designed with men in mind. Therefore, the gender perspective must be reflected more strongly and effectively in development of mechanisation, and stakeholders in the supply chain must focus on manufacturing and introducing more women friendly machinery which can be smaller in size, and more convenient and easier to operate. Whilst the trends in such machinery are emerging, there exists a need for a conscious effort to accelerate the introduction of such machinery in the marketplace.

Financing

A cost-effective funding mechanism must be found to relieve the burden of high financing costs which make machinery unaffordable for farmers or erode their earnings. Supportive programmes can be initiated at the national or regional/global levels by engaging with established development finance institutions to facilitate refinancing schemes targeting this sector.

Development of a well-planned programme which engages national level policymakers and can be implemented in a sustainable manner holds significant promise since the benefits that will accrue in terms of food production and consequently food security would far exceed the costs. For instance, multilateral development banks could consider initiating across the Asia-Pacific region a national loan refinancing scheme specifically targeting smallscale farmers to help them purchase basic agricultural machinery. The loans can be disbursed through the central banks of each country, who in turn can appoint the respective participating banks locally. To better ensure that such a loan scheme benefits the small farmer, the type of machinery and a cap on the maximum loan to be disbursed per individual could be specified.

Custom Hiring Centres

As observed in this study, custom hiring centres can be a useful alternative for those farmers who cannot afford to purchase his or her own machinery or perhaps for whom such purchase is not economical in terms of the land holding size. Such initiatives have been implemented in India and China. However, the establishment of custom hiring centres require large capital outlays with extended investment repayment periods. Considering the national importance of custom hiring for agriculture, the Governments of China and India have stepped into setting up public-private-partnerships and provided initial seed capital for the establishment of custom hiring centres. Further research can be carried out on the existing projects to understand the dynamics of this model, to assess the key challenges and successes, and to share relevant information with concerned stakeholders.

Spare parts and after-sales-services

The diversity of spare parts from brand to brand even amongst the same type of machinery drives up the overall costs in the supply chain as well as the whole industry. Often the end result is that all such costs are finally loaded on to the farmer and affect his cost of inputs and therefore net earnings. Manufacturers across the region should look at working together to standardise some or most of the common parts, which can bring about substantial savings across the industry, the benefits of which can ultimately be passed down to the farmer.

After-sales-services, and reliability and adaptability of machinery are key factors considered by farmers in making their purchase decisions. Here, gaps exist both in regard to the provision of timely after-sales-services by manufacturers and/or their representatives. Such after-sales-services include ensuring adequate supply of economically priced spare parts, support to farmers during warranty periods, and also capturing and sharing feedback on practical issues faced by farmers when the machines are put into use. What is recommended is closer cooperation between the partners in the supply chain to ensure that the machinery supplied to markets are adequately supported and information is shared both ways i.e. from markets to manufactures and vice-versa. The role of intermediaries is important in this regard, who need to provide information to manufacturers in regard to specific needs, soil and other agronomic conditions so that the machinery produced is suitable to such needs and also to ensure that specific requirements which demand local adaptation are identified.

Logistics

Agricultural machinery and implements are bulky items and therefore transportation involves substantial costs due to space taken. As an alternative and with a view to minimising logistical costs, it is recommended that manufacturers seriously consider moving such machinery and implements in knock-down form with provisions to assemble them in proximity to markets. Logistic costs become even higher and become an important factor when shipping goods across national borders.

Research and Development (R&D)

A closer dialogue is strongly recommended between R&D teams on either side of the demand and supply equation, i.e. R&D teams working on product development and R&D teams working on market development. A more integrated approach is recommended for both sides to work closely, so as to ensure machinery and implements manufactured are suited to market conditions. Efforts should be encouraged to link such R&D teams on a regular basis, discuss current developments and emerging agricultural sector challenges, and draw up common agendas based on the priority issues identified. This will benefit the region as a whole.

Training and Capacity Building

Technical expertise and skills in field application are two important dimensions for promoting sustainable agricultural mechanization. Those who are closest to the farmer and therefore the market are the distributors and retailers. Their knowledge and skills in regard to the machinery sold are critical to build conviction and trust in the mind of the farmers.

Therefore, it is recommended that manufacturers should build into their marketing efforts regular programmes through which such knowledge and skills are transferred to their distribution & marketing partners, who in turn can transfer such expertise to the end-user.

Sustainability and Inclusiveness

Climate smart agriculture: Policy makers should be encouraged to promote conservation agriculture practices in their respective markets which can help in integrating the social, economic and environmental dimensions of sustainable agricultural development, particularly for smallholder farmers. Farmers in many parts of the region still have traditional mindsets and therefore a patient and pragmatic approach is required to enable behaviour change. Awareness and availability of mechanization solutions which can promote conservation agriculture should be enabled. Such awareness programmes should include field level demonstrations, field trials and village level technology introduction programmes.

Mechanization for other field crops: This area of agriculture is often dominated by small family holdings and particularly engages women farmers. It is highly labour oriented, and there is strong need to support development and adoption of mechanization solutions here. Small-scale and cost-effective machinery, especially women friendly and easy to use solutions, should be actively promoted. To overcome procurement or financing problems, village level and women-led cooperative societies can be encouraged (such as micro-finance schemes), so as to enable sharing of machinery amongst a group rather than have individual ownership. Public-private-partnerships can be leveraged to support such an approach.

Empowerment of youth and women farmers: This segment of the rural population requires close attention. Youth represent the future and they need to be motivated to engage in agriculture. Similarly, women in rural areas are also a key part of the productive workforce who should be actively supported and encouraged. With the advent of mechanisation and modernisation of technology, more opportunities are opening up for youth as well as women in modern agricultural development. All stakeholders need to cooperate to have a cohesive and integrated approach to empower the youth and the women workforce through adoption of appropriate and climate smart agricultural machinery.

Way forward

Agricultural practices today must adapt to various challenges including natural resource degradation and a changing climate. Climate smart agriculture and smart crop production techniques have already been introduced and been spoken of widely. Mechanization solutions too will have to adapt and integrate with other dimensions of the sector as we race against a growing population that will mean more mouths to feed in the future. While farmers of all scales must be empowered to cope with the challenges, small farmer are in particular need of support. Mechanization is one major input and a catalyst. Manufacturers, research & development institutions and other stakeholders must work together to develop machinery that is suitable for small scale cultivation and for women farmers. Mechanization solutions are also needed to build long term resilience in agriculture and make the sector more attractive to youth. In the case of large-scale farming too, technological advancement is key, and precision agriculture, navigation and water management must play a major role in order to promote sustainability. Manufacturers, exporters, importers, distributors and end-users of agricultural machinery must work in close collaboration, sharing information on a regular basis, conducting field trials and benchmarking good practices to ensure economically, socially and environmentally sustainable mechanization solutions can be scaled up.

Photo by Meixing Li

References

India

Agri start-ups: Innovation for boosting the future of agriculture in India. (2018). Available at http://ficci.in/publication.asp?spid=23049 FICCI India.

Annual Report (2016-17). Department of Agriculture, Cooperation & Farmers Welfare (DAC&FW), Ministry of Agriculture & Farmers Welfare New Delhi.

Brian G. Sims and Josef Kienzle. (2009). Farm equipment supply chain. Guidelines for policymakers and service providers: experiences from Kenya, Pakistan and Brazil. FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS Rome, (FAO Rome).

Department of Agriculture & Cooperation (M&T Division), Govt. of India, Krishi Bhawan, New Delhi (2014). Operational Guidelines – Sub Mission on Agricultural Mechanization (Twelfth Five Year Plan).

Department of Agriculture & Cooperation (M&T Division), Govt. of India, Krishi Bhawan, New Delhi (2017). State of Indian Agriculture. Directorate of Economics and Statistics,

Department of Agriculture & Cooperation (M&T Division), Govt. of India, Krishi Bhawan, New Delhi (2017a). Horticultural Statistics at a glance. Directorate of Economics and Statistics.

Department of Agriculture & Cooperation (M&T Division), Govt. of India, Krishi Bhawan, New Delhi (2018). Final Report on Monitoring, concurrent evaluation and impact assessment of Sub-Mission on Agricultural Mechanization.

FICCI (2015). Transforming Agriculture through Mechanization: A knowledge paper on Indian Farm Equipment Sector. The Federation of Indian Chambers of Commerce and Industry (FICCI)

FICCI (2017). Mechanization: Key to higher productivity to double farmers' income. A report submitted by The Federation of Indian Chambers of Commerce and Industry (FICCI) to eima-agrimach 2017.

IASRI, New Delhi (2006). Final report of the project entitled "Study relating to formulating long term mechanization strategy for each agro climatic zone/State".

Kale V.K.N. (2015). Sub Mission on Agricultural Mechanization (SMAM) –a new Initiative of Government of India. Agricultural Machinery Manufacturers' Meet (AMMM) – 2015. Held at Hotel Le Meridien, Coimbatore during July 17-18.

Livestock Census (2003). Directorate of Economics and Statistics, Department of Agriculture, Cooperation & Farmers Welfare (DAC&FW), New Delhi.

Singh Gajendra and Singh Surendra. (2016). The Agricultural Mechanization in India. "The 25 years of the Club of Bologna - Evolution and perspectives of agricultural mechanization in the world". The paper presented at Club of Bologna meeting. 12-13 November.

Singh R S; Singh S P; Singh Surendra (2009a). Sales of tractors of different makes in India. Agricultural Engineering Today, 33(3): 20-37.

Singh R.S., Singh Surendra, Singh S.P. (2015). Farm power and machinery availability on Indian farms. Agricultural Engineering Today, 39(1): 45-56.

Singh S P; Singh R S; Singh Surendra (2009). Tractor production and sales in India. Agricultural Engineering Today, 33 (1): 20-32.

Singh S P, Singh R S; Singh Surendra (2011). Sales trend of tractors and farm power availability in India. Agricultural Engineering Today, 35(2): 25-35.

Singh Surendra (2016). Agricultural Machinery Industry in India. Agricultural Mechanization in Asia Africa & Latin America (AMA). 47(2): 26-35.

Singh Surendra, and Singh R S. (2018). Current Status of Farm Mechanization in India. Souvenir, Agricultural Machinery Manufacturers' Meet (AMMM) – 2018. Held at Hotel Four Points by Sheraton, Pune. September 8.

Singh, Punjab (2019). Presidential address: Feeding 1.7 Billion. On the occasion of Foundation Day and 26th General Body Meeting of national Academy of Agricultural Sciences (NAAS), New Delhi.

Singh, Surendra (2016a). Data Book - Agricultural Mechanization in India. Agricultural Machinery Manufacturers' Association (AMMA-India).

Tyagi K.K., Singh Jagbir, Kher K.K., Jain V.K., Singh Surendra (2010). A project Report on 'Study on Status and Projection Estimates of Agricultural Implements and Machinery'. IASRI New Delhi.

Sri Lanka

Department of Census & Statistics, Ministry of National Policies and Economic Affairs, General Report, Economic Census 2013/14, Agricultural Activities, Sri Lanka

S.K. Kumara, R. Weerakody, S. Epasinghe., (2016) Mechanization in Other Field Crop Sector: A Situational Analysis, Hector Kobbekaduwa Agrarian Research and Training Institute

Clarke, L.J., (2000), Strategies for Agriculture Mechanization Development – The Roles of Private Sector and Government, Food and Agriculture Organisation, UN

Denis,N., Fiocco,D., and Oppenheim, J. (2015), From liability to opportunity- How to build food security and nourish growth, McKynsey & Company [Online], Available at: https://www.mckinsey.com/industries/chemicals/our-insights/from-liability-to-opportunity-how-to-build-food-security-and-nourish-growth [accessed 6th May 2019]

Sustainable Agricultural Mechanization, (2019). FAO's Official website [online], Available at: http://www.fao.org/sustainable-agricultural-mechanization/overview/why-mechanization-is-important/en/ [accessed 6th May 2019]

Mechanization, (2019). FAO's Official website [online], Available at: http://www.fao.org/tc/exact/sustainable-agriculture-platform-pilot-website/energy-management/mechanization/en/ [accessed 7th May 2019]

Sustainable Development Goals, 17 Goals to transform our world, Retrieved from https://www.un.org/sustainabledevelopment/

Trade and Investment Policies on Mechanization of Agriculture: Case Studies of Selected Member Countries of the Regional Council of Agricultural Machinery Associations in Asia and the Pacific (ReCAMA), (2018). CSAM Official website [online], Available at: http://www.un-csam.org/publication/ReCAMA/CaseStudies-ReCAMA.pdf [Accessed 7th May 2019]

Thailand

Bank of Agriculture and Agricultural Cooperatives. (2019). News. Available at: https://www.baac.or.th/th/ [Accessed 07 August 2019]

Bangchongduang, S. (2018). Survey finds 40% of farmers live under poverty line. Available at: https://www.bangkokpost.com/thailand/general/1475901/survey-finds-40-of-farmers-live-under-poverty-line [Accessed 18 July 2019]

Centre for Agricultural Information. (2018). Thailand Foreign Agricultural Trade Statistics 2018. pp.127-143.

Centre for Agricultural Information. (2016). Thailand Foreign Agricultural Trade Statistics 2016. pp.135-150.

Chantarat, S., Autawanich, W., Sngaemnetr, B. (2018). Available at: https://www.pier.or.th/ [Accessed 07 August 2019]

CSAM. (2017). Trade and Investment Policies on Mechanization of Agriculture. [Online]. Available from: http://www.un-csam.org/publication/ReCAMA/CaseStudies-ReCAMA.pdf [Accessed 1 Aug 2019]

Department of Agricultural Extension. (2019). Farmer Map 2561, pp. 62-63.

Embassy of India. (2015). Thai Market for Agricultural Machinery. Available at: http://www.indianembassy.in.th/pdf/Market%20Survey%20Thailand%20Market%20for%20Agricultural%20Machinery%20Jan%202016.pdf [Accessed 3 August 2019]

Food and Agriculture Organisation of the United Nations. (2019). Machinery supply chain. Available at: http://www.fao.org/sustainable-agricultural-mechanization/strategies/machinery-supply-chain/en/ [Accessed 07 August 2019]

National Strategy Secretariat Office. (2017). National Strategy 2018 – 2037. Available at: http://www.nesdb.go.th/download/document/SAC/National%20Strategy%20(Summary).pdf?fbclid=IwAR15JP6McDiJhlBVQFDQI_nuH6l9Kktjy2WIT2CP_d14DztPLefilspaLv8 [Accessed 6 Aug 2019]

Office of Agricultural Economics. (2018). Available at: http://www.oae.go.th/assets/portals/1/ebookcategory/38_commodity2561/#page=10 [Accessed 02 August 2019]

Thepent, V. (2015). AGRICLUTURAL MECHANIZATION IN THAILAND. Available at: http://www.tsae.asia/2015conf/proceeding/agricultural_mechanization_in_thailand.pdf [Accessed 25 June 2019]

Udomkitmongkol, J. (2011). Agricultural Machinery. Available at: http://www.oie.go.th/sites/default/files/attachments/study_report/Agricultural%20Machinery-Feb2554.pdf [Accessed 5 July 2019]

Bibliography

Houmy, K., Clarke, L.J., Ashburner, J.E., Kienzel, J., (2013), Agricultural Mechanization in Sub-Saharan Africa Guidelines for preparing a strategy, Integrated Crop Management, Vol. 22